Plant gatherers, plant managers or agriculturalists? The importance of wild and domestic plants in Mesolithic and Neolithic Scotland

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Plant gatherers, plant managers or agriculturalists? The importance of wild and domestic plants in Mesolithic and Neolithic Scotland

Rosie R. Bishop

Abstract

The breakdown of the traditional rigid distinction between ‘hunter-gatherers’ and ‘farmers’ has lead to increased interest into the different types of human-plant relationships that existed in hunter-gatherer and early farming societies during the Mesolithic-Neolithic transition. This thesis assesses the scale and nature of human-plant exploitation in Mesolithic and Neolithic Scotland. Following Zvelebil (1994), several plant exploitation models are tested using palaeobotanical evidence: 1) opportunistic and incidental wild plant use; 2) systematic and intensive wild plant use; 3) wild plant food management, husbandry or cultivation; 4) the cultivation of domestic plants. It is concluded that wild plant exploitation was most probably systematic and intensive in Mesolithic Scotland, but there is no clear-cut evidence to substantiate the suggestion that Mesolithic hunter-gatherers managed wild plants. The relative importance of wild and domestic plants in the Neolithic economy is difficult to establish due to differences in the deposition, preservation, recovery and recording of cereals and wild plants. However, the importance of agriculture in the economy appears to have varied considerably between different sites and areas. In the Northern Isles and Outer Hebrides, settled agricultural communities were present and wild plant collection was insignificant. In contrast, a mixed plant subsistence economy based on both wild plant collection and cereal cultivation was probably the predominant subsistence strategy in mainland Scotland, though it appears that some apparently contemporary groups cultivated cereals on a large-scale, and others primarily focused on the collection of wild plants. The absence of cereals in assemblages from the Inner Hebrides and the West coast mainland suggests a greater degree of continuity in Mesolithic and Neolithic subsistence strategies in this area than elsewhere in Scotland. Differences in the importance of arable agriculture in each region may reflect the density of settlement in the Mesolithic and the natural availability of wild resources in the environment.

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VOLUME 1 OF 2

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Table of contents for volumes 1 and 2

VOLUME 1 OF 2

List of Tables

List of Figures

Statement of copyright

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Chapter 1: Introduction

1.1 Theoretical context

The level and nature of plant exploitation in Mesolithic and Neolithic Europe is a contentious area of debate. In traditional Western thought, hunter-gathering and farming have been perceived as diametrically opposed economic and social systems with the transition between these two ways of life occurring during a period of abrupt change during the Neolithic (Childe 1936:74, 1965:55; Pliciennik 2002:115). Consequently, whereas Mesolithic peoples have been seen as mobile hunters that had little control over their environment, Neolithic people have been viewed as sedentary agriculturalists that actively modified their environment through large-scale woodland clearances (Austin 2000:72-3; Warren 2005:69).

However, since the late 1960s this dichotomy has been increasingly questioned (e.g. Anderson 2006:252; Harris 1989:12-13; Layton et al 1991:260; Simmons 1969; Simmons et al 1981:103; Smith 1970:82; Woodburn 1980:100-1), and there has been increasing recognition that Mesolithic hunter-gatherers may have undertaken similar levels of plant exploitation to Neolithic farmers, through the active management of wild resources (Harris 1989; Zvelebil 1994). There has also been increasing recognition that the transition from hunting and gathering to farming during the Mesolithic and Neolithic was a gradual process, with multiple intermediary human-plant exploitation strategies occurring prior to the initiation of the large-scale cultivation of domestic crops (e.g. Harris 1989; Jarman et al 1982:53-4). At the same time, the widespread existence of highly developed and intensive systems of wild plant exploitation in modern hunter-gatherer societies in Africa, North America and Australia (e.g. Anderson 2006; Lewis 1982; Mellars 1976; Rowley-Conwy and Layton 2011; Vincent 1985) indicates that similarly sophisticated systems of wild plant exploitation of non-domesticated native species may have existed in Mesolithic Europe (Zvelebil 1994:36), without this necessarily leading to the agricultural production of these resources (Rowley-Conwy 2001:58-9; Rowley-Conwy and Layton 2011:854).

Equally, it has been recognised that hunter-gathering and farming are not mutually exclusive strategies (Harris 1989; Layton et al 1991:260; Panter-Brick et al 2001:2), and that both wild and domestic resources may have formed an important part of Neolithic economies (Barclay 2003a:148; Crone 1993:376). At the same time, the realisation that not all aspects of the so-called ‘Neolithic package’ of traits: monuments; pottery; permanent houses; and domestic plants and animals, occurred together at the same time in all parts of Europe, has called into question the idea that all European Neolithic societies were centred around sedentary settlements and the large-scale cultivation of domestic crops (Armit and Finlayson 1992:671, 1996:287; Barrett 1994; Thomas 1996, 1999:7-17, 2003:72, 2004, 2008b:70; Whittle 1999).

1.2 Models of plant use during the Mesolithic-Neolithic and their recognition in the archaeological record

The breakdown of the rigid distinction between 'hunter-gatherers' and 'farmers' has lead to increased interest into the different types of human-plant relationships that existed in hunter-gatherer and early farming societies during the Mesolithic-Neolithic transition. Consequently, various authors have proposed different models to describe the levels of active management, control and cultivation of plant resources in hunter-gatherer and early farming societies, each using different terms to describe the different types of plant exploitation (e.g. Harris 1989; Hynes and Chase 1982; Jarman et al 1982:53-4; Rindos 1984; Smith 2001; Zvelebil 1994). For example, Zvelebil (1994) outlined five different types of plant exploitation in the archaeological record, each differing in the level of intensity of plant use: 'Opportunistic and incidental use of plant food', 'Systematic and intensive plant use', 'Plant food management or husbandry', 'Cultivation of wild species' and the 'Cultivation of domesticated species'.

There are three main distinctions that are identified in most of these models. Firstly, there is the distinction between hunter-gatherers using plants on a small-scale without storage and hunter-gatherers that systematically exploit specific plants and store particular resources on a large-scale (Zvelebil 1994). This division aligns with anthropological categories of hunter-gatherer economic and social systems, such as Woodburn's (1980) 'Immediate Return' and 'Delayed Return' hunter-gatherers and Binford's (1980) definitions of 'Foragers' and 'Collectors.' Secondly, there is the division between plant food procurement (the gathering of wild plants) on the one hand and plant food production (the management or cultivation of wild plants) on the other (Harris 1989; Smith 2001). Wild plant management can be defined as a set of human practices that result in the increased production or control over specific plants and/or their habitats (Zvelebil 1994:40). The final distinction is between the cultivation or management of wild plants and the cultivation of domestic plants, which have morphological and genetic differences to wild species (Smith 1995b:18).

However, the recognition of these different plant exploitation strategies in the archaeological record is highly problematic, since most specific plant exploitation practices leave little discernible archaeological trace. As a result, most of these discussions have remained essentially theoretical and, with the exception of the model proposed by Zvelebil (1994), these models have rarely been tested using archaeobotanical evidence. While it is rarely possible to identify *specific* wild plant use activities, such as wild plant tending, arguably *different levels of intensity* of human plant use should be identifiable in the archaeological record. For instance, plant remains would rarely be recovered and high-density plant deposits and evidence for deliberate fuel selection strategies would be absent in economies only using plants in an incidental and infrequent manner. In contrast, systematic plant use should be recognisable in the archaeological record, through the consistent presence of particular species on many different sites, and intensive plant use through the presence of contexts with high-concentration plant remain deposits. These high-density deposits may be evidence for large-scale plant exploitation and possibly storage or feasting.

It may also be possible to recognise systematic wood harvesting strategies through the detailed analysis of archaeobotanical wood charcoal assemblages (e.g. Church et al 2007a). For instance, the presence of rootwood in charcoal assemblages would indicate that whole trees where utilised – either from naturally occurring uprooted trees or through deliberate felling (Dufraisse 2006:50). The condition of the wood can also indicate the type of collection strategy employed. For instance deadwood collection may be recognisable by the presence of boreholes in charcoal fragments created by insects which attack deadwood rather than living trees, by the presence of fungi in wood vessels or perhaps by higher mineral concentrations or signs of decay prior to charring (Dufraisse 2006:48-9; Prior and Price Williams 1985:471-2; Salisbury and Jane 1940:311; Scheel-Ybert 2002:163; Smart and Hoffman 1988:193). Conversely, greenwood collection may be indicated by the presence of radial cracks and cellular collapse in charcoal fragments (Dufraisse 2006:48-9). Likewise, branch stripping, can be recognised from disarticulation scars on larger charcoal fragments, and perhaps also by the presence of charred tree buds (Church et al 2007a:667), which are more likely to occur on live branches than on deadwood collected from the forest floor. Also, specific trees may have been targeted for harvesting for fuels, and by comparing the abundance of tree species in archaeological charcoal assemblages to vegetation reconstructions created using pollen analysis, it may be possible to identify firewood selection strategies.

Recognising wild plant management in the archaeological record is even more problematic. Most of the specific activities associated with the cultivation or enhancement of wild edible seeds (in this thesis the term ‘seed’ is used to refer to all wild seeds), berries and roots/tubers, such as replanting, transplanting, sowing, weeding, pruning, soil improvement, watering or fencing, leave no clear-cut archaeological signature and the effects of such practices would be virtually indistinguishable from intensive gathering in the archaeobotanical record. However, it is potentially possible to look for the consequences of some of these practices in the archaeobotanical record where appropriate assemblages exist.

For instance, by examining the changes in the sizes or features of particular seed species in archaeobotanical assemblages through time it is potentially possible to identify wild seed cultivation (Smith 1995b:23; Zohary 1992). These phenotypic changes are indicative of genetic changes, which would have occurred as a result of the repeated planting of seeds with particular characteristics (Smith 1995b:21). Though this is a methodology that has been used to identify the initial stages of the cultivation of wild cereals and other modern domesticates (e.g. Smith 1995b; Zohary 1992), it has also been used to identify the cultivation of wild seeds that never became modern agricultural staples. Such seeds can be considered genetically and morphologically 'domestic' or in an intermediary stage between 'wild' and 'domestic' forms (Rowley-Conwy and Layton 2011:850; Smith 2006:12228). For example, in North-America, several authors have argued that hunter-gatherers cultivated 'wild' Goosefoot (*Chenopodium berlandieri* ssp. *jonesianum*) seeds from 2nd millennium BC-18th century AD by showing that the seed coats of charred seeds in archaeobotanical samples decreased in thickness through time, a change which would have increased germination rates (Smith 1995b:187, 2006:12225, 2011:839). This interpretation is supported by documentary evidence from the 18th century that describes native Americans broadcasting the Goosefoot seed on the sandbanks of the Mississippi River and using their feet to cover the seeds with sand (Smith 2011:839). Phenotypic changes in native edible 'wild' seeds could potentially be recognised in archaeobotanical samples from Mesolithic Europe, provided large samples of seeds are available for study from multiple sites.

It may also be possible to recognise specific woodland management practices through the detailed analysis of archaeological wood and charcoal assemblages. For instance, the coppicing of trees to produce a regular supply of long, straight, flexible branches of a uniform diameter, for fuel and construction (Anderson 2006:209; Loewenfeld 1957:39; Rackham 2006:298) may be recognisable in the archaeological record. The presence of waterlogged wooden artefacts such as fish traps, which have been made from coppiced branches of a regular size and/or age, are frequently recovered in Mesolithic waterlogged contexts in Europe, particularly in Scandinavia (e.g. Christensen 1997). The analysis of archaeobotanical samples of wood charcoal can also be used to identify the selection of particular sizes/ages of branches or periodic branch stripping or harvesting (e.g. Church et al 2007a). Since a normal distribution of ages and sizes of wood would be expected from a random collection of branches collected from a woodland, skewed age and size distributions of particular species of roundwood charcoal may indicate deliberate selection practices; providing only large assemblages are analysed and appropriate consideration is made of the charcoal taphonomy. Specific management practices, such as pollarding may also potentially be indicated by ring thickness and the presence of anatomical features such as earlywood pores in latewood (Thiébault 2006:100). Moreover, general plant promotional practices used to control the distribution, abundance or productivity of plant resources, such as controlled woodland, grassland or heathland burning may be visible in the palynological record through changes in the proportions of the pollen of different plant species and increases in microcharcoal (Edwards and Ralston 1984).

At first sight, the recognition of the adoption of agriculture in the Neolithic archaeobotanical record may appear less ambiguous. Since domestic cereals are not native to Europe, once cereal grains are present in Neolithic archaeobotanical assemblages and cereal pollen present in the palynological record, it may be inferred that cereals have been introduced and cultivation initiated. However, many Northern and North-West European Neolithic assemblages contain a mix of edible wild and domestic plants (Jones and Rowley-Conwy 2007; Kirleis et al 2012; Kroll 2007; McClatchie 2007; Moffett et al 1989; Out 2009; Robinson 2007). Though the relative importance of wild and domestic plants in Neolithic economies can be suggested by calculating the proportion of wild and domestic plants in archaeobotanical assemblages, a range of potential interpretations are possible because of the differing taphonomies of the major wild and domestic species exploited (Jones 2000b; Jones and Rowley-Conwy 2007; Moffett et al 1989; Rowley-Conwy 2004). For example, it is possible that many ‘Neolithic’ communities maintained a largely hunter-gatherer existence (e.g. Thomas 2004:121), obtaining grain by trade or only growing crops on a small-scale. Likewise, while some communities may have had mixed economies, utilising a range of wild and domestic plants (e.g. Barclay 2003a:148), other groups may have subsisted predominantly on domestic plants (e.g. Jones and Rowley-Conwy 2007; Rowley-Conwy 2004). Therefore, the extent to which gathering and cultivation contributed to the Neolithic economy is difficult to evaluate.

Assessing the scale of cultivation in the Neolithic is also problematic. Various techniques have been proposed so look for different agricultural systems. For instance, large-scale cultivation may be suggested by the presence of large burnt cereal stores or high concentration cereal deposits on archaeological sites (Cooney 1997:27; Rowley-Conwy 2000:51, 2004:90). It may also be possible to distinguish shifting cultivation, the intensive cultivation of permanent small-scale ‘garden plots’ and extensive cultivation, through a comparison of the weed seed assemblages from archaeological sites to weed data from traditional farming studies and/or experimental evidence (e.g. Bogaard 2002, 2004; Bogaard and Jones 2007:367). Though manuring may be undertaken in both small-scale and large-scale cultivation, it provides evidence of a considerable investment in the arable economy. Manuring may be indicated through the analysis of the weed ecology of seed assemblages (Bogaard 2004) or by elevated nitrogen isotope levels in archaeological cereal grains (Bogaard et al 2007; Fraser et al 2011). It can also be identified using soil micromorphology, through the identification of soil inclusions, such as fuel ash, or using phosphate analysis to identify increased organic matter in archaeological soils (Guttmann 2005:227). Large-scale cultivation may also be suggested by field evidence for ard marks in buried soils and linear arrangements of post-holes or earthworks indicating the existence of former field systems.

1.3 Plant use in Mesolithic and Neolithic Scotland

Scotland is a key region for assessing the nature of Mesolithic and Neolithic plant exploitation, as it is was the last area of Europe to which agriculture spread, and presented an extremely diverse and challenging environment for human settlement. Consequently, both indigenous hunter-gatherer practices and incoming agricultural systems would have been highly developed.

Despite the importance of Scotland in understanding the nature of hunter-gatherer and farmer plant use, the Scottish archaeobotanical dataset has been largely ignored in discussions about the nature of human-plant interaction during the Mesolithic and Neolithic. Though some have argued that plants may have been an important component of the Mesolithic hunter-gatherer economies of Europe (Clarke 1976a:2; Hather and Mason 2002; Mason et al 1994; Mellars 1976:30; Mithen et al 2001; Zvelebil 1994), research in Mesolithic Scotland has almost exclusively focused on lithics and zooarchaeological assemblages and there has been no detailed consideration of the Mesolithic plant economy. Likewise, past reviews of Neolithic plants in Scotland (Boyd 1988b; Dickson and Dickson 2000) have included a restricted range of sites and wider British archaeobotanical reviews have considerably underestimated the number of Scottish sites with archaeobotanical remains (Brown 2007; Jones and Rowley-Conwy 2007). Thus, Mesolithic and Neolithic archaeobotany in Scotland is an understudied area, with much potential for increasing understanding of the nature of human-plant interaction during the Mesolithic and Neolithic in North-West Europe.

1.4 Research aims

The overall aim of this PhD thesis is to assess the scale and nature of human-plant exploitation in Mesolithic and Neolithic Scotland using palaeobotanical evidence. Following Zvelebil (1994), the criteria outlined in table 1 will be used to assess the extent to which plant use in Mesolithic and Neolithic Scotland involved:

1) opportunistic and incidental wild plant use;
2) systematic and intensive wild plant use;
3) wild plant food management, husbandry or cultivation;
4) the cultivation of domestic plants.

It should be noted that a progressivist model of increasing economic complexity is not advocated and that each of these categories can be considered as alternative options rather than inevitable 'stages' of people-plant interaction (Rowley-Conwy 2001).

Table 1: Palaeobotanical evidence associated with increasing levels of plant exploitation, based on Zvelebil's (1994) definitions. Zvelebil's (1994) 'plant food management or husbandry' and 'cultivation of wild species' categories have been combined, because it is considered that there is little theoretical or practical distinction between these categories.

Plant exploitation strategy	Intensity of plant usage	Archaeobotanical Evidence	Pollen Evidence
Opportunistic and incidental wild plant use	Low	Wild edible plant species occasionally present in archaeobotanical samples in low frequencies; no evidence for high density plant deposits or stored plant foods	No evidence for human impact
Systematic and intensive wild plant use	Intensive	Consistent evidence for wild edible plants on many sites, evidence for intensive plant use (samples with high density concentrations of plant remains and evidence for small-scale plant storage may be present), selective wood exploitation strategies may be apparent in charcoal assemblages	No evidence for human impact or evidence for the decline in the incidence of targeted species
Wild plant food management, husbandry or cultivation	Intensive, deliberate strategies to increase the control of plant resources and conditions favourable to the growth of specific species or the systematic sowing and planting of wild species	Consistent evidence for wild edible plants on many sites, evidence for intensive plant use (samples with high density concentrations of plant remains and evidence for small-scale plant storage may be present), selective wood exploitation strategies may be apparent in charcoal assemblages and changes in sizes/shapes of specific seed species may be discernible through time	Repeated burning episodes associated with increase in incidence of targeted species and/or maintenance of open landscapes
Cultivation of domesticated species	Intensive, intentional selective breeding of domesticated species	Domesticated crops present in archaeobotanical samples; wild plant species relatively insignificant in archaeobotanical samples	Maintenance of open landscapes, cereal pollen

1.5 Research questions

The following research questions will be addressed:

- What evidence is there for the gathering, processing and cooking of wild plants in the Scottish Mesolithic?
- Is there any evidence for a selective wood exploitation strategy in the Scottish Mesolithic?
- Is it possible to identify intensive plant use in the Scottish Mesolithic?
- Is there any archaeological or palynological evidence for plant management in the Scottish Mesolithic?
- What evidence is there for the gathering, processing and cooking of wild and domestic plants in the Scottish Neolithic?
- How important were wild and domestic plants in Scottish Neolithic palaeoeconomies?
- Was there any difference in the scale and nature of plant exploitation between the Mesolithic and Neolithic?
- What is the future potential of the Scottish Mesolithic-Neolithic archaeobotanical resource for studying the nature of human-plant interaction?

1.6 Thesis content and structure

Three main approaches will be used in this thesis to assess the level of human-plant interaction:

1) A review of Mesolithic and Neolithic archaeobotanical remains from Scotland;
2) Two detailed case-studies of human-plant interaction in the Northern and the Western Isles of Scotland using new archaeobotanical data from a Neolithic settlement at the Braes of Ha'breck, Wyre, Orkney and a Mesolithic old ground surface at Northton, Harris;
3) Holistic integration of these multiple lines of evidence to test the models.

Chapter 2 will review the pre-existing archaeobotanical dataset for plant gathering, processing and consumption in Mesolithic Scotland. In chapter 3, the charcoal evidence from Mesolithic Scotland will be used in conjunction with selected palynological evidence to assess the possibility of deliberate firewood selection strategies. Chapter 4 will extend this theme with a consideration of whether intensive wild plant use or plant management strategies can be recognised in the Scottish Mesolithic. In chapter 5, the relative importance of wild and domestic plants in the Scottish Neolithic will be assessed through a review of archaeobotanical evidence.

In chapters 6-7, the general themes addressed in chapters 1-5 will be considered in more detail with 2 case studies. Chapter 6 will analyse the archaeobotanical data from a recently excavated Mesolithic old ground surface at Northton, Harris to assess the importance of plant gathering at the site. Chapter 7 will assess the scale and nature of wild and domestic plant exploitation in Neolithic Orkney in detail, through a consideration of the archaeobotanical data from a newly excavated Neolithic site at the Braes of Ha'breck, Wyre, Orkney, together with the wider archaeobotanical and archaeological evidence for agricultural practices in Neolithic Orkney. Descriptions of the methodologies used in chapters 2-7 have been embedded in the individual chapters to relate directly to the appropriate research undertaken in each chapter.

Chapter 8 will further develop and link together the themes addressed in the previous chapters. In particular, the similarities and differences in the nature of plant exploitation between Mesolithic and Neolithic Scotland will be discussed. Finally, chapter 9 will provide suggestions for future archaeobotanical research in Mesolithic and Neolithic Scotland and will conclude the thesis.

Chapter 2: What evidence is there for the gathering, processing, cooking and consumption of wild plants in the Scottish Mesolithic?

2.1 Introduction

2.1.1 Chapter outline

This chapter seeks to assess the archaeobotanical evidence for the gathering, processing, cooking and consumption of wild plants in the Scottish Mesolithic. The first section will discuss the wider context of Mesolithic economic research in Europe and Scotland to provide a background to this study. The formation processes of Mesolithic archaeobotanical assemblages will then be discussed and the alternative modes of entry for wild plants into the archaeological record will be considered. The methodologies employed to compile and analyse the Scottish Mesolithic archaeobotanical dataset will then be described, before a brief summary of results is provided. Each of the major plant taxa that may have been used for consumption will then be discussed in detail, through a consideration of the archaeobotanical taphonomy and the historical and ethnobotanical evidence for wild plant use in Europe, Russia and North America. The final section will consider the range of plants potentially exploited by Mesolithic people in Scotland, which may be missing in archaeobotanical assemblages due to taphonomic factors.

2.1.2 Research context

European Mesolithic ‘hunter-gatherers’ have often been perceived primarily as hunters rather than gatherers (e.g. Jarman 1972; Price 1987:288). Processual approaches in Mesolithic subsistence studies have concentrated on the ranking of ‘staple’ resources, and there has been an overemphasis on the species which have been considered to be of most calorific importance, such as red deer, at the expense of foodstuffs thought to be of relatively minor significance, such as wild plants (Finlay 2000; Milner 2009:71). This is in spite of the fact that plants are widely acknowledged to play a crucial physiological and nutritional role within the human diet (Crowe 2005:6; King 1994:196; Speth 1989; Vaughan and Geissler 1997:200; Zvelebil 1994:58) and that abundant evidence exists for the importance of plants within many past and present hunter-gatherer economies (Anderson 2006:242; Crowe 2005:8-9; Kuhnlein and Turner 1991:10; Moerman 1998:15; Rowley-Conwy and Layton 2011:855).

Though some have argued for the importance of plants within European Mesolithic subsistence strategies (Clarke 1976a; Holst 2010; Mason et al 1994; McComb 2009; Mellars 1976:30; Mithen et al 2001; Zvelebil 1994), and there has been much debate about the potential role of Mesolithic communities in the management of wild plant resources (see chapter 4; Harris 1989; Zvelebil 1994), little detailed and systematic archaeobotanical research has been undertaken to substantiate these suggestions. This is largely a consequence of the widespread assumption that plant remains are rarely preserved in the Mesolithic, and as a result, detailed environmental sampling and analysis has not been systematically undertaken on Mesolithic sites (Hather and Mason 2002:2; Mason et al 1994:54). In fact, where appropriate methods have been employed, diverse assemblages of plant remains have frequently been recovered (Hather and Mason 2002:2; Mason et al 2002:195). Instead, research has focused on stone tools - the most well-preserved finds on Mesolithic sites - which have primarily been viewed as hunting rather than plant processing implements (Clarke 1976a:452; Finlayson and Edwards 2003:122; Warren 2005:86). However, recent use-wear and residue analyses have shown that many Mesolithic stone tool types were probably used for multiple purposes, including wood and plant processing (Finlayson 2004:224-5; Grace 1992:62; Milner 2009:66).

In Scotland, this situation has been compounded by the nature of the history of research. Since most Mesolithic sites identified on the East coast of Scotland consist of unexcavated lithic scatters (Finlayson 2004:222), evidence for the use of edible plants has rarely been recovered, reinforcing the view that meat was the primary foodstuff consumed. Moreover, research-driven excavation projects in Scotland have focused on West coast shell midden sites rather than on terrestrial sites because of the excellent organic preservation in shell middens and the difficulty of locating inland sites (Wickham-Jones 2004c:2, 2009:478), and this has skewed the picture of the Mesolithic diet towards marine foods (Finlayson 2004:222). Since shell middens are specialised sites involving marine exploitation (Wickham-Jones 2009:481), it is perhaps unsurprising that plant remains are relatively less abundant in such contexts compared to marine resources. Also, many shell middens were excavated in the 19th or early 20th century before the development of modern sampling procedures (Wickham-Jones 2004c:5) and so no plant remains have been recovered from these sites. Equally, the plant remains recovered from modern excavations of Scottish shell middens have rarely been studied in detail, with research focussing almost exclusively on animal resources (e.g. Mellars 1978, 1987). Consequently, the true significance of plants in such contexts remains uncertain. Furthermore, shell middens are often highly visible, easy to access and are easily identified as a result of coastal erosion. In contrast, inland sites are much harder to find due to large areas being covered in blanket bog, moors and mountains and the probable destruction of lowland Mesolithic sites as a result of development (Wickham-Jones 2004c:2). Therefore, though a number of shell middens have been excavated, they form only a very minor proportion of Mesolithic sites in Scotland (Wickham-Jones 2009:478-9), and so the contents of middens arguably cannot be regarded as typical of the overall Mesolithic diet.

The marine orientated view of the Mesolithic economy has been further emphasised by recent isotopic analyses of the human bone from the Oronsay shell middens, which have produced highly marine isotopic signatures (Schulting and Richards 2002). However, since only 4 human bones from two of the Oronsay shell midden sites have been analysed, this does not imply that marine foods were the dominant food resource utilised by all the inhabitants of Mesolithic Scotland. Due to the highly marine isotopic signature from these bones and the current uncertainties of the marine reservoir correction that should be applied to dates of this period, the calibrated dates from these bones are equivocal and have fluctuated across the Mesolithic-Neolithic transition in different publications (Milner and Craig 2009; Richards and Sheridan 2000; Schulting and Richards 2002). Consequently it is possible that several of the radiocarbon dates are contemporary with dates from the earliest Neolithic period (Schulting and Richards 2002). Even if these human bones are accepted to be 'Mesolithic', they may represent groups of coastal hunter-gatherers with more marine-orientated diets than inland communities (Milner 2009:66; Milner et al 2003). Indeed, isotopic analyses on Mesolithic human bones from elsewhere in Britain and Ireland have produced a much more varied picture, with some individuals with a predominantly terrestrial diet, some with a more marine-orientated diet and others with mixed diets (Milner 2009:66; Richards et al 2003). Thus, the role of plants within Scottish Mesolithic subsistence strategies requires reassessment.

2.1.3 The recognition of food plants in archaeobotanical assemblages

Plants that were consumed in the past may become charred in domestic fires during processing for consumption or storage by a range of techniques, such as grinding, grating, pounding, roasting, boiling, drying, leaching or soaking (King 1994:189; Minnis 1981:145; Stahl 1989:172; van der Veen 2007:979). They may also become carbonised accidentally during storage or if fires were lit on top of former processing areas, and deliberately if the waste products were burnt as a fuel (Minnis 1981:145; Sievers and Wadley 2008:2916; van der Veen 2007:979). However, establishing which plants in Scottish Mesolithic assemblages were deliberately gathered for food is highly challenging. There is not a clear-cut distinction between edible and non-edible plants since the extent of palatability of sour, bitter and astringent plants is culturally – and perhaps genetically – determined

(Ertuğ 2009:68; Johns 1994:46,49), factors which are clearly impossible to establish for past populations. Also, many species that are poisonous, harmful or unpalatable can be made edible through elaborate processing techniques (Johns 1994:48). Since such processing methods usually leave little archaeological trace, it is usually difficult to discern whether these practices were undertaken in the Mesolithic. Even simple plant processing techniques, such as hearth or pit roasting, are difficult to identify archaeologically, since hearths or pit features can be used for multiple purposes and for cooking many different foodstuffs using divergent methods (King 1994:191).

Historical or ethnographic evidence of wild plant gathering by modern hunter-gatherers in North America and by traditional farming peoples in Turkey, Europe and Russia, can give important information about the edibility and processing of specific plant species recovered from Scottish Mesolithic sites (Ertuğ 2009:69; Stoličná 2000:195). However, edibility does not necessarily equate to consumption in the Mesolithic, since the range of food consumed by a social group is culturally defined and plants, which were historically or ethnographically important, may not have been important food sources in Mesolithic Scotland (Milner 2009:74). It should also be noted that though wild plants were often merely minor dietary components or considered only as 'famine foods' by some farmers in Europe or Russia (Fenton 2000:192; Tardío et al 2006:39) they may have been of greater importance to hunter-gathering peoples reliant on wild resources. The use of ethnographic evidence to assess wild plant consumption in the past should therefore be treated with caution.

Moreover, wild plants may arrive on archaeological sites through non-anthropogenic sources, such as the wind, or birds and other animals may act as vectors for seeds either externally on their fur or internally via consumption (Minnis 1981:145; Pearsall 2000:502; Sievers and Wadley 2008:2911). Seeds and other plant remains may also become transported accidentally onto archaeological sites attached to human hair or clothing. Thus, considering the low frequency of many of the species identified in this review, it is conceivable that some of these plants were deposited without deliberate human collection.

Also, not all wild plants deliberately brought onto Mesolithic sites were collected for human consumption. Most wild plants have many potential non-edible uses: they may be used as medicines, cosmetics, toys or for dyeing, bedding, construction, tools, fuel, bedding, cordage, utensils, basketry and hunting poisons, and some species might have become deposited on archaeological sites as a result of these activities (Etkin 1994:10; Fenton 2000:184; King 1994:196; Moerman 1998; Tomlinson and Hall 1996). As Ertuğ (2009:69) notes, "Almost all routine subsistence activities and their social organisation, as well as most of the material objects that we encounter in the rural daily life, are somehow related to plants."

Furthermore, plants can be consumed as part of ritual practices, rather than primarily for calorific purposes (Milner 2009:80). For instance, if the Mesolithic pit alignment at Warren Field, Crathes was a symbolic monument (table 2), then it is possible that the plant remains from the site, became deposited as a result of 'ritual' rather than domestic activities. However, with the exception of Warren Field, all the sites in this review are considered to primarily provide evidence of 'domestic' economic activity. All of these sites are suggestive of temporary/semi-permanent settlement or specialised processing, tool production or other economic activities; though clearly so-called 'domestic/functional' activities may have been embedded with social and symbolic meaning (Brück 1999).

Also, there is not a clear-cut distinction between plants used as foods and medicines. Ethnobotanical research in Europe and North-America suggests that many wild plants have traditionally been collected for multiple purposes and may be considered both food and medicines or 'medicinal foods' which were used to improve health or to prevent illnesses (Carvalho and Morales 2010:160,164; Christanell et al 2010:62; Ertuğ 2000:177; 2009:67; Etkin 1994:9-10; Moerman 1998:16; Nebel and Heinrich 2010:183; Pieroni 2005:29, 2010:41; Tardío 2010:230; Tardío et al 2006:38). However, different parts of the same plant were often used for food than those used for medicine (Moerman 1998:16). The remains of wild plants can therefore enter archaeological sites by a number of different taphonomic pathways, which may be unrelated or only partially related to domestic consumption.

The Mesolithic date of single seed identifications in archaeological assemblages can also be questioned. Isolated seeds may become worked down into earlier layers as a result of ploughing, or by burrowing earthworms or small mammals (Minnis 1981:145) and so there is a possibility that species represented by single seed identifications may be intrusive into Mesolithic layers. In general, however, where dense concentrations (ibid:149) or multiple identifications of a particular species exist from secure stratigraphic contexts, the species can be reliably attributed to the Mesolithic.

Therefore plants can become deposited on Mesolithic sites as a result of a range of processes and it is not always clear-cut whether charred plant remains represent food remnants. This chapter will consider the possible evidence for the human collection of plants for consumption in Mesolithic Scotland.

2.2 Methodology

2.2.1 Data selection

A database of 47 Mesolithic sites with archaeobotanical remains was compiled (table 2) by systematically searching through regional and national journals and major monograph series from January 1960-September 2011, as well as published excavation reports, Mesolithic publications and references obtained from previous reviews of plant macrofossils and Mesolithic radiocarbon dates (Ashmore 2004b; Dickson and Dickson 2000). Unpublished data from several sites was also obtained from archaeological units and academics researching Mesolithic Scotland (see acknowledgments). In addition, sites with Mesolithic radiocarbon dates from Discovery and Excavation in Scotland 1970-2010 were also investigated further where possible. However, some of these sites were either still in the initial stages of the post-excavation process or had not yet been fully published. Therefore, the review is a comprehensive, but not a complete list of all Mesolithic sites with plant remains in Scotland.

Sites were included in the review if they met the following criteria. All Mesolithic sites where the remains of charred nuts, fruits, roots/tubers/parenchyma or seeds (in this thesis the term ‘seed’ is used to refer to all wild seeds) have been recovered by hand-collection or sampling were included in the database. In addition, sampled sites where wood charcoal was the only plant component recovered, were included in the database of sites (table 2) and are discussed in chapter 3, but are only included in this chapter with regards to the total number of site blocks. While it would have been preferable to only include sites where sampling was undertaken, to ensure the data was representative of the plant remains present on site (Jones 2000b:79; van der Veen 1984:193), this would have severely restricted the number of sites available for synthesis because sampling on Mesolithic sites has not been universally undertaken. Plant remains from natural soil profiles were excluded from the database.

Plant remains were considered to be Mesolithic in date if they were from secure contexts and were either directly radiocarbon dated or associated with material radiocarbon dated to within accepted chronological ranges for the Mesolithic period in Scotland: 8600-4000 cal BC (Ashmore 2004a, 2004b), or if they were from undated contexts securely associated with Mesolithic artefactual material. Undated plant remains from insecure contexts containing radiocarbon-dated material of both Mesolithic and later date or concentrations of cereal grains or post-Mesolithic artefacts were also excluded from the review. In addition, radiocarbon dated Mesolithic plant remains in contexts clearly of post-Mesolithic date were excluded. However, directly dated Mesolithic plant remains from secure contexts were included if only a single intrusive cereal grain or radiocarbon date of post-Mesolithic date was present.

Table 2: Description of each site in the review. For a description of the woodland zone classifications see section 2.2.2. EM: earlier Mesolithic; LM: later Mesolithic; M: Mesolithic. The locations of the sites are shown in figure 1. The bold text in the Site Description column indicates the contexts of recovery of the plant remains.

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
Ailsa View	1	2	mid 8th-early 7th millennium cal BC	EM	**possible hearth pits**, **pits** and a lithic scatter	judgement sampling, bulk samples, flotation	Cook and Engl 2002; Gooder 2002, 2004; Gooder and Engl 2002; Miller 2002
Aird Callanais	2	3	early 6th-mid 5th millennium cal BC	LM	**old ground surface**	total sampling, bulk samples, flotation	Flitcroft and Heald 1997; O'Brien et al 2009
Auchareoch	3	1	late 8th-late 7th millennium cal BC	EM	lithic scatter, **fire spots** and a **pit**	no information available	Affleck et al 1988
Beattock	4	2	late 7th-early 6th millennium cal BC	LM	**a pit**	total sampling, bulk samples, sieving	Dunbar 2008
Biggar Common	5	2	mid 6th-early 5th millennium cal BC	LM	**stakeholes**, postholes, charcoal spread and shallow hollow (stake-built structure)	judgement sampling, bulk samples, no further information available	Crone 1997; Johnston 1997
Camas Daraich	6	1	late 8th-late 7th millennium cal BC	EM	occupation layers, **scoops** and a **possible hearth**	bulk samples, no further information available	Cressey 2004; Wickham-Jones et al 2004
Carn Southern	7	1	associated with Mesolithic artefacts	M	flint scatters, **occupation layer**, but no hearths or structures	wet sieving of most deposits, no further information available	Searight 1990
Castle Street	8	1	late 8th-early 6th millennium cal BC	M	**occupation layers** containing artefacts and ecofacts and incorporating a possible hearth	soil wet sieved to 5mm, no further information available	Dickson 1985; Wordsworth et al 1985
Chapelfield Pit 5	9	2	late 7th-mid 6th millennium cal BC	M	3 pits (**only pit 5 securely dated and included in this analysis**)	hand collection, bulk samples, flotation, no further information available	Alldritt 2002; Atkinson 2002

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
Cnoc Coig	10	1	early 5th-early 4th millennium cal BC	LM	**shell midden**, occupation surfaces, possible stake-built structures and hearths	3-stage cluster sampling; bulk samples and flotation to 1mm; all soil wet-sieved to 3mm	Boyd and Kenworthy 1991-2:18; Mellars 1978, 1979, 1987; Peacock 1978;
Cramond	11	2	early-late 9th millennium cal BC	EM	lithic scatter, **old ground surfaces**, **pits**, **a scoop and stakeholes (phase 1 & 2 only in this analysis)**	100% sampling, bulk samples, flotation	Hastie 2003e; Lawson 2001; Reed 1995
Daer Valley Site 84	12	2	late 5th millennium cal BC	LM	old ground surface, **a pit** and a lithic scatter	total sampling, bulk samples, flotation to 1mm	Ward 2005a, 2005b, 2005c
East Barns	13	2	late 9th-early 8th millennium cal BC	EM	**sunken floor** with postholes and **burnt walling** around it and **a possible hearth**, stakeholes and slot features within floor (oval structure with internal furniture), and **pits** and **an occupation horizon** around structure	bulk samples, flotation, no further information available	Gooder 2007; Hall 2002
Elginhaugh	14	2	associated with Mesolithic artefacts	M	lithic concentration in sand layer and **natural feature**, no definite man-made features	judgement sampling, bulk samples, flotation	Clapham 2007; Hanson 2007
Fife Ness	15	2	early 8th-late 8th millennium cal BC	EM	**occupation layer**, **pits**, shallow scoops, linear cut, possible hearth, curving line of pits (possible windbreak structure)	total sampling, bulk samples, flotation	Holden 1996b; Wickham-Jones and Dalland 1998a, 1998b
Fordhouse Barrow	16	2	early: mid 8th-early 7th millennium cal BC; late: mid-late 5th millennium cal BC	Early:EM; Late:LM	**pits and old ground surfaces** beneath barrow	no information available	Peterson and Proudfoot 1996, 1997; Proudfoot 1999, 2001

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
Gallow Hill	17	2	late-mid 5th millennium cal BC	EM	**pits** and a lithic scatter	no information available	Donnelly and Macgregor 2005; Miller 2005
Garthdee	18	1	early-mid 5th millennium cal BC	LM	**a pit**	100% sampling, bulk samples, flotation	Murray and Murray Forthcoming; Timpany 2008b
Glenbatrick Waterhole	19	1	associated with Mesolithic artefacts	M	**occupation layer** and lithic scatter	no information available	Mercer 1972-4
Irish Street	20	2	associated with Mesolithic artefacts	M	lithic scatter in a **layer and cut feature** containing postholes and stakeholes (possible wind break or drying rack)	dry sieving to 5mm; no further information available	Mackenzie et al 2002
Kilellan Farm	21	1	associated with Mesolithic artefacts	M	areas of laid pebbles and flat stones, a pit and lithic scatter **in sand layer**	bulk samples, no further information available	Boardman 2005; Ritchie 2005
Kinloch	22	1	late 9th-late 7th millennium cal BC	EM	**pits**, postholes, **hollows**, stakeholes, slots and lithic scatter	no sampling, soil sieved to 3mm	Wickham-Jones et al 1990
Lealt Bay	23	1	associated with Mesolithic artefacts	M	lithics and ecofacts in **gravel/sand layers**	no sampling, main occupation horizon partially wet sieved to 3mm	Mercer 1967-8
Links House	24	3	late 8th-early 7th millennium cal BC	EM	lithic scatter, **stakeholes**, **postholes**, **pits**, hollows, **natural features and thin occupation layers** (stake and post structures, external structures)	100% sampling of features, bulk samples, flotation, top soil 100% wet sieved to 4mm	Alldritt 2011; Lee and Woodward 2008, 2009a, 2009b; Woodward 2008
Littlehill Bridge	25	2	late 7th millennium cal BC	EM	**scooped features**, occupation deposit and lithic scatter	bulk samples, flotation, no further information available	Macgregor et al 2001; Miller and Ramsay 2001b

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
Lon Mor	26	1	late 7th-early 4th millennium cal BC	M	**organic rich horizon** containing artefacts and ecofacts	no information available	Bonsall et al 1993; Bonsall 1996
Long Howe	27	3	late 8th-early 7th millennium cal BC	EM	**old ground surface** beneath a barrow	total sampling, bulk samples, flotation	Robertson and Woodward 2007; Wickham-Jones and Downes 2007
Lussa Wood	28	1	late 9th-mid 7th millennium cal BC	EM	**3 conjoined stone rings in a scoop**, area of flat stones and **occupation layers**	no sampling, soil wet sieved to 3mm	Mercer 1978-80; Moore 1978-80
Manor Bridge	29	2	mid 9th-early 8th millennium cal BC	EM	lithic scatter, cobble area and **possible pit**	bulk samples, flotation, no further information available	Hastie 2002; Warren 1998, 2003; Graeme Warren pers. comm.
Morton	30	2	Morton A:mid 8th-early 5th millennium cal BC; Morton B: early 6th-early 5th millennium cal BC	Morton A: M; Morton B: LM	Morton A: lithic scatters, **occupation floors**, **hearths** and stakeholes (possible shelters/windbreaks); Morton B: **shell midden** incorporating hearths, stakeholes, postholes and stone walling	Site A = hand collection; Site B = judgement sampling, bulk samples, flotation	Coles 1971
Newton	31	1	late 8th-late 7th millennium cal BC	EM	**gullies**, pits and **depression** containing artefacts and ecofacts (possible structure)	bulk samples, flotation to 0.35mm, no further information available	McCullagh 1989a, 1989b

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
North Carn	32	1	mid-late 7th millennium cal BC	EM	lithic scatter, scoops and an **L-shaped stone setting in an old land surface**	some soil sieved, no further information available	Mercer 1971-2
Northton 2001	33	3	late 8th-late 7th millennium cal BC	EM	**old ground surface** containing artefacts and ecofacts	total sampling, bulk samples, flotation	Gregory et al 2005; Simpson et al 2006a
Redkirk Point	34	2	late 8th-mid 7th millennium cal BC	EM	**hearth** within shallow hollow	bulk samples, sieving, no further information available	Masters 1981
Silvercrest	35	1	post-circle 1: late 7th-early 6th millennium cal BC; post-circle 2: mid-late 8th millennium cal BC	Silvercrest 1 & 2: EM	**2 post-circle structures** and a possible post alignment	bulk samples, flotation, no further information available	Cressey and Lyons Forthcoming; Cressey and Suddaby 2002; Suddaby 2007
Sketewan	36	2	mid-late 7th millennium cal BC	EM	70 possible **pits/tree holes** in old land surface	bulk samples, no further information available	Dickson 1997; Mercer and Midgley 1997
Skilmafilly	37	1	mid 5th-early 4th millennium cal BC	LM	**a large pit**	total sampling, bulk samples, flotation	Cressey 2003, Forthcoming; Hastie 2003b, Forthcoming; Johnson and Cameron Forthcoming
Smittons	38	2	mid 6th-late 5th millennium cal BC	LM	lithics scatter, **fire spots** and arc of stakeholes	no information available	Affleck 1983; Edwards 1996b

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
Spurryhillock	39	2	early-late 5th millennium cal BC	LM	**a pit**	hand collection, judgement sampling, bulk samples, flotation	Alexander et al 1997; Clarke 1997
Staosnaig	40	1	F24:late 8th-early 6th millennium cal BC; F41 & F49:late 8th-late 7th millennium cal BC; F30:late 5th millennium cal BC	F24:M; F41 & F49:EM; F30:LM	**pits**, a hearth and **a large pit** containing a posthole (probable hut reused for disposing of knapping debitage and plant processing debris)	feature F24:25-50% random sampling of 0.5m grid squares, bulk samples and flotation; other features: wet sieved to 3mm	Carruthers 2000; Hather 2000b; Mason and Hather 2000; Mithen 2000; Mithen et al 2001
Summerston	41	2	late 5th millennium cal BC	LM	**a post-pit**	no information available	Baker 1998
Temple Bay	42	3	early-mid 6th millennium cal BC	LM	**old ground surfaces** containing artefacts and ecofacts	100% sampling, bulk samples, flotation	Blake et al 2012b; Church et al 2012a
Tràigh na Beirigh	43	3	late 4th millennium cal BC	LM	**shell midden**	100% sampling, bulk samples, flotation	Blake et al 2012a; Church et al 2012b
Tulloch Wood	44	1	pit 1:early-mid 6th millennium cal BC; pit 2: early-late 6th millennium cal BC; pit 3: early-late 5th millennium cal BC	Pits 1-3: LM	**pits**	judgement sampling, bulk samples, flotation	Carter 1993

Site	Site Number	Woodland Zone	Site Period	Period Block	Site Description	Sampling Information	References
Ulva Cave	45	1	early 7th-late 5th millennium cal BC	M	**shell midden**	column samples, dry sieving to 2mm, no further information available	Bonsall et al 1991, 1992, 1994; Russell et al 1995
Upper Largie	46	1	mid-late 5th millennium cal BC	LM	**pits and postholes**	bulk samples, flotation, no further information available	Gale 2007; Cook et al 2010; Vandorpe 2007
Warren Field	47	1	pit 5: late 8th-mid 6th millennium cal BC; other pits:late 9th-mid 8th millennium cal BC	pit 5:M; other pits:EM	**pit alignment**	bulk samples, flotation, no further information available	Hastie 2004a; Lancaster 2009a; Murray et al 2009; Timpany 2006c
Weston Farm	48	2	early: late 6th-early 5th millennium cal BC; late: late 8th-early 7th millennium cal BC	Early:EM; Late:LM	lithic scatter, **pits**, **old ground surface** containing artefacts and ecofacts	bulk samples, flotation, every feature sampled	Ward 2005d, 2006

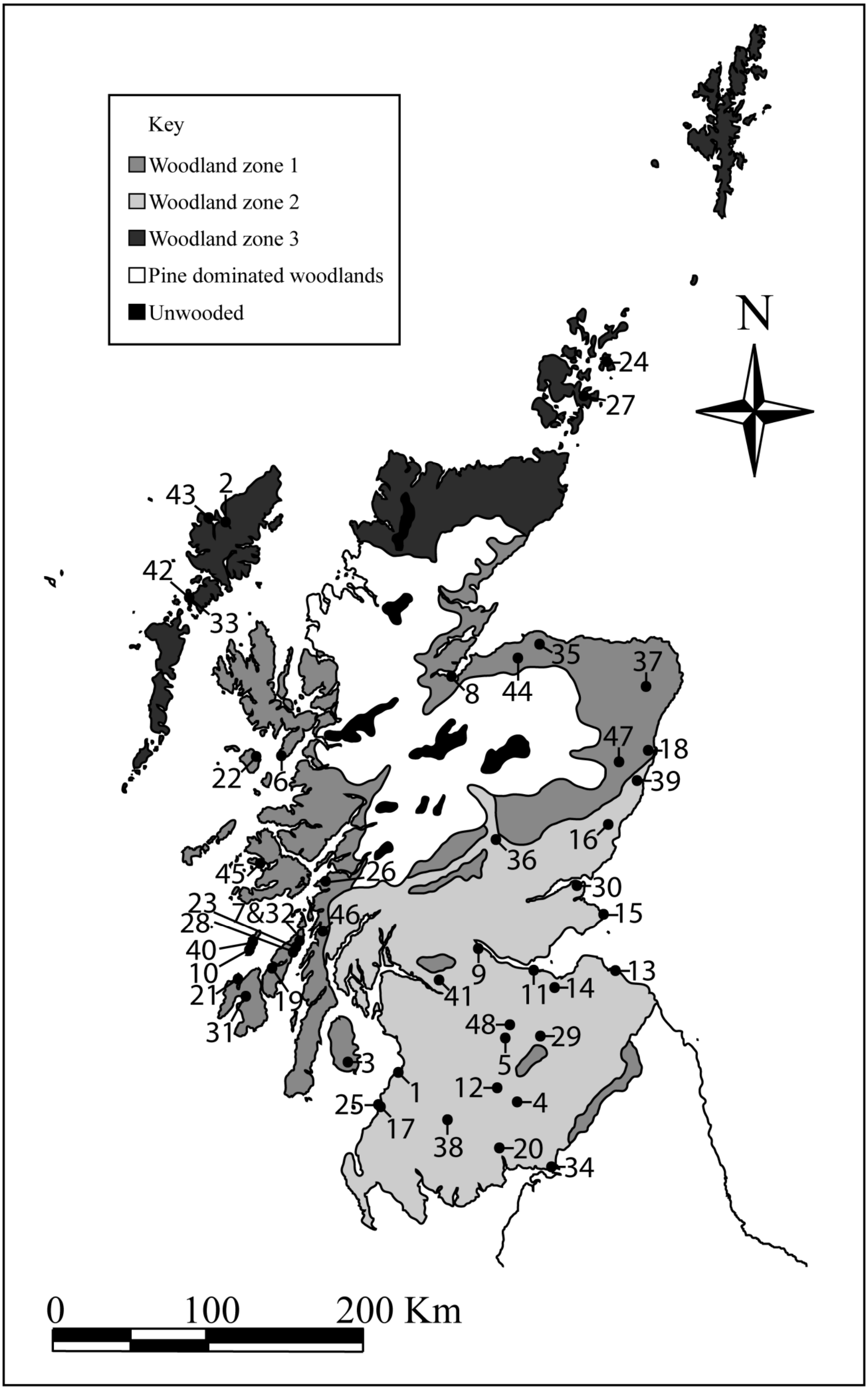
2.2.2 Geographical and chronological site classifications

In order to assess whether there were any chronological trends in the dataset, uncalibrated radiocarbon dates from each site were calibrated using OxCal v 4.1.7 (Bronk Ramsey 2009) using IntCal09 (Reimer et al 2009) and each site was classified as earlier Mesolithic (8600-6000 ± 20 cal BC) or later Mesolithic (6000-4000 ± 20 cal BC) using the arbitrary date of 6000 cal BC as the divider between these periods. Where possible, different site contexts were separated into these chronological categories. Sites that could not be placed into these period blocks due to an absence of radiocarbon dates or an insufficiently tight radiocarbon chronology were classed as 'Mesolithic' (8600-4000± 20 cal BC). Therefore, there chronological categories were used: 1) earlier Mesolithic, 2) later Mesolithic and 3) Mesolithic.

These chronological groupings are clearly very coarse, but finer chronological categories were not possible for several reasons. Firstly, some dates spanned multiple millennia, making the division of sites into millennium-scale categories problematic. Secondly, it was not always clear how undated plant remains related to the different site phases when radiocarbon dates from other materials spanned several millennia.

The sites were further divided into 3 geographical categories based on Tipping's (1994, 2004) woodland classification scheme for the period c. 4000 cal BC: woodland zone 1: Inner Hebrides, West Coast Mainland and North-East Scotland, woodland zone 2: Southern and Central Scotland, and woodland zone 3: Northern and Western Isles of Scotland (see figure 1). Tipping's (1994, 2004) 'pine & pine/birch woods' zone was excluded from the analysis because no Mesolithic sites with archaeobotanical remains were present in this area. Whilst it is recognised that the vegetation changed considerably between 8000-4000 cal BC, these zones represent useful geographical regions for comparison, reflecting the major woodland zones available for wild plant exploitation. Where possible, site features that were clearly spatially distinct were separated into different site blocks.

Figure 1: Map of Scotland showing Mesolithic site locations. Numbers correspond to the sites listed in table 2 and woodland zones are taken from Tipping (1994, 2004).



2.2.3 Data recording and analysis

For each site in the review, the abundance of each plant taxon present within each assemblage was recorded numerically where possible and on a scale of ‘present’ (‘P’), absent (blank), or ‘abundant’ (‘A’) when plant components were not numerated in the archaeobotanical reports. The sampling methodologies employed and background information about each site was also recorded to aid the comparison between different sites (table 2). The archaeobotanical species identifications were summarised by grouping the plant taxa into different categories (a full list of the plant taxa and components in each of these categories is given in table 3). The term "seeds" is used in the text to include all small botanical fruits/nuts: achenes, fruits, nuts and caryopses (table 3). Plant species classed as ‘cf.’ were added to the definite species identifications, for example cf. *Malus sylvestris* (L.) Mill was placed in the Crab Apple seed/fruit fragment category (table 3). Quantification in tables 4-7 was based on numerical counts of plant components presented in the archaeobotanical reports where possible, but the masses of hazelnut shell were also noted where this information was available because identifications were not universally presented as numerical counts in the archaeobotanical reports. Seed totals for plants with edible and inedible components are given in table 4. Species identifications for plants with edible seeds and seeds from plants with edible leaves, stems, shoots, flowers and roots are shown in tables 5 and 6 respectively. Seeds from inedible plants and seeds identified at too high a taxonomic level to be certain of edibility are listed in table 7.

It was not possible to use semi-quantitative or quantitative methods to analyse the edible plant macrofossil dataset because there were severe discrepancies in the sampling, recovery and recording methods employed between different sites. Also, the differential fragmentation of different types of plant remains means that quantitative methods would have been unsuitable for comparing different plant components, such as seeds and tubers. Direct quantitative comparisons between different sites would also have been problematic because plant remains were only present in low frequencies in most assemblages and on some sites, the plant remains probably represent palimpsests of multiple behaviour episodes and periods of site use. Consequently, in this review, the plant macrofossil data will be considered on a presence/absence basis only.

Table 3: Common and scientific names of plant components included in each plant group in tables 4-7.

Plant group	Common name	Latin name	Plant Part
Hazelnut shell	Hazelnut	*Corylus avellana* L.	Nutshell
Whole hazelnut	Hazelnut	*Corylus avellana* L.	Cotyledon
Lesser Celandine tuber/ bulbil	Lesser Celandine	*Ranunculus ficaria* L. (ssp. *ficaria*/ssp. *bulbilifer* Lambinon)	Root tuber
Lesser Celandine tuber/ bulbil	Lesser Celandine?	cf. *Ranunculus ficaria* L. (ssp. *ficaria*/ssp. *bulbilifer* Lambinon)	Root tuber
Lesser Celandine tuber/ bulbil	Lesser Celandine	*Ranunculus ficaria* L. (ssp. *bulbilifer* Lambinon)	Bulbils
Unidentified parenchyma/ root/ vesicular material	Aggregate parenchyma	n/a	Parenchyma
Unidentified parenchyma/ root/ vesicular material	Aquatic aerenchyma	n/a	Aerenchyma
Unidentified parenchyma/ root/ vesicular material	Aquatic aerenchyma?	n/a	Aerenchyma
Unidentified parenchyma/ root/ vesicular material	Tap root	n/a	Tap root
Unidentified parenchyma/ root/ vesicular material	Tap root?	n/a	Tap root
Unidentified parenchyma/ root/ vesicular material	Unidentified parenchyma	n/a	Parenchyma
Unidentified parenchyma/ root/ vesicular material	Vesicular parenchyma	n/a	Parenchyma
Unidentified parenchyma/ root/ vesicular material	Vitreous/vesicular carbonised material	n/a	Parenchyma/ seaweed/ processed plant material fragment
Stem/ rhizome	Grass stem?	cf. Poaceae family	Stem
Stem/ rhizome	Indeterminate rhizome	n/a	Rhizome
Stem/ rhizome	Indeterminate stem	n/a	Stem

Plant group	Common name	Latin name	Plant Part
Seaweed fragment	Knotted Wrack seaweed?	cf. *Ascophyllum nodosum* (L.) Le Jolis	Seaweed
Hawthorn stone	Hawthorn?	cf. *Crataegus monogyna* Jacq.	Fruit stone
Hawthorn stone	Hawthorn genus?	cf. *Crataegus* sp.	Fruit stone
Crab Apple seed/fruit fragment	Crab Apple	*Malus sylvestris* (L.) Mill	Seed
Crab Apple seed/fruit fragment	Crab Apple?	cf. *Malus sylvestris* (L.) Mill	Seed
Crab Apple seed/fruit fragment	Crab Apple	*Malus sylvestris* (L.) Mill	Pericarp
Pear pip	Pear genus?	cf. *Pyrus* sp.	Seed
Seeds from other edible species	Orache genus	*Atriplex* sp.	Seed
Seeds from other edible species	Common Orache	*Atriplex patula* L.	Seed
Seeds from other edible species	Sedge genus	*Carex* sp.	Nut
Seeds from other edible species	Fat-hen	*Chenopodium album* L.	Seed
Seeds from other edible species	Spike-rush genus?	cf. *Eleocharis* sp.	Nut
Seeds from other edible species	Black-bindweed	*Fallopia convolvulus* (L.) Á. Löve.	Nut
Seeds from other edible species	Cleavers	*Galium aparine* L.	Fruit
Seeds from other edible species	Ribwort Plantain	*Plantago lanceolata* L.	Seed
Seeds from other edible species	Knotgrass	*Polygonum aviculare* L.	Nut
Seeds from other edible species	Meadow Buttercup/Creeping Buttercup/Bulbous Buttercup	*Ranunculus acris*/*repens*/*bulbosus* L.	Achene
Seeds from other edible species	Dock genus	*Rumex* sp.	Nut
Seeds from other edible species	Charlock	*Sinapis arvensis* L.	Seed

Plant group	Common name	Latin name	Plant Part
Seeds from other edible species	Corn Spurrey	*Spergula arvensis* L.	Seed
Seeds from other edible species	Common Chickweed	*Stellaria media* (L.) Vill.	Seed
Seeds from other edible species	Vetch/tare genus	*Vicia* sp.	Seed
Seeds from other edible species	Vetch/tare genus?	cf. *Vicia* sp.	Seed
Seeds from other edible species	Vetch/tare genus	*Vicia*/*Lathyrus* sp.	Seed
Seeds from other edible species	Vetch/tare genus?	cf. *Vicia*/*Lathyrus* sp.	Seed
Seeds from other edible species	Violet genus	*Viola* sp.	Fruit
Other seeds	Grass family	Poaceae family	Caryopsis
Other seeds	Goosefoot family	Chenopodiaceae family	Achene
Other seeds	Sun Spurge	*Euphorbia helioscopia* L.	Seed
Other seeds	Bluebell?	cf. *Hyacinthoides non-scripta* (L.) Chouard ex Rothm.	Seed
Other seeds	Wood-rush genus?	cf. *Luzula* sp.	Seed
Other seeds	Slender Naiad	cf. *Najas flexilis* (Willd.) Rostk. & W.L.E. Schmidt	Fruit
Other seeds	Annual Knawel	*Scleranthus annuus* L.	Calyx
Other seeds	Branched Bur-reed	*Sparganium erectum* L.	Seed
Other seeds	Indeterminate seeds	n/a	Seed
Unidentified carbonised material	Unidentified carbonised material	n/a	All unidentified carbonised macroplant remains

2.3 Results

This section presents the results of the review of 48 Scottish Mesolithic sites with archaeobotanical remains, split into 57 site blocks (table 2). Of these site blocks, 24 were classed as earlier Mesolithic, 20 as later Mesolithic and 13 as Mesolithic. There was an even spread of sites in woodland zones 1 and 2, with 21 sites located in both zones. In contrast, there are currently only six Mesolithic sites with archaeobotanical remains in woodland zone 3. The small number of sites in woodland zone 3 is a reflection of the lower level of modern development in this region compared to other areas of Scotland, together with the fact that *in situ* Mesolithic archaeology has only been discovered in the Northern and Western Isles in the last decade and so there has been no systematic search for Mesolithic sites in this area. The plant remains were recovered from a range of different feature types, including pits, postholes, scoops, stakeholes, hearths/fire spots, gullies, old ground surfaces/occupation horizons, shell middens and possible natural features (table 2), which were representative of the diversity of features present in Mesolithic Scotland.

Of the 42 site blocks reviewed which noted the sample processing procedure, bulk sampling and flotation was undertaken on 29 site blocks, dry or wet sieving at 12 site blocks and hand collection only at one site block (figure 2a). Of the 12 site blocks using dry or wet sieving, all seven site blocks that mentioned the mesh size, used a mesh ≥ 2mm, which would prevent the recovery of most charred seed remains. Most reports did not record the type of sampling strategy (Jones 1991b:57; van der Veen 1984:193) employed, but for the 25 site blocks where this information was noted, 13 used total/random sampling, eight judgement sampling and five were 100% sampled (figure 2b). Small numbers of samples were analysed from most sites, with the majority of the assemblages deriving from fewer than ten samples (figure 2c). Counts/weights of edible plant remains were only available for 18 site blocks.

Overall, Hazel (*Corylus avellana* L.) nutshells were by far the most frequent edible plant species recovered from Scottish Mesolithic sites. In fact, hazelnut shell was virtually ubiquitous and it was present at 39 of the 57 site blocks in this review. Many assemblages also contained large quantities of nutshell, with particularly notable concentrations coming from Staosnaig, Colonsay and Crammond, East Barns and Weston Farm in Southern Scotland. There was no chronological trend in terms of the presence of sites with large concentrations of hazelnuts, with large samples present in both the earlier and later Mesolithic. However, there was a decline in the presence of hazelnuts in the site blocks between the earlier and later Mesolithic, with hazelnut shell present on 83% of site blocks in the earlier Mesolithic and 47% of site blocks in the later Mesolithic. At first sight this appears to support Ashmore's (2004a:89) suggestion that there may have been a decline in the number of sites with hazelnuts between 6000-4000 cal BC. However, the apparent decline in the abundance of hazelnut shell is probably a function of the small size of many of the later Mesolithic sites and the consequent low volume of soil processed at these sites; where low volumes of soil are processed, the chances of recovering non-charcoal plant remains is low. Furthermore, it is likely that the decline in the number of radiocarbon dates on hazelnut shell in the later Mesolithic (Ashmore 2004a:89) was a result of the relative abundance of shell midden contexts in the later Mesolithic and the lack of sampling for plant remains on these sites. Added to this was the choice of material for radiocarbon dating, with many shell middens frequently dated using shell or bone, and several sites dated using charcoal despite hazelnut shell being present.

Other edible species were much more scarce. With the exception of one site - Staosnaig – no sites had more than 30 plant remains from other edible species and many taxa were only represented by a single identification. However, considering the data from the review as a whole, there is some evidence that the inhabitants of Mesolithic Scotland exploited a diversity of edible plants. A range of edible fruit species – Hawthorn (cf. *Crataegus monogyna* Jacq./ cf. *Crataegus* sp.), Crab Apple (*Malus sylvestris* (L.) Mill) and pear (cf. *Pyrus* sp.) - have been recovered from Scottish Mesolithic sites (table 4). A variety of edible seeds were present at nine site blocks: Black Bindweed (*Fallopia convolvulus* (L.) Á. Löve.), Charlock (*Sinapis arvensis* L.), Corn Spurrey (*Spergula arvensis* L.), dock (*Rumex* sp.), Fat-hen (*Chenopodium album* L.), Knotgrass (*Polygonum aviculare* L.), Common Orache/orache (*Atriplex patula* L./*Atriplex* sp.), Ribwort Plantain (*Plantago lanceolata* L.), sedge (*Carex* sp.) and vetch/tare (*Vicia*/*Lathyrus* sp.) (table 5). The archaeobotanical remains of a number of seeds of plants with edible leaves, shoots, stems or roots, which may have been eaten in the Mesolithic have also been found on nine site blocks: buttercup (*Ranunculus acris*/*repens*/*bulbosus* L.), Charlock, Cleavers (*Galium aparine* L.), Common Chickweed (*Stellaria media* (L.) Vill.), dock, Fat-hen, Lesser Celandine (*Ranunculus ficaria* L.), orache, Ribwort Plantain, spike-rush (cf. *Eleocharis* sp.) and vetch/tare (table 6). Several species that are probably not edible - Sun Spurge (*Euphorbia helioscopia* L.), Annual Knawel (*Scleranthus annuus* L.), Bluebell (cf. *Hyacinthoides non-scripta* (L.) Chouard ex Rothm.), Branched Bur-reed (*Sparganium erectum* L.), Slender Naiad (cf. *Najas flexilis* (Willd.) Rostk. & W.L.E. Schmidt), violet (*Viola* sp.) and wood-rush (cf. *Luzula* sp.) seeds - were also present in the Mesolithic assemblages (table 7).

Edible roots and seaweed have only been identified to species level at one Scottish Mesolithic site. At Staosnaig, the edible root tubers of Lesser Celandine were recovered together with the remains of aquatic rhizomes, seaweed fragments and fleshy tap roots, which may also have been edible. The presence of vesicular material and unidentified roots/stems/rhizomes at two other sites, suggests that edible roots/tubers may also have been present on other Mesolithic sites.

Table 4: Summary of the plant macrofossils present at Scottish Mesolithic sites; where possible each site is split into chronological blocks (see section 2.2.2). P: present; A: abundant. For a description of the woodland zone classifications see section 2.2.2. Site numbers correspond to site locations in figure 1.

Site	Site number	Woodland zone	Hazelnut shell	Whole hazelnut	Lesser Celandine tuber/ bulbil	Unidentified parenchyma/ root/ vesicular material	Stem/ rhizome	Seaweed fragment	Hawthorn stone	Crab Apple seed/fruit fragment	Pear pip	Seeds from other edible species	Other seeds	Unidentified carbonised material
Earlier Mesolithic														
Ailsa View	1	2	459 (10.35g)						1					
Auchareoch	3	1	P											
Camas Daraich	6	1	8											
Cramond Phases 1-2	11	2	120/161 samples											
East Barns	13	2	>234.38g (sample volume =246.8l)											
Fife Ness	15	2	P			P								
Fordhouse Barrow (E)	16	2	P											
Gallow Hill	17	2	P											
Kinloch	22	1	P											
Links House G3-5	24	3	44 (1.03g)			1	2							
Littlehill Bridge	25	2	P									P	P	
Long Howe	27	3	P				3							
Lussa Wood	28	1	P											
Manor Bridge	29	2	5/7 samples											

Site	Site number	Woodland zone	Hazelnut shell	Whole hazelnut	Lesser Celandine tuber/ bulbil	Unidentified parenchyma/ root/ vesicular material	Stem/ rhizome	Seaweed fragment	Hawthorn stone	Crab Apple seed/fruit fragment	Pear pip	Seeds from other edible species	Other seeds	Unidentified carbonised material
Newton	31	1	P										3	
North Carn	32	1	P											
Northton 2001	33	3	31 (sample volume=85l)				1						2	
Silvercrest circle 1	35	1										1		
Staosnaig F41 &49	40	1	>553.6g (sample volume =152l)		2	1						1		
Warren Field (Other pits)	47	1	1									1		
Weston Farm (early)	48	2	574											
Later Mesolithic														
Aird Calanais	2	3	3 (sample volume = 28l)											
Cnoc Coig	10	1	A											P
Fordhouse Barrow (L)	16	2	P											
Morton B	30	2										26	1	
Skilmafilly	37	1										1	1	
Smittons	38	2	P											

Site	Site number	Woodland zone	Hazelnut shell	Whole hazelnut	Lesser Celandine tuber/ bulbil	Unidentified parenchyma/ root/ vesicular material	Stem/ rhizome	Seaweed fragment	Hawthorn stone	Crab Apple seed/fruit fragment	Pear pip	Seeds from other edible species	Other seeds	Unidentified carbonised material
Spurryhillock	39	2												P
Staosnaig F30	40	1	25.4g (sample volume=36l)											
Summerston	41	2	P											
Temple Bay	42	3	P											P
Tràigh na Beirigh	43	3	P											P
Tulloch Wood 3	44	1	1 (sample volume=68l)											
Upper Largie	46	1											4	
Weston Farm (late)	48	2	954											
Mesolithic														
Carn Southern	7	1	P								1?			
Castle Street	8	1	P											
Chapelfield Pit 5	9	2							1			18		
Elginhaugh	14	2										1		
Glenbatrick Waterhole	19	1	P											
Irish Street	20	2	2											
Lealt Bay	23	1	13											

Site	Site number	Woodland zone	Hazelnut shell	Whole hazelnut	Lesser Celandine tuber/ bulbil	Unidentified parenchyma/ root/ vesicular material	Stem/ rhizome	Seaweed fragment	Hawthorn stone	Crab Apple seed/fruit fragment	Pear pip	Seeds from other edible species	Other seeds	Unidentified carbonised material
Lon Mor	26	1	P											
Morton A	30	2	P									1		
Staosnaig F24	40	1	c.15848g (c. 30-40,000 whole nuts)	1	412	>62	>2	1		21		33	11	
Ulva Cave	45	1	0.8g (sample mass=251kg)											P
Warren Field (Pit 5)	47	1										3		

Table 5: Edible seeds present at Scottish Mesolithic sites; where possible, each site is split into chronological blocks (see section 2.2.2). P: present.

Site	Woodland zone	Black Bindweed seed	Charlock seed	Corn Spurrey seed	Dock seed	Fat-hen seed	Knotgrass nutlet	Orache seed	Ribwort Plantain seed	Sedge nut	Vetch/ tare seed
Earlier Mesolithic											
Littlehill Bridge	2		P								
Silvercrest circle 1	1										1
Warren Field (Other pits)	1					1					
Later Mesolithic											
Morton B	2			c. 10		4	3				
Skilmafilly	1									1	
Mesolithic											
Chapelfield Pit 5	2	1				10		7			
Morton A	2	1									
Staosnaig F24	1				2				1	1	9
Warren Field (Pit 5)	1										1

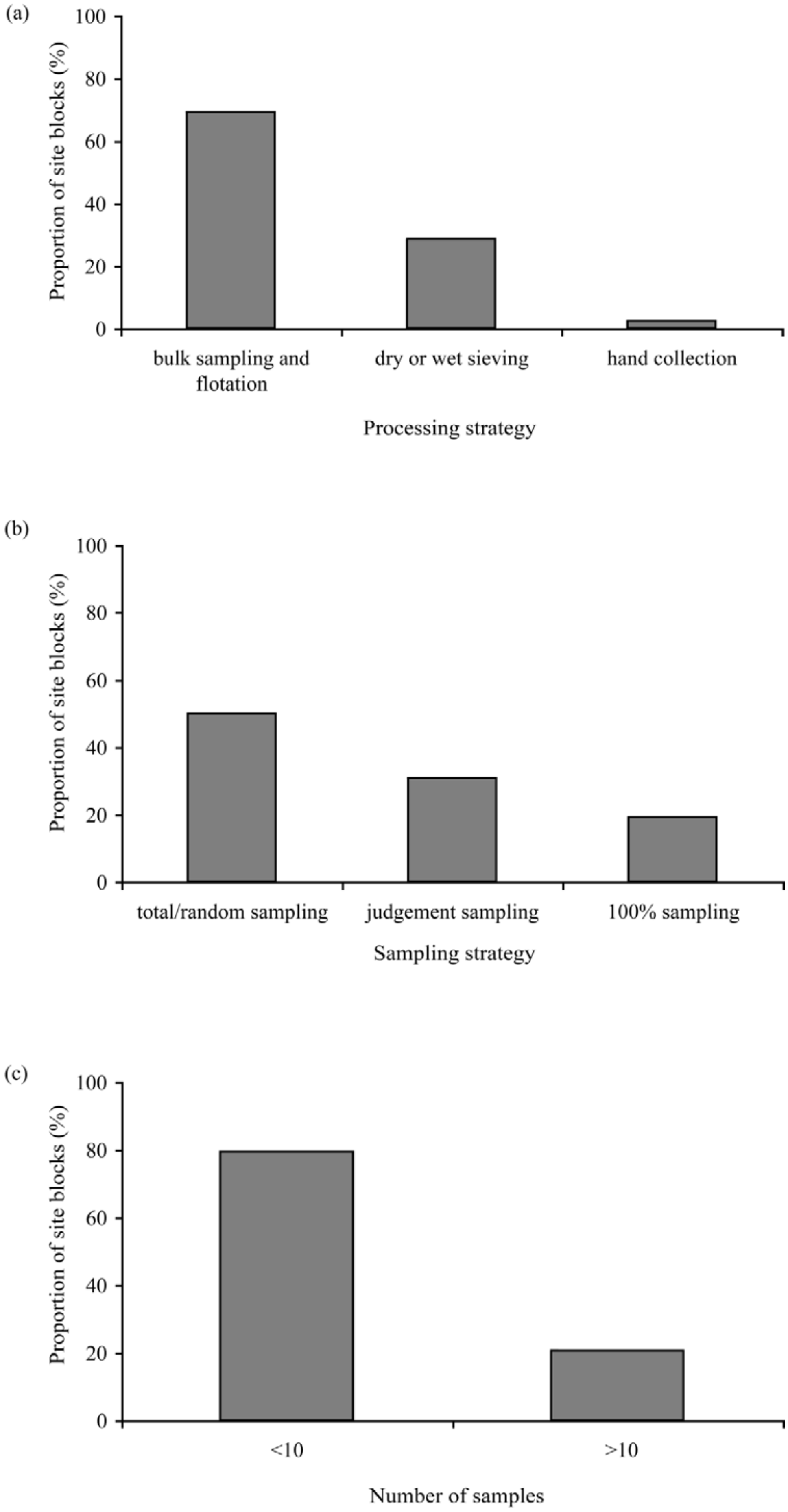
Table 6: Seeds identified on Scottish Mesolithic sites from plants with edible leaves, stems, shoots, roots, flowers, sap and buds; where possible, each site is split into chronological blocks (see section 2.2.2). L: leaves, sh: shoot, st: stem, f: flower, r: roots/bulbs, sa: sap, b: buds. References are for the edibility of each plant component and correspond to the ethnobotanic sources in appendix 1.

Site	Woodland zone	Buttercup achene	Charlock seed	Cleavers seed	Corn Spurrey seed	Common Chickweed seed	Dock seed	Fat-hen seed	Hawthorn fruit stone	Lesser Celandine tuber/ bulbil	Orache seed	Ribwort Plantain seed	Sedge nut	Spikerush nutlet	Vetch/ tare seed	Violet fruit
Edible component		l?, r?	l, f	l, sh	l	l, st, sh	l?,sh?, st?	l, sh, st	l, b, f	l	l, sh	l	r?, st?	r?, sa?	sh?/r?	l?, f?, b?
References		21, 22, 25, 32	8, 25 ,28, 31, 32, 37	3, 12, 25, 29, 31, 35	25	3, 22, 23, 28, 29, 31, 35, 37	3, 9, 18, 21, 20, 22, 23, 28, 29, 31, 32, 33, 35, 37	3, 9, 18, 21, 22, 25, 28, 29, 30, 31, 32, 33, 35, 37	3, 25, 28, 29, 31, 32	22, 25	3, 12, 28, 29, 32, 33, 35	3, 25, 31	31, 33	33	3, 8, 9, 22, 25, 31, 33	9, 25
Earlier Mesolithic																
Littlehill Bridge	2		P			P										
Staosnaig F41 &49	1			1						2						
Warren Field (Other pits)	1							1								
Later Mesolithic																
Morton B	2				c. 10	2		4			7					
Skilmafilly	1												1			
Mesolithic																
Chapelfield Pit 5	2							10			7					
Elginhaugh	2	1														
Staosnaig F24	1			19			2			412		1	1		9	
Warren Field (Pit 5)	1													1	1	1

Table 7: Inedible or poisonous species and seed identifications at too high a taxonomic level to be certain of edibility. Those marked with a * are known to be poisonous, those marked with † are not known to be edible and those not marked ** are identifications to family level only.

Site	Woodland Zone	Period	Annual Knawel seed †	Bluebell seed *	Branched Bur-reed seed †	Grass family Seed **	Goosefoot family Seed **	Slender Naiad fruit †	Sun Spurge seed *	Wood-rush family seed †
Littlehill Bridge	2	EM							P	
Morton B	2	LM	1							
Northton 2001	3	EM				2				
Skilmafilly	1	LM					1			
Staosnaig F24	1	M		3?	1			1?		1?
Upper Largie	1	LM				1				
Warren Field (Pit 5)	1	M								

Figure 2: Sampling and processing strategies used on Scottish Mesolithic sites from sites where this information was provided in the reports: (a) processing strategy (N=42), (b) sampling strategy (N=26), and (c) number of Mesolithic samples (N=29).



2.4 Plant gathering, processing and cooking in the Scottish Mesolithic

In the following section, the likelihood that each plant taxa in tables 4-7 was collected for consumption will be discussed, through a consideration of the archaeological taphonomy and the ethnographic and historical evidence for the use of each taxon. The likely processing methods and taphonomic pathway of each taxon into the archaeological record will also be considered. A full list of the ethnobotanical sources systematically consulted is given in appendix 1.

2.4.1 Hazelnuts

Of all the species recovered from the Scottish Mesolithic plant assemblages considered in this review, hazelnuts are the only indisputable foodstuff. Not only are hazelnut shells virtually ubiquitous on Scottish Mesolithic sites, they are also extremely abundant on several individual sites (table 4). It is unthinkable that hazelnuts accumulated on domestic hearths on so many sites and in such large quantities by natural processes. The Mesolithic date of hazelnut consumption is also not in doubt, given that many nutshells have been directly radiocarbon dated (Ashmore 2004b). Though some historical herbals from Britain and ethnographic accounts from North America note a few traditional medicinal uses for hazelnuts (Dickson and Dickson 2000:260; Gerard 1597:1251; Moerman 1998:181-2), they have primarily been used for food historically in Britain (Cameron 1977:70; Hill 1941:41; Howes 1948:179; Lightfoot 1777:587; Loewenfeld 1957:39; Mabey 1997:90; Milliken and Bridgewater 2004:40) and are still collected for food by many in Britain today (Burrows 2005:23; Irving 2009:64; Mabey 2001:122; Phillips 1983:138). Likewise there is also considerable ethnographic evidence for the use of hazelnuts for food by modern hunter-gatherer groups in North America and Canada (Ebeling 1986:209; Gilmore 1991:22; Gunther 1973:27; Hamel and Chiltoskey 1975:37; Kuhnlein and Turner 1991:18; Marles et al 2000:150; Moerman 1998:181-2), though the species exploited, were, American Hazelnut (*Corylus americana* Walter), California Hazelnut (*Corylus cornuta* subsp. *californica* (A. de Candolle) E. Murray) and Beaked Hazelnut (*Corylus cornuta* subsp. *cornuta*), rather than the native British Hazel species (*Corylus avellana* L.) which is absent from North America (ibid; Flora of North America Editorial Committee 1993+).

Hazelnuts would have been gathered from the trees in September/October, using cut branches to bend down high Hazel branches to pick the nuts or to shake loose ripe nuts, and ripe nuts would also have been gathered from the ground (Burrows 2005:23; Mabey 2001:122). The annual gathering and processing of hazelnuts may well have been a social experience involving groups of gatherers, as was often the case in 17th-19th century Britain

(Finlayson 2005:38; Mabey 1997:90). However, the trees would not have been climbed to gather the nuts (contra Finlayson 2005:30) because the nuts would have been difficult to reach from the ends of the slender branches whilst sitting in the trunk of the tree (Dickson and Dickson 2000:258). Since not all nuts ripen simultaneously on a single tree, harvesting would most probably have been undertaken in a series of stages across an area of trees (Mason 1996a:2). There may also have been differences in ripening times between different stands of trees (Talalay et al 1984:348) and perhaps hunter-gatherers moved between different areas of woodland as the nuts ripened during the period of hazelnut availability. Talalay et al (1984:348) suggest that the optimal harvesting time (in terms of yield per hour) was after the leaves had fallen, but while the ripe nuts were still retained on the trees, because of the higher visibility of the nuts. However, this does not take into account competition with predators.

Hazelnuts can also be collected whilst green and immature in August (Howes 1948:22) to reduce the competition with other animals, such as squirrels, birds, mice and insects which consume hazelnuts (Carruthers 2000:414; Lightfoot 1777:587). Though the full potential impact of red squirrels on hazelnut yields in post-glacial forests is uncertain, modern experiments and observations suggest that (grey) squirrels have a major impact on hazelnut yields since they consume the nuts before they are ripe (Carruthers 2000:414; Howes 1948:179; Irving 2009:64; Mason 1996b:3; McComb 2009; McComb and Simpson 1999; Rackham 2003:210; Talalay et al 1984:343). Consequently, it is possible that hazelnuts may have been collected in a green (milk-ripe) state by Mesolithic hunter-gatherers in Scotland to maximise the hazelnut harvest (Carruthers 2000:411; Holst 2010:2874; McComb 2009:228). In North America, hunter-gatherers often collected hazelnuts when they were still green and the green nuts were either eaten immediately without ripening or allowed to ripen in the sun for several days before being stored for winter use (McComb 2009:228; Moerman 1998:181). However, comparison of the Staosnaig nutshell with modern semi-ripe nutshell under an SEM suggests that the nuts at this site were gathered when fully ripe (Carruthers 2000:412). Also, Loewenfeld (1957:40) states that:

> "Unripe nuts should not be picked, as they shrink when dried, lose their pleasant flavour and soon become mouldy. As they store best if picking is delayed until some of the nuts begin to fall, it is a good idea to inspect the hazel bushes daily if possible, and collect the nuts which have fallen until those on the bush are ready to be picked. But as squirrels, dormice and the nuthatch are just as interested in hazelnuts as we are, it would not do to allow them to go on falling for too long."

Furthermore, green nuts are more time-consuming to process than ripe nuts because the husks adhere more tightly to the nuts (Talalay et al 1984:351). Consequently, it is probable that ripe hazelnuts were of greater importance to hunter-gatherers than green nuts in Mesolithic Scotland. It should be noted that modern commercial nut growers shoot large numbers of grey squirrels to protect their Hazel trees (Mason 1996a:2). Perhaps, Mesolithic people occupied temporary camps beside important hazelnut bushes to protect them from predators during the nut ripening period (McComb 2009:228). Alternately, given the abundance of Hazel in the environment of Mesolithic Scotland (see chapters 3-4), predation may not have been such a serious issue.

There are several practices that could result in the deposition of charred nutshell on Mesolithic sites, of which cooking was probably a major cause. Hazelnuts can be difficult to digest in large quantities (Gerard 1597:1251; Mears and Hillman 2007:26), and so it is probable that cooking was necessary to make hazelnuts suitable for use as a staple food. Ethnographic evidence suggests that though hunter-gatherers often ate hazelnuts raw, they were also frequently roasted, boiled in soups, cooked into a mush or ground and mixed with other ingredients to make bread or cakes (Ebeling 1986:209; Gilmore 1991:22; Gunther 1973:27; Marles et al 2000:150; Moerman 1998:181). Bread can also be made from ground hazelnuts without mixing with other ingredients (McComb and Simpson 1999:14), a process which Lightfoot (1777:587) noted was sometimes undertaken in Scotland in the 18th century. Interestingly, in 18th century Scotland, hazelnut bread was thought to be particularly useful for consumption on long journeys (Milliken and Bridgewater 2004:40), and it is interesting to speculate that hazelnut bread might have been used for a similar purpose in the Mesolithic.

Based on the shape and composition of possible roasting pits found at various Mesolithic sites in Europe, and experimental hazelnut roasting trials, it has been suggested that in the Mesolithic, hazelnuts may commonly have been roasted in shallow pits lined and sealed with sand or gravel, on top of which a small fire was lit for a short time period (Hastie 2003e:7; Perry 1999:232; Score and Mithen 2000:508). However, though there are numerous ways of roasting plant foods, most ethnographic literature describes the use of hot coals for cooking rather than the direct use of fire (Hastie 2003e:4; Pokotylo and Froese 1983:130-131; Turner and Kuhnlein 1982:424-6; Wandsnider 1997:21-22). Considering this, it is possible that hazelnuts may also have been roasted by mixing the nuts into sand heated with hot charcoal from a fire that had already burned down (Holst 2010:2874). This method, which was used to cook nuts and roots by the !Kung in South Africa (Yellen 1977:143), leaves behind a shallow depression containing mixtures of ash, charcoal and sand (ibid:87), similar to Mesolithic features containing abundant nutshell in

Europe (Holst 2010:2874). The ground depression results from the raking of the nuts, charcoal, ash and sand during cooking and was not a formal dug cooking pit (Yellen 1977:87). Given that about 25% of hazelnuts may become charred during roasting (Score and Mithen 2000:510), hazelnut roasting could have been a major source of carbonised nutshell on archaeological sites. However, the potential absence of formal cooking pits (Yellen 1977:87) and hearths (Sergant et al 2006) on Mesolithic sites presents a problem for recognising roasting in the archaeological record.

There are several benefits of hazelnut roasting. Not only does hazelnut roasting improve flavour and digestibility, but it also increases the ease of grinding for bread or cake making and would have facilitated transportation by reducing the mass of the nuts up to 50% (Hastie 2003e:5; Holst 2010:2874; Mason 1996b:1; Mears and Hillman 2007:26-28; Mithen 2000:435; Mithen et al 2001:228; Score and Mithen 2000:511; Stahl 1989:181). Several authors have also proposed that roasting increases the storability of hazelnuts (Hastie 2003e:5; Holst 2010:2874; Mears and Hillman 2007:28; Mithen et al 2001:228). However, Mason (1996b:1) argues that roasting would not increase storability and ethnographic and historical descriptions state that hazelnuts should be dried rather than roasted for storage (Howes 1948:184; Kuhnlein and Turner 1991:16; Loewenfeld 1957:40; Moerman 1998:182). This is supported by modern commercial hazelnut roasting trials, which suggest that roasting at high temperatures actually reduces shelf life, unless the nuts are first heated at a lower temperature (Alamprese et al 2009). Also, though recent experiments require further confirmation, current research suggests that roasted hazelnuts may store less well in pits than unroasted nuts (Cunningham 2010).

Consequently, a further process that may have preserved hazelnut shell on Mesolithic sites is the drying of the nuts beside the fire for storage (Ebeling 1986:209; Kuhnlein and Turner 1991:16; Mithen 2000:435). Drying hazelnuts prior to storage prevents them from going mouldy and once dried, they can be stored for at least six months (Cunningham 2010; Howes 1948:185; McComb 2009:229). The smoke, as well as the heat from the fire may also have helped to prevent mould attack (Howes 1948:27). A further benefit of drying is that it makes hazelnuts easier to dehusk compared to fresh nuts (Talalay et al 1984:351). In continental Europe, nuts were traditionally sun-dried by laying the nuts out on trays a few inches deep during the day and frequently stirring them and then covering them at night (ibid). With constant hot weather this process took 2-3 days (ibid). Clearly this drying method would not have been suitable in the relatively cooler/wetter climate of Scotland and it is probable that fire drying was necessary. Therefore roasting and drying are both potential mechanisms for the charring of hazelnut shell on Mesolithic sites.

As in some regions of 20th century Europe, the nuts would probably have been cracked individually on a stone or block of wood using a hammer stone or wooden baton (Howes 1948:32). Experimentation with hammerstones and anvils of different shapes and sizes has shown that elongated pebble tools, like those found at Staosnaig, were most effective for hazelnut cracking (Score and Mithen 2000:511). Experiments suggest that 125g of kernel per hour may be produced using this method (Talalay et al 1984). It is also possible that wooden nut-crackers were produced from the branches of Hazel trees. Mabey (1997:90) describes one such wooden nut-cracker made from Hazel wood,

> "I have seen a pair of these made by a Sussex hurdle-maker in the 1930s, which he used to carry when working in the coppices in autumn. After shaping a piece of straight wood with his knife, he soaked it, doubled it over, and then bound it tightly with a strip of split hazel until it dried out."

Hazelnuts may also have been cracked by pouring cold water over nuts heated by burning vegetation on top of them (Carruthers 2000:414).

After cracking, or cooking/drying and then cracking, the hazelnut shells may also have become charred if they were deliberately thrown onto fires to dispose of the unwanted nutshell after nut consumption (Kubiak-Martens 1999:123; McComb 2009:227). Hazelnut shell may also have been deliberately kept for use as kindling or as a fuel source because hazelnut shell burns well and produces a hot flame (Kubiak-Martens 1999:123; Mason 1996b:2; Munson et al 1971:427). Alternatively, considering the durability of nutshell, it may have become charred if a fire was lit on the soil surface in an area formerly used for nut cracking (Sievers and Wadley 2008).

2.4.2 Lesser Celandine root tubers

Despite the fact that Lesser Celandine tubers have only been recovered from one site in Mesolithic Scotland (table 4), it is highly likely that they were used as food. At Staosnaig, Colonsay, over 400 Lesser Celandine root tubers and bulbils were recovered from a single, discrete pit context, together with nutshell radiocarbon dated to the Mesolithic. Considering the secure nature of the deposit, the lack of *in situ* burning in the pit and the large number of small, fragile charred Lesser Celandine remains present, it is unlikely that the root tubers accumulated naturally within the pit and so they were most likely deliberately deposited through human action (Mason and Hather 2000:421; Mithen et al 2001:230). The discovery of charred Lesser Celandine tubers at several Neolithic sites in North-West Europe supports this contention (e.g. Bakels 1988:159; Fairbairn 1999; Out 2009:357-8; Robinson and Kempfner 1987)

Ethnographic and historic observations also support the idea that Lesser Celandine roots may have been collected for food in the Mesolithic. While Lesser Celandine is not native to North America, it has been introduced and modern hunter-gatherers have made use of the roots for food (Kuhnlein and Turner 1991:317) and the roots of several other *Ranunculus* species have also been traditionally consumed by North American hunter-gatherers (Gunther 1973:30; Kuhnlein and Turner 1991:318; Moerman 1998:468-9). Lesser Celandine roots have also been used historically as food in Scotland in times of famine (Darwin 1996:145) and are collected for food today by modern foragers in Britain (Irving 2009:73; Mears and Hillman 2007:106). Though Lesser Celandine has traditionally been used as a cure for piles in Britain (Darwin 1996:145; Gerard 1597:669; Grieve 1992:181; Grigson 1975:50; Milliken and Bridgewater 2004:206; Pierpoint Johnson 1862:17; Ranson 1949:39), this tradition derived from the 15th and 16th century 'Doctrine of Signatures' (Darwin 1996:145; Ranson 1949:16-17) which linked the visual similarity of the root tubers to haemorrhoids, rather than originating from any medicinal effects of consuming the tubers (Dickson and Dickson 2000:264; Grieve 1992:181; Hogg and Johnson 1864:115; Pierpoint Johnson 1862:17). Having said this, considering that British Pharmacopoeia has reintroduced Lesser Celandine as a cure for piles, it is possible that despite the dubious origin of the cure, the plant does indeed provide effective treatment for this condition (Dickson and Dickson 2000:264; Grieve 1992:181; Mason and Hather 2000:423). Therefore, though the possibility that the roots were collected for medicinal purposes cannot be discounted, it seems more likely that the root tubers were collected for food in Mesolithic Scotland.

The Lesser Celandine root tubers may have been dug up using antler mattocks like those found in the Scottish Mesolithic (Bonsall and Smith 1989, 1990; Mears and Hillman 2007:30; Smith 1989; Zvelebil 1994:55) or using a simple pointed wooden digging stick, like those used by hunter-gatherers in North America and Canada (Kuhnlein and Turner 1991:15). The two most probable situations in which Lesser Celandine roots used for food would become charred and preserved are during cooking prior to consumption or drying for future storage. It is unlikely that Lesser Celandine roots would be consumed raw, because all members of the *Ranunculus* family contain protoanemonin, a poisonous substance, which can be reduced or removed by cooking or drying (Forsyth 1968:35; Frohne and Pfänder 1984:309; Kuhnlein and Turner 1991:231; Mason and Hather 2000:422; Milliken and Bridgewater 2004:32). However, Grieve (1992:181) notes that Lesser Celandine has a low acridity compared to the other *Ranunculus* species and a small-scale study suggests that the protoanemonin is mostly concentrated in the flowers and stems rather than the roots and leaves (Bonora et al 1988). Considering this, together with the fact that protoanemonin content can be reduced by cooking and that there is ethnographic evidence for the consumption of the roots of other *Ranunculus* species (see above; Lightfoot 1777:292), there is no reason to reject the idea that Lesser Celandine was eaten in the Mesolithic.

Roots have traditionally been cooked either by steaming in a pit over hot rocks under layers of vegetation and earth or by boiling (Kuhnlein and Turner 1991:17; Lightfoot 1777:292; Mason and Hather 2000:422; Mithen 2000:433; Pokotylo and Froese 1983:130-131; Turner and Kuhnlein 1982:424-6). They could also have been roasted (Irving 2009:73), perhaps in the ashes of the fire or using hot charcoal mixed with sand (Yellen 1977:143). Accidental charring during drying by hearths for storage is also another process that could have resulted in the deposition of the root tubers. As with nuts, roots and tubers can be stored for long periods once dried (Kuhnlein and Turner 1991:16) and given that the root tubers at Staosnaig were well preserved, it is likely they were already dry prior to charring (Hather 1993:22, 2000a:46; Mason and Hather 2000:417) or were charred by the drying process if they were slowly dried and left too long beside the heat (Mithen 2000:438). The fact that the Lesser Celandine tubers were identified to species therefore suggests that they represent an accidentally charred stored dried product or that the tubers were charred accidentally whilst being slowly dried for storage.

2.4.3 Seaweed

Only one fragment of charred seaweed was present in the Mesolithic assemblages (table 4). The fragment of possible Knotted Wrack (cf. *Ascophyllum nodosum* (L.) Le Jolis) seaweed from Staosnaig probably represents a deliberately gathered foodstuff since all seaweeds, except sea sorrels (*Desmarestia* sp.) are edible in Britain (Mears and Hillman 2007:61; Milliken and Bridgewater 2004:52) and it is improbable that it became accidentally charred and deposited within a pit outwith the immediate vicinity of the seashore. Knotted Wrack is a common seaweed that is easily collectable, since it is abundant on rocks and boulders in the middle shore zone (Kosch et al 1963:32; Newton 1931:220). In Iceland and Greenland, Knotted Wrack seaweed was historically collected for food in times of famine (Aaronson 2000:235; Hallsson 1964:399), and though it does not have a history of human use in Britain and Europe, it has been much used as an animal fodder and fuel source (Chapman 1970:69; Hallsson 1964:400; Indergaard and Minsaas 1991:23) and meal made from this species is now used as a health food (Indergaard and Minsaas 1991:54; Irving 2009:363; Vaughan and Geissler 1997:194). Though seaweed can be burnt as a fuel (Fenton 1978:206), the availability of wood in Mesolithic Scotland suggests that Knotted Wrack was more likely to have been collected for consumption than for use as a fuel. The seaweed fragment may have been charred accidentally during cooking or drying for storage. Seaweeds are commonly cooked by frying, steaming, boiling or adding to soups and stews (Irving 2009:362; Kuhnlein and Turner 1991:27-33). Ethnographic descriptions show that hunter-gatherers have traditionally preserved seaweeds for future consumption by both sun drying and by drying on racks over fires (Kuhnlein and Turner 1991:27-33). As with the Lesser Celandine tubers, the slow drying over a fire, would seem the most likely method of preservation of moisture-rich seaweed in archaeological samples.

2.4.4 Fruits and berries

Despite considerable evidence for the consumption of hawthorns historically in Britain (Hedrick 1919:198; Pierpoint Johnson 1862:98; Lightfoot 1777:256; Mabey 1997:215; Phillips 1983:139), as well as by hunter-gatherers in North America and Canada (Kuhnlein and Turner 1991:236-7; Moerman 1998:183), the collection of hawthorns for food by Scottish Mesolithic people is open to question. Given that only single hawthorn stones have been recovered from 2 sites (table 4), it is possible that they may have been transported to these sites by natural processes and so there is also an element of doubt over whether they can be securely dated to the Mesolithic. However, considering their high mass, natural deposition or bioturbation and redeposition is unlikely. Hawthorn berries have also been used historically in Britain as a cardiac tonic and as a diuretic, and were also used to correct high or low blood pressure and cure sore throats (Darwin 1996:149; Grieve 1992:385), and have numerous traditional hunter-gatherer medicinal uses (Moerman 1998:183-4).

If the hawthorns were eaten in the Mesolithic, they may have been consumed raw (Burrows 2005:7; Kuhnlein and Turner 1991:236-7; Moerman 1998:183-4; Tardío et al 2006:67) or after roasting in the ashes of a fire (Kuhnlein and Turner 1991:236). Hawthorns may also have been dried for storage (Ertuğ 2000:176; Out 2009:351) either whole or by first processing into cakes (Kuhnlein and Turner 1991:236-7; Mears and Hillman 2007:216-7; Moerman 1998:183-4). North-American hunter-gatherers traditionally preserved hawthorns by crushing, removing the skins and stones, pressing into cakes and drying by the fire (ibid). Thus, the charred Hawthorn stones in the Mesolithic assemblages may represent the waste material deposited after consuming the hawthorns raw or preparing them for storage or they may have become charred accidentally during cooking or drying if conditions within the fire existed which would preserve the stone but not the fruit.

It is also questionable whether pears formed part of the Scottish Mesolithic diet because the native status of the wild pear in Britain is uncertain. Stace (1997:368-9) states that Wild Pear (*Pyrus pyraster* (L.) Burgsd.) is not native to Britain and Clapham et al (1987:244) suggest that it was probably introduced. Both authors agree that Plymouth pear (*Pyrus cordata* Desv.) was probably native, but given that its current distribution is restricted to “2 hedges near Plymouth” and “3 sites near Truro” (Stace 1997:369), it is not clear if this species was ever native to Scotland. The difficulty of identifying whether pear forms part of the natural vegetation of Scotland is compounded by the fact that the wood and pollen of *Malus* and *Pyrus* species are indistinguishable (Out 2009:352). Therefore, considering that only one pear pip has been found in Mesolithic Scotland (table 4), it seems likely that it was intrusive into the Mesolithic deposits. There is little ethnographic evidence for the use of wild pear in Britain and several authors have noted that it is small, hard, tasteless or inedible (Mabey 1997:200; Mears and Hillman 2007:223; Pierpoint Johnson 1862:99). It is possible that drying makes wild pears palatable, since ethnobotanic records from Slovakia note that *Pyrus pyraster* (L.) Burgsd. was consumed after drying (Stoličná 2000:201). However, considering the questionable native status of wild pear and the fact that only a single pear pip has been discovered in the Scottish Mesolithic, overall wild pear is an unlikely Mesolithic foodstuff.

On the other hand, the presence of large quantities of Crab Apple pips and fruit fragments at Staosnaig (table 4), does suggest that Crab Apples were deliberately collected at this site. Though the consumption of Crab Apples has a number of health benefits and they have been used historically to relieve burns and inflammations, spasms, sprains, bruises and cramps (Darwin 1996:151; Gerard 1597:1277-8; Grieve 1992:46-7; Lightfoot 1777:258; Pierpoint Johnson 1862:100), they have primarily been eaten for food in Britain (Grieve 1992:45-9; Grigson 1975:193; Hill 1941:39; Irving 2009:296; Mabey 1997:201; Mears and Hillman 2007:222; Phillips 1983:131). Most fresh Crab Apples are very bitter and astringent and require cooking or drying to make them palatable (Dickson and Dickson 2000:247; Grieve 1992:46; Lightfoot 1777:258; Mabey 1997:201; Mears and Hillman 2007:222; Pierpoint Johnson 1862:100; Wiltshire 1995:391). Indeed, Moerman (1998:334) makes no reference to any North American hunter-gatherers who ate the native Crab Apple (*Malus sylvestris* (L.) Mill.) without drying or cooking. Crab Apples can also be dried for future use (Helbaek 1952:111; Mears and Hillman 2007:222; Moerman 1998:334; Renfrew 1973:139). The dried fruits of Crab Apple could either be consumed dried or rehydrated after storage since astringency is still reduced even when they are rehydrated (Moerman 1998:334; Wiltshire 1995:394). Since raw Crab Apples are very bitter, it seems unlikely that they would have been eaten fresh and therefore the burnt fruit fragments are unlikely to represent burnt apple core debris that was deliberately disposed of onto a fire. Also, fresh Crab Apples survive the carbonisation process extremely poorly due to their high water content and it is unlikely that they would survive and be identifiable archaeologically (Carruthers 2000:412; Helbaek 1952:111). Considering the unpalatabilty of fresh Crab Apples, together with the poor preservation of the Crab Apple remains from Staosnaig, it is probable that the Crab Apples were charred accidentally whilst being dried or cooked by a fire before consumption or storage.

Overall, it seems likely that the source of most carbonised fruit and berry remains in archaeological assemblages was through processing for storage. Considering the relatively cool climate of Scotland, it seems most probable that fruits were dried, at least partially, using fire rather than purely by air-drying, because without the use of heat the fruits would probably go mouldy before drying out (Wiltshire 1995:386, 395). A common method of preserving fruits, such as apples, pears and hawthorns for storage used by modern hunter-gatherer groups in North America, was to mash the fruits up, press them into small 'cakes' and dry them by the fire or in the sun (Moerman 1998:183-4, 334, 458). If this method was not utilized, larger fruits, such as Crab Apples or pears would probably have been cut up to aid the drying process. They may also have been cut into thin slices or halves and hung on twine to air dry (Ellison et al 1978:172; Kohler-Schneider 2007:215; Moerman 1998:458) or cut into halves or quarters to dry by the fire, as is evident in Neolithic/Bronze Age Switzerland, Austria and Denmark (Helbaek 1952; Jacomet 2007:243; Jacomet et al 1989; Kohler-Schneider 2007:212). Fire drying of Crab Apples may also have been undertaken by placing the fruits on a basketry griddle over hot embers or by rolling heated stones over the fruits (Wiltshire 1995:392).

2.4.5 Edible seeds

Edible seeds have been discovered in many Scottish Mesolithic assemblages (table 5). Overall, however, vetches/tares are the most probable wild seeds gathered for consumption in Mesolithic Scotland. Though these seeds are only identified to genera, most *Vicia* or *Lathyrus* species have edible seeds (Irving 2009:131; Mears and Hillman 2007:177-185). *Vicia* and *Lathyrus* species grow in pods, are easy to collect and open and unlike many seeds do not require dehusking or grinding prior to consumption. The seeds of vetches and tares vary in size from species to species, but many produce quite large seeds (Irving 2009:231). Also, though they are not present in large quantities on individual sites, the seeds of *Vicia* or *Lathyrus* species are present in three Scottish Mesolithic assemblages (table 5), suggesting their presence was not merely accidental. Seeds of several wild native species of these plants were eaten historically in Britain, Holland, France and Sweden (Fenton 2000:192; Hedrick 1919:327, 592-3; Pierpoint Johnson 1862:80) and the seeds of these species are collected by modern gatherers today in Britain (Irving 2009:242,231-6; Mears and Hillman 2007:179-180; Phillips 1983:95) and Spain (Tardío et al 2006:36,56). Also, many *Vicia* and *Lathyrus* species are extensively exploited for food by modern hunter-gatherers in North America (Ebeling 1986:241; Kuhnlein and Turner 1991:190,192; Moerman 1998:595-6). North American hunter-gatherers used an infusion of the roots or the whole plant for various medicinal purposes (Moerman 1998), but the seeds are not noted by Gerard (1597:1053-4), Kuhnlein and Turner (1991), Moerman (1998) or Grieve (1992) as having medicinal properties.

Though the seeds can be eaten raw in small quantities (Mears and Hillman 2007:179; Moerman 1998:299; Phillips 1983:95), they were probably cooked before consumption or soaked in water because the seeds of some *Vicia* and *Lathyrus* species are toxic if eaten raw in large quantities (Cooper and Johnson 1984:146; Frohne and Pfänder 2005:196, 213; Kuhnlein and Turner 1991:192). Considering that most hunter-gatherer groups in North America boil or roast *Vicia* or *lathyrus* species before eating them (Moerman 1998:595-6), the seeds were probably preserved by charring accidentally during roasting; since seeds prepared by boiling are unlikely to have been preserved in archaeobotanical assemblages (Minnis 1981:149). Dried *Vicia* or *Lathyrus* pods/seeds can also be dried for storage (Moerman 1998:595-6). The seeds of Yellow-vetch (*Vicia lutea* L.) (native to Britain) and Common Vetch (*Vicia sativa* ssp. *sativa*) (not native to Britain) were historically added to soups and flour for breadmaking in France and Spain, and in Holland and France the seeds of Bitter-vetch (*Lathyrus linifolius* (Reichard) Bässler) (native to Britain) were roasted (Hedrick 1919:327, 592-3; Tardío et al 2006:56).

Fat-hen is also a likely Scottish Mesolithic dietary component. Though no more than ten seeds were recovered from any individual site, its presence in three different archaeobotanical assemblages suggests deliberate collection rather than accidental charring (table 5). Like *Vicia* and *Lathyrus* seeds, Fat-hen is easy to harvest and process and can produce return rates similar to cultivated cereals (Mears and Hillman 2007:166; Stokes and Rowley-Conwy 2002). The seeds can be easily stripped from the seed head and require only gentle rubbing and winnowing to remove the sepals (ibid). Fat-hen seeds have been eaten historically in Britain, Poland and Russia and by hunter-gatherers in North America, and concentrations have been recovered from the stomach contents of seven prehistoric North-West European bog bodies (Behre 2008:68; Burrows 2005:34; Ebeling 1986:146; Grieve 1992:366; Grigson 1975:104; Hedrick 1919:160; Kuhnlein and Turner 1991:152;

Moerman 1998a:154-5). Though the leaves, stems and roots are noted to have some medicinal uses, the seeds are not noted by Gerard (1597:259), Kuhnlein and Turner (1991), Moerman (1998:154) and Grieve (1992) as having been used as a drug. Ethnographic evidence from North America suggests that the seeds would have been processed by grinding into a mush or by parching and then grinding into flower to make bread, or dried for future use (Kuhnlein and Turner 1991:152; Moerman 1998:154-5). Therefore, the most likely activities that would result in the carbonisation and preservation of Fat-hen seeds in archaeological assemblages are parching, cooking to make bread or drying for storage.

The seeds of the other edible species are less certain Mesolithic foodstuffs (table 5). Though there is either evidence for ethnographic, historical or contemporary human consumption of the seeds of Black Bindweed (Darwin 1996:139; Mears and Hillman 2007:260; Renfrew 1973:182), Charlock (Milliken and Bridgewater 2004:37), Corn Spurrey (Darwin 1996:94; Irving 2009:246; Milliken and Bridgewater 2004:37; Pierpoint Johnson 1862:53), Knotgrass (Irving 2009:176; Mears and Hillman 2007:259) and Ribwort Plantain (Irving 2009:250; Mears and Hillman 2007:288), the seeds of these species are only present in low frequencies at one or two sites, and they could easily have arrived on each site as a result of non-anthropogenic processes. All of these species are common agricultural weeds and indicators of disturbed ground, which would have been found growing around human occupation areas (Clapham et al 1987; Long 1929:104; Stace 1997). There are also several seeds that come from genera, which include several species with edible seeds (table 5), such as the docks (*Rumex crispus* L., *Rumex maritimus* L.) (Moerman 1998:498), oraches (nine *Atriplex* sp. listed, but none native to the UK) (ibid:114-117) and sedges (multiple native edible *Carex* sp.) (Kuhnlein and Turner 1991:76; Mears and Hillman 2007:324; Moerman 1998:138), but since not all species in these genera are known to be edible, human collection is uncertain. However, the seeds of all of these plants, if eaten, would have been processed by drying and parching before being ground down into flour and either eaten raw with water or boiled into a mush or baked into bread (Anderson 2006:260-1; Moerman 1998). If these seeds were deposited on archaeological sites through human action then they were probably charred accidentally during parching, drying or cooking.

2.4.6 Edible shoots, roots and leaves

The seeds from a number of plants with edible leaves, shoots, roots and stems were present in the Mesolithic assemblages, many of which are edible raw, steamed, roasted or boiled (see table 6 and appendix 1 for references). As noted in section 2.4.5, several of these seed identifications (e.g. *Rumex* sp., *Atriplex* sp., *Carex* sp., *Ranunculus* sp., *Eleocharis* sp., *Viola* sp.), are only to genus level and so it is not certain whether they are definitely from the edible species in these genera. Also, the seeds of plants that were gathered for their leaves, shoots, stems or roots are highly unlikely to be preserved in archaeobotanical assemblages. Leaves, shoots and stems, would have been harvested and eaten before the plants flowered and set seed, whilst the plants are young and soft during spring (Behre 2008:71; Cameron 1977:56; Hill 1941:11; Pieroni 2005:29) and the roots would have been gathered after flowering (Cameron 1977:56). Therefore, while it is possible that all of the plants listed in table 6 were eaten in Mesolithic Scotland, the seeds of these species most probably arrived on Mesolithic sites as a result of the collection of the seeds for consumption or medicines (as appropriate) or through natural processes.

2.4.7 Poisonous and inedible plants

The seeds of several plants that were probably poisonous or inedible were also recovered (table 7). The latex that exudes from the stems of the Sun Spurge causes inflammation to the skin when touched and consumption of the plant can cause inflammation of the mouth and throat, gastroenteritis, vomiting, and diarrhoea (Cooper and Johnson 1984:117; Forsyth 1968:74; Frohne and Pfänder 2005:190-191). The seeds and bulbs of the Bluebell are also poisonous to humans (Cooper and Johnson 1984:169-170; Grieve 1992:424). In addition, several taxa – cf. wood-rush family, cf. Slender Naiad, Annual Knawel and Branched Bur-reed were not recorded as edible or poisonous in any of the ethnobotanical, historic or modern practical plant collection references consulted (see appendix 1). Considering that 44 different references were consulted, it seems unlikely that these species would have been important sources of food. The leaves and seeds of several species in the Goosefoot (Chenopodiaceae) and Grass (Poaceae) families are also edible, but without identification to genus or species this is highly speculative and so the seeds of these species were listed in table 7 together with the inedible plants.

2.5 Hazelnuts: a staple food in the Mesolithic?

The abundance of Hazel in the environment and hazelnut shell on Mesolithic sites in Europe has led many to suggest that hazelnuts may have been a staple food source in the Mesolithic (Dickson and Dickson 2000:257; Holst 2010; Regnell 2012; Zvelebil 1994:62). Hazelnuts would have been important resources for hunter-gatherers, since they are high in energy and fat, containing approximately 400 kcal per 100g when fresh (Howes 1948:23) or about 650 kcal per 100g when dried (Holland et al 1991:314) and could have provided sufficient calories for use as a staple food (Jarman et al 1982:68; Loewenfeld 1957:36). They can also be easily collected in large quantities and stored over the winter (Carruthers 2000:415; Dickson and Dickson 2000:258; Howes 1948:184; McComb and Simpson 1999:3), a practice that was frequently employed by modern hunter-gatherers (Marles et al 2000:150; Moerman 1998:181-2). Hazelnuts are also a much more predictable resource and require less energy to process than meat, and would consequently have provided a reliable winter food source (Hastie 2003e:4; Jacobi 1978:82-3). It seems probable that during the short, intense hazelnut gathering season in September/October, specialised hazelnut processing camps may have been established in the vicinity of particularly productive Hazel woodland areas to protect the nuts from predators and to dry the nuts (Holst 2010:2878; McComb 2009:228). Such camps could have been occupied throughout the winter to make use of the stored nuts, as well as other plant resources gathered for winter storage (Clarke 1976a:474).

Though it is difficult to assess the productivity of Hazel in the Mesolithic, the widespread availability of Hazel within the Scottish Mesolithic environment and the existence of unshaded, Hazel-dominated woodlands in many areas, would have provided the ideal environment for Hazel to flower and provide abundant nuts for exploitation (see section 4.3.3.2; Dickson and Dickson 2000:258; Holst 2010:2876). Using estimates of the calorific yield produced from modern commercial Hazel orchards in Britain and the frequency of Hazel in early Holocene pollen diagrams in England, Jacobi (1978:82) has suggested that a 0.75-1 mile square area of woodland would have supplied enough hazelnuts for four families for 25% of their diet for four months. More useful figures are available from hazelnut calorific return rate experiments, which show that processing time rather than harvesting time is the major factor influencing return rates (Holst 2010:2877; Talalay et al 1984:356). Experiments with the American Hazelnut (*Corylus americana* Walter), suggest that a single person working for eight hours (collecting and cracking nuts) could produce the necessary calories (0.087 kg/5920 kcal nutmeat per hour) for approximately three adults for one day or a single adult for three days (Talalay et al 1984:356). Holst (2010:2877-2878) estimates that approximately, "950 storable nuts (0.9 kg nutmeat, 5130 kcal per hour) could be obtained per person per hour, equivalent to about 7600 nuts (6.8 kg nutmeat, 40,800 kcal) per day", or allowing for a 30% loss rate, "4.8 kg nutmeat (28,800 kcal) per person per day" and that an individual could produce 44% of the required annual energy in the 14 day hazelnut season. As Holst (2010:2878) points out these return rates greatly exceed estimates produced for wild cereals (c. 900-1200 kcal per hour) and acorn return rates (c. 850-1350 kcal per hour) (Barlow and Heck 2002), showing the potential importance of hazelnuts in the diet.

However, there are several factors that could potentially have limited the use of hazelnuts as a staple food. Firstly, competition with other animals and inter-annual fluctuations in hazelnut production would have restricted hazelnut yields and reduced the reliability of this resource (McCullagh 1989b:43). It should also be remembered that the values commonly quoted in support of the productivity of Hazel relate to modern planted woodlands (ibid) or incomparable ecological environments, such as North America (Holst 2010 table 2), and there is no detailed data available on the productively of native Hazel in an unmanaged Hazel-dominated woodland. Consequently, estimates of hazelnut yields in the Mesolithic should be treated with caution. However, considering the abundance of Hazel in the Mesolithic environment, even allowing for predation, it seems likely that hazelnut availability would have exceeded the available labour for nut harvesting rather than vice versa (Holst 2010:2878). Therefore given the ubiquity of hazelnut shell on Scottish Mesolithic sites, their availability, calorific properties and storability, it is clear that hazelnuts would have been a key aspect of the Mesolithic diet.

2.6 Just a hazelnut based plant economy?

The contribution of hazelnuts to Mesolithic plant subsistence strategies should not be overestimated. The recovery of a range of edible fruits (Hawthorn, Crab Apple and possibly pear) and seeds (Black Bindweed, Charlock, Corn Spurrey, dock, Fat-hen, Knotgrass, orache, Ribwort Plantain, sedge and vetch/tare) in Scottish Mesolithic assemblages, and the abundance of Lesser Celandine tubers at Staosnaig, hints at the potential contribution of these species to the Scottish Mesolithic diet.

In fact, it is likely that Scottish Mesolithic hunter-gatherers utilised a wide diversity of other wild plants, many of which are virtually archaeologically invisible. Several authors have emphasised the wide variety of resources exploited by Mesolithic hunter-gatherers, and have seen the increased exploitation of nuts in the Mesolithic as a part of a diversified subsistence strategy (Clarke 1976a:475-6; Price 1989:48). Clarke (1976a:464) suggests that there were between 250-450 edible plant species in temperate deciduous woodlands in Europe and ethnographic evidence from North America and Canada indicates that temperate hunter-gatherers usually exploit a wide range of plant species, with at least 1649 species in North America and 550 species in Canada known to have been exploited for food (Kuhnlein and Turner 1991:10; Moerman 1998:15). Indeed Anderson (2006:242) estimates that between 60-70% of the diet of most tribes in California consisted of plants. Despite Keeley's (1992) prediction that hunter-gatherer plant use declines in higher latitude regions where plants are more seasonal, there is considerable historic and archaeobotanical evidence for the importance of wild plants in the diet in temperate parts of Europe and Asia. Archaeobotanical evidence from Abu Hureyra in Syria, shows that in the Epipalaeolithic, hunter-gatherers exploited over 250 wild plants species for food (Hillman 2000:397). Furthermore, Eurasian countries with detailed ethnobotanical and historic records of plant use indicate wild plants were extensively and routinely used for food historically, even in agricultural societies, and were not merely utilised in times of famine. For instance, across Spain, 419 edible plants have been recorded as being used historically and by contemporary people, of which 206 species were wild vegetables (Tardío 2010:214; Tardío et al 2006:33). Indeed, in contemporary Eurasia, ethnobotanical research shows that even today between 48-143 species (48 recorded for Italy, 59 for Portugal, 84-143 for different regions of Turkey) are recognised as food plants by older inhabitants in certain areas (Carvalho and Morales 2010:153; Ertuğ 2009:65; Nebel and Heinrich 2010:176). In Britain, Lightfoot (1777) listed about 80 edible plants in Scotland, and contemporary plant gathering guides in Britain list over 250 edible plants (Irving 2009).

In particular, though edible roots and tubers have rarely been recovered from Scottish Mesolithic sites, they may have formed an important component of the Mesolithic diet because of their predictability, storability, high carbohydrate content and year-round availability (Clarke 1976a:476; Hardy 2007:6; King 1994:187). In the highly forested environment of Mesolithic Scotland, edible roots/tubers would also have been more readily available that annual seeds (Clarke 1976a:476), and probably would have provided the major carbohydrate component of the diet, as in most modern hunter-gatherer societies today (Vincent 1985:132). Moreover, ethnographic research shows that the energy and time expended was much greater for seed collection and processing than for tuber gathering and processing (Hardy 2007:5), suggesting that tubers may have had a greater importance in hunter-gatherer diets than seeds. Similarly, as an underground resource, humans faced much less competition with other animals for the exploitation of roots/tubers (Hardy 2007:6) than hazelnuts.

The dearth of edible tubers/roots recovered from archaeological samples can be explained by the fact that charred roots/tubers are rarely recognised by archaeobotanists, because they cannot be identified using conventional archaeobotanical methods because they require specialist skills and an SEM for full identification (Hather and Mason 2002:2; Mason et al 1994:55; Zvelebil 1994:48). However, roots and tubers have been frequently found in European assemblages analysed appropriately (Hather and Mason 2002:5; Mason et al 2002:195). The presence of vesicular material and stems/rhizomes at four Scottish

Mesolithic sites, suggests that unidentified edible roots/rhizomes/tubers may have been present at several sites.

Furthermore, many edible plants may not have been calorifically important components of the plant economy, but they may have played an essential nutritional role in the diet (Etkin 1994:2-3). In particular, the importance of edible leaves has probably been severely underestimated in the Mesolithic diet. Leafy green plants were probably important dietary components for Mesolithic hunter-gatherers since they are easy to collect and are high in vitamins and minerals (King 1994:187). Since they are usually eaten in a raw state at the point of collection and are extremely fragile, leaves are not preserved in archaeobotanical assemblages (Ertuğ 2009:64; King 1994:189).

In part, the numerical frequency of hazelnuts relative to other plant remains in Mesolithic assemblages probably relates to the fact that nutshell is a waste product of consumption. Whereas hazelnut shells would be deliberately discarded– often onto domestic fires - or used as a fuel, tubers, seaweed, fruits and seeds are intended to be consumed and would only be charred occasionally during cooking or processing accidents (Jones 2000b:80; Jones and Rowley-Conwy 2007:400; Mithen 2000:437; Munson et al 1971:427; Pearsall 2000:204). This problem is highlighted by the fact that only one whole hazelnut kernel has been recovered from Mesolithic Scotland, despite the abundance of nutshell. Moreover, hazelnut shells are small, dense and robust and therefore are more likely to fall quickly into the ashes of domestic fires and be carbonised and preserved than lighter seeds and moisture-rich tubers, leaves, seaweed and hazelnut kernels which would more frequently be burnt to ash (Anderson 2006:267; Carruthers 2000:411; Dark 2004:2; Hillman 1981b:140; King 1994:187-188; Minnis 1981:149; Mithen 2000:437; Munson et al 1971:427; Pieroni 2005:29; Popper 1988:56; Score and Mithen 2000:508; Wilson 1984; Wright 2003:578). Indeed, as Carruthers (2000:413), suggests, considering the low chance of edible seed carbonisation, it is probable that even when present in low frequencies in archaeobotanical assemblages, they were probably deliberately collected.

Hazelnut shell is also much more frequently recovered from sites where the only recovery method utilised is hand collection and/or wet/dry sieving with coarse meshes due to its higher visibility, whereas small plant remains are not recovered using such methods (King 1994:190; Minnis 1981:143; Pearsall 2000:502; Renfrew 1973:21; Wagner 1988). Though flotation was employed on most sites, a notable proportion (31%) of site blocks were derived from hand collected or wet/dry sieved samples (figure 2a). It is important to note that with the exception of three site blocks that contained less than five non-hazelnut identifications (Morton A, Staosnaig F41/F49 and Carn Southern), seeds, fruit remains and parenchyma/vesicular material/roots/stems were only recovered from the sites where bulk samples had been taken and flotation employed. The small volume of soil processed may also be responsible for the lack of non-hazelnut remains at many sites (figure 2c). Clearly, the larger the sample size, the greater the diversity of species recovered from a site (Jones 1991a:64). However, the extent to which this was a problem is uncertain, since the type of sampling strategy employed was only detailed for half of the site blocks (49%). Whilst some assemblages from sites where a total sampling strategy had been employed contained low volumes of plant macrofossils, such as Links House, all the sites with large plant macrofossil assemblages were well sampled: Staosnaig F24, Cramond, Weston Farm and East Barns. This suggests that the dearth of non-hazelnut shell remains in the Scottish Mesolithic is partially a consequence of the sampling strategies employed.

2.7 Conclusions

Despite the scarcity of plant remains in Scottish Mesolithic assemblages, hazelnut shell was consistently present on most sites. This suggests that, far from being of incidental importance, hazelnuts were a deliberately targeted species, which formed an important component of the Mesolithic diet. The consumption of the other species discussed is more open to question, but it seems probable that Lesser Celandine tubers, seaweed, Crab Apples, Hawthorn, vetches/tares and Fat-hen were also consumed in Mesolithic Scotland. However, considering the taphonomy of different wild plants and the diversity of plants in hunter-gatherer diets past and present, it is likely that a much greater range of plants was exploited by Scottish Mesolithic hunter-gatherers than has been identified archaeologically.

Chapter 3: Firewood selection in the Scottish Mesolithic?

3.1 Introduction

3.1.1 Chapter outline

This chapter will assess whether deliberate firewood selection strategies can be recognised in the Scottish Mesolithic. The first section will discuss the theoretical models that have been developed to understand firewood exploitation in the past from archaeological charcoal assemblages. The methodologies utilised to compile and analyse the wood charcoal dataset from Mesolithic Scotland and the pollen data used to summarise the vegetation in each region of Mesolithic Scotland will then be described. The following section will outline the overall composition of the charcoal and palynological assemblages in Mesolithic Scotland. The final section will compare the archaeological wood charcoal evidence to the palynological evidence for woodland composition and ethnographic evidence for fuel wood properties.

3.1.2 Research context

Whilst there has been considerable discussion about the changing nature of the woodland composition in Mesolithic Britain and the potential role of hunter-gatherers in woodland management in Mesolithic Scotland by palynologists (see chapter 4), there has been little discussion of the implications of the composition of Mesolithic archaeological charcoal assemblages from Scotland beyond a consideration of the species present. In contrast, there has been much debate about the meaning and significance of the composition of continental European charcoal assemblages. The theoretical context of this discussion will be outlined in the following section to provide a basis for the discussion of the charcoal evidence from Mesolithic Scotland.

There are two main paradigms in the study of fuel wood selection using archaeological charcoal. In the first view, it is argued that people in the past collected the wood that was easiest to obtain from their immediate surroundings in direct proportion to the abundance of the wood species growing in the local environment (e.g. Carrión 2002; Dimbleby 1967:115; Fletcher 2002:91; Heinz 2002:96; Minnis 1987:129; Ntinou and Kotjabopoulou 2002:84; Salisbury and Jane 1940; Willcox 2002:141). This is the so-called “Principle of Least Effort” (Shackleton and Prins 1992). According to this hypothesis, the composition of archaeological charcoal samples are analogous to palynological samples and so they can be used to create reconstructions of the past vegetation. As Dimbleby (1967:115) argues,

> "the choice of species used was not always predetermined by the use to which the wood was to be put. Sometimes any wood would do; this could apply, for instance, to a fire. Consequently the species used might reflect the availability of those species in the surrounding neighbourhood."

More recent proponents of this view – the so-called "Montpellier School" (Asouti and Austin 2005:1) - have stressed the importance of the study of firewood from general occupation levels to reconstruct the past vegetation because this context type represents long time periods, rather than charcoal from specific features or burnt structures, which are argued to be unrepresentative (Chabal 1997; Théry-Parisot 2002:246-7; Théry-Parisot et al 2010:143). However, though authors in the Montpellier School frequently state that charcoal does not directly reflect the past vegetation, they then proceed to use charcoal to provide vegetation reconstructions. For example, Willcox (2002:141), contends that,

> "Unlike pollen data archaeological wood charcoal does not directly reflect the vegetation cover, it only provides information concerning taxa used. Most charcoal comes from fuel for which there is less selection than for building timber. Fuel is generally collected from the nearest resources, thus the charcoal assemblages, to a greater extent, reflect the availability within the site catchment area. It is highly probable that for domestic firewood availability played the most important role in terms of the choice of wood gathered; thus wood will be collected from trees or shrubs nearest to the site, regardless of other factors such as combustibility."

Other recent papers within this school of thought have accepted that firewood selection probably occurred, but have argued that selection would be masked by multiple site burning activities and that the species of the wood was not an important criteria for wood selection in the past (see below for further discussion; Théry-Parisot 2002; Théry-Parisot et al 2010). In contrast, in the second paradigm, the proportions of different charcoal species in archaeological assemblages are argued to directly reflect the cultural selection of wood species gathered and burnt as fuels by humans (e.g. Boyd 1988a:314; Dufraisse 2006:48; Ford 1979:305; Godwin and Tansley 1941:118; Kreuz 1992; Marston 2009; Out 2010:1; Pessin 2002; Shackleton and Prins 1992; Smart and Hoffman 1988:170).

A major problem with "The Principle of Least Effort" when applied to archaeological charcoal is that it ignores or discounts the effects of taphonomy on archaeological assemblages. Clearly, the composition of archaeological charcoal assemblages do not directly reflect the species originally utilised by humans on site, since some species will survive carbonisation and post-depositional processes better than others and the sampling procedures employed by archaeologists in the field and archaeobotanists in the lab will influence the species identified from the site.

Once in contact with fire, some species are more likely to become carbonised and preserved than others due to differences in the size, moisture content, burning properties and the chemical composition of the wood (Rossen and Olson 1985; Smart and Hoffman 1988:172). For instance, shrubby taxa with narrow diameter branches or species used as kindling are more likely to be completely consumed by the fire and turned into ash rather than forming charcoal (Smart and Hoffman 1988:173). Likewise, the speed of combustion varies between species due to their differing densities and chemical compositions (Forestry Commission 2010a, 2010b; Lingens et al 2005; White and Dietenberger 2010) and so faster burning species may be less frequently carbonised. Also, different woods of the same mass produce different quantities of charcoal and so some species would be overrepresented relative to the quantities combusted (Shackleton and Prins 1993; Smart and Hoffman 1988:173). The temperature of the fire may also affect the extent of fracturing in the microstructure of the charcoal and thus the fragmentation of the charcoal (Théry-Parisot et al 2010:147; Vaughan and Nichols 1995). However, the extent to which the carbonisation process affects the preservation of different species in archaeobotanical assemblages has not been universally agreed. For instance, Théry-Parisot et al (2010:147) propose that combustion affects different species in a random manner, and argue that “The sum of all combustion biases affecting a plant species, during successive fires, tends to minimise frequency distortions in the sample recovered during fieldwork.” This is difficult to evaluate without the full publication of the methodologies and results used in their experiments.

Charcoal fragmentation and preservation is also influenced by the age of the charcoal, and depositional and post-depositional disturbances, such as trampling, bioturbation, freeze-thaw and dry/humidity cycles, wind action, soil moisture levels and acidity, sediment accumulation rate and digenesis (Cohen-Ofri et al 2006; Shackleton and Prins 1993:43; Théry-Parisot et al 2010:148). Once carbonised, some species are more fragile than others due to different amounts of shrinkage and weight-loss that occur during carbonisation between different species (Rossen and Olson 1985; Smart and Hoffman 1988:175). For instance, diffuse porous species undergo much greater shrinkage and weight loss than ring porous and semi-ring porous woods (Rossen and Olson 1985:450). Therefore depositional and post-depositional disturbances would affect different species by variable amounts. Théry-Parisot et al (2010:150) contest this suggestion, by showing that the distribution of fragments of different sizes from the French sites of le Marduel and Lattara were the same for different species. However, since this data is based on only two assemblages it is difficult to assess how representative this pattern is for other sites. Thus, differential preservation, depositional and post-depositional processes may affect the relative proportions of different species in charcoal assemblages to some extent.

A further problem with the "Principle of Least Effort" is that it is based on the questionable theoretical assumption that humans were passive components of the biosphere, that adapted to, but did not actively control or shape their environments (Shackleton and Prins 1992:632). It therefore disregards the role of human agency in the deliberate selection of wood species for different purposes. This is in spite of the fact that specific fuel wood selection practices are well documented in anthropological accounts of hunter-gatherer societies (Smart and Hoffman 1988:168; Théry-Parisot 2002:243).

Wood selection for fuel may be based on several features, such as the diameter and physiological state of the wood, the burning, heating and splitting properties of the wood, and cultural preferences (Asouti and Austin 2005:9; Dufraisse 2006:48; Kreuz 1992:389; Smart and Hoffman 1988:168; Théry-Parisot 2002:243-4). Wood species differ in their suitability as fuels because of their differing thermal and mechanical properties due to differences in moisture content, density, resin/oil/tar content and the chemical composition of the woods (Marston 2009:2194). The calorific value of wood varies relatively little between species dried to the same moisture content, and it is the differences in the natural moisture content and the rate of drying between species that causes the biggest differences in the calorific contents between different wood species (Forestry Commission 2010a, 2010b). However, the choice of wood species for firewood is not solely based on the energy content and heat production of the wood (contra Marston 2009), but also combustion speeds and the amount and smell of the smoke produced. The density and the chemical composition of the wood influences how quickly a fuel will burn and these properties differ by species (Boulton and Jay 1946:112; Forestry Commission 2010a, 2010b; Lingens et al 2005; White and Dietenberger 2010:422).

Different species may have been deliberately selected to produce fires of differing intensities and longevities or with differing scents, depending on whether the intended purpose of the fire was for light, heat, protection, smoking or drying food, cooking, protection and warmth at night, craft-production, ritual purposes or a combination of these functions (table 11; Asouti and Austin 2005:9; Dimbleby 1967:55; Smart and Hoffman 1988:191; Théry-Parisot 2002:244). Since different species burn at variable rates, different species would also be chosen for fire ignition than those selected for burning as a main fuel or those chosen to keep the fire smouldering until later required (Dimbleby 1967:55). As well as the deliberate selection of species for specific purposes, some species would also have been actively avoided for burning due to poor burning properties or cultural preferences (Ford 1979:290; Shackleton and Prins 1992:632-3).

However, fuel wood properties are highly dependent on how dry the wood is prior to burning, since most green wood or dead wood collected directly from the forest floor does not burn well due to its high moisture content (Edlin 1973:156; Forestry Commission 2010b:2b; Mears 1992:42; Théry-Parisot 2002:244; Théry-Parisot et al 2010:144; Wicks 1975:61). In fact, wood selection may have been more influenced by the physiological state, the dryness and the size of the wood than the species and its physical properties (Asouti and Austin 2005:9; Théry-Parisot 2002:244; Théry-Parisot et al 2010:144). Considering that deadwood would have had a lower moisture content than greenwood, deadwood would probably have been initially favoured for burning (Shackleton 1998:139; Shackleton and Prins 1992:633), provided it was healthy and not been attacked by microorganisms (Théry-Parisot 2002:244). Therefore wood selection was probably guided by the availability of different species as deadwood and fallen branches, which may vary by species, depending on the relative age structure of the woodland and differences in the rates of branch shedding, self-coppicing and decay between species (Asouti and Austin 2005:8; Ford 1979:305; Godwin and Tansley 1941:118; Smart and Hoffman 1988:169).

Yet, Théry-Parisot et al's (2010:144) suggestion that the moisture content rather than the species is key in firewood selection is contradictory, since as noted above, the moisture content varies by species. Even if wood was selected purely on the basis of its moisture content, some species would have a naturally lower moisture content than others and would be preferentially selected. Therefore, the species is key in firewood selection, particularly when the wood has not been well seasoned. Moreover, there seems no reason why specific species of deadwood that burned at preferable rates could not have been preferentially selected (contra Théry-Parisot 2002:245; Théry-Parisot et al 2010:144) since deadwood can be easily and quickly dried. Detached deadwood lodged in tree branches above the ground burns well without drying (Mears 1992:42), and damp deadwood from the ground could be dry enough for burning after a few days storage above ground level or could be quickly dried around the edge of a fire before burning (Davies 2002:51). Also, even if there was no deliberate selection in favour of specific species during deadwood collection, species that are particularly poor fuels may have been deliberately avoided.

It has also been questioned whether greenwood would have been collected in hunter-gatherer societies. Though the collection of greenwood rather than deadwood would undoubtedly have allowed much greater selection for particular combustion qualities, the wood would have required cutting and drying for long periods (a minimum of 8 months) to produce optimum burning properties (Théry-Parisot 2002:245). As Théry-Parisot (2002:244) argue, “We may ask ourselves about the necessity…to manage stocks of healthy and dry wood when dead wood, presenting a wide range of states and perfectly convenient for the requirements of every kind of combustion, was available in the environment."

However considering the amounts of firewood required on a daily basis for many activities, it is doubtful whether deadwood in the local surroundings would have provided sufficient supplies of wood beyond the immediate needs of a temporary camp or specialised activity site, especially considering that much deadwood would have been decayed and of poor burning quality (Boulton and Jay 1946:112; Kreuz 1992:388; Shackleton 1998:139). It therefore seems likely that firewood would have been acquired from living trees in the Mesolithic, with some wood storage occurring at seasonal sites for future use, and larger quantities stored at more permanent settlements. Young trees in areas of regeneration may have been particularly targeted, as an easily exploitable and renewable resource (Asouti and Austin 2005:8). On the other hand it does seem unlikely that the storage of green/dead wood would have been undertaken at temporary specialised activity camps (provided they were not repeatedly used) and in this case, the optimum strategy would have been to use the deadwood immediately available in the environment (Théry-Parisot 2002:245-6); though firewood collection may still have involved some selection or avoidance of particular woods. It must also be pointed out that greenwood will burn in a hot, well established fire, because the flames will dry the wood before it is burnt (Davies 2002:51) and so some greenwood would probably also have been utilised in a fresh state. Wood species with lower moisture contents, such as ash (*Fraxinus* sp.) and oak (*Quercus* sp.), burn better when green than woods with high moisture contents, such as elm (*Ulmus* sp.) and coniferous species, and so even as greenwood, some species would have been preferred over others (Forestry Commission 2010b:5). Indeed, it seems unlikely that deadwood and greenwood exploitation would have been mutually exclusive strategies as Shackleton and Prins (1992) and Théry-Parisot (2002:243) propose.

Théry-Parisot (2002:246) further contends that at longer-lived sites, specific fuel selection practices would be masked by the fact that a range of activities would be represented. However, it is probable that on a long-lived site, the dominant fire-use function, such as cooking/heating, would be apparent in charcoal assemblages, with species used for specialised activities, such as smoking fish, represented relatively less frequently. Similarly, wood species that burn steadily would probably have been used more frequently on domestic hearths overall during the course of the site use, than slow or fast burning woods which would have to have been mixed with other species for most purposes.

Having said this, collection strategies were clearly influenced by the availability of different species in the environment to some extent. Some species were probably neither particularly favoured nor avoided for burning and these species were probably collected in proportion to their abundance in the environment (Shackleton and Prins 1992:632-3). The importance of availability in shaping the composition of archaeological charcoal assemblages would also have differed according to the abundance and species diversity of natural woodlands in the period in question. In periods and places where woodlands were abundant, such as in Mesolithic Scotland (Tipping 1994), selection/avoidance would have played a more prominent role than in periods with restricted woodland availability (Asouti and Austin 2005:9; Shackleton and Prins 1992; Smart and Hoffman 1988:190). Species diversity also has a major impact on the extent to which firewood selection was possible (Smart and Hoffman 1988:190) and in regions where few species were available for exploitation, such as Iceland and Greenland, firewood selection would have been low. As will be discussed further in the following section, a diverse range of species was available for exploitation in Scottish woodlands, providing a choice of fuels for Mesolithic inhabitants.

The population size and permanency of settlement would also have affected the availability of firewood species, with larger, more permanent settlements causing increased harvesting pressure on preferred species (ibid). Assuming that the Mesolithic inhabitants of Scotland predominantly lived in temporary/semi-permanent settlements and that the population was relatively low in comparison to later periods, it is probable that preferred fuel woods would have remained abundantly available in the environment. Additionally, Asouti and Austin (2005:9) propose that the type of subsistence pattern operating in a hunter-gatherer society might further influence the degree of fuel selection, with delayed return hunter-gatherers undertaking a higher degree of fuel selection than immediate return hunter-gatherers that collected wood in a purely opportunistic manner. Thus, several cultural and natural influences affect the composition of charcoal assemblages: selection, avoidance and availability as deadwood/greenwood and it seems unlikely that archaeological charcoal assemblages would directly reflect the composition of the natural vegetation.

Whilst the precise factors affecting fuel selection in the past cannot be identified in the archaeological record (Théry-Parisot et al 2010:144), it is possible to observe whether selection is occurring, by comparing the proportions of different charcoal species on archaeological sites to the composition of the contemporaneous natural vegetation, which can be reconstructed through pollen analysis. Therefore, though the differing combustion qualities of different species cannot purely explain wood selection practices in the past (Théry-Parisot 2002:243), once selection has been identified in the archaeological record using palaeoenvironmental data, the burning properties of different species can provide an important guide to understanding one of the major parameters influencing human fuel choice, provided taphonomic factors are taken into account.

3.2 Methodology

3.2.1 Data selection and recording

3.2.1.1 Wood charcoal assemblages

A database of 32 Mesolithic sites with identified charcoal remains was compiled (table 9) using the same methodology outlined in chapter 2 (see section 2.2.1, paragraph 1). Wood charcoal was recorded for all sites with edible plant remains (table 4), but was only recorded for sites lacking non-wood charcoal remains where environmental samples had been taken so that semi-quantitative methods could be applied to the charcoal data from the sampled sites. In addition, sites with plant macrofossil remains from trees and shrubs from chapter 2 (table 4) were also listed in table 9.

The abundance of each tree/shrub taxon present within each assemblage was recorded numerically where possible and on a scale of ‘present’ (‘P’), absent (blank), or ‘abundant’ (‘A’) or as a proportion of the number of samples when plant components were not numerated in the archaeobotanical reports. Quantification in table 9 was based on numerical charcoal fragment counts where possible, as this was the most consistently used recording method for Mesolithic charcoal assemblages in Scotland, but the masses were also noted where this was the only information available. Research suggests that proportions calculated using charcoal fragment counts and masses are approximately equivalent (Miller 1985:4), but since proportions based on fragment counts and masses were not calculated for this study (see section 3.2.2) this is not an issue. To summarise the archaeobotanical species identifications made at each site the plant species were grouped into different charcoal taxa categories (table 8). Species classed as ‘cf.’ were added to the definite genus identifications, for example cf. *Crataegus* sp. was placed in the Hawthorn charcoal fragment category in table 8. The sampling methodologies employed and background information about each site are recorded in table 2.

As in chapter 2, where possible the charcoal sites were classed as earlier Mesolithic (8600-6000 ± 20 cal BC) or later Mesolithic (6000-4000 ± 20 cal BC), but where they could not be fitted into these categories, they were classified as ‘Mesolithic’ (8600-4000±

20 cal BC) (see section 2.2.2). Site features that were clearly spatially or chronologically distinct were separated into different site blocks, creating 38 site blocks for analysis. In order to assess the possibility of fuel wood selection in the Mesolithic, the sites were also divided into three woodland zones, based on Tipping's (1994, 2004) woodland classification scheme for the period c. 4000 cal BC: woodland zone 1: Inner Hebrides, West Coast Mainland and North-East Scotland, woodland zone 2: Southern and Central Scotland, and woodland zone 3: Northern and Western Isles of Scotland (see section 2.2.2 and figure 1). As noted in chapter 2, the vegetation changed considerably between 8000-4000 cal BC and so these zones should be regarded as general regions of similar woodland types, rather than fixed woodland categories.

Table 8: Common and scientific names of wood charcoal included in each charcoal taxa group in Table 9.

Plant group	Common name	Latin name
Alder	Alder genus	*Alnus* sp. (only native species: *Alnus glutinosa* (L.) Gaertn.)
Alder/ Hazel	Alder/Hazel genus	*Alnus*/*Corylus* sp.
Ash	Ash genus?	cf. *Fraxinus* sp. (only native species: *Fraxinus excelsior* L.)
Birch	Birch genus	*Betula* sp.
Cherry/Blackthorn	Cherry/Blackthorn	*Prunus* sp.
Crab Apple	Crab Apple	*Malus* sp. (only native species: *Malus sylvestris* (L.) Mill)
Crab Apple /pear /whitebeam /Rowan /Hawthorn/ Wild Service	Hawthorn/Crab Apple	*Crataegus*/*Malus* sp.
Crab Apple /Pear /whitebeam /Rowan /Hawthorn/ Wild Service	Crab Apple /pear /whitebeam /Rowan /Hawthorn/ Wild Service	Pomoideae/Maloideae (Malus/Pyrus/Sorbus/Crataegus)
Crab Apple /Pear /Whitebeam /Rowan /Hawthorn/ Wild Service	Rowan/Wild Service/whitebeam	*Sorbus* sp.
Crab Apple /Pear /Whitebeam /Rowan /Hawthorn/ Wild Service	Rowan/Wild Service/whitebeam?	cf. *Sorbus* sp.
Elm	Elm	*Ulmus* sp.
Hawthorn	Hawthorn?	cf. *Crataegus* sp.
Hazel	Hazel	*Corylus* sp. (only native species: *Corylus avellana* L.)
Field Maple	Maple?	cf. *Acer campestre* L.
Oak	Oak	*Quercus* sp.
Oak	Oak?	cf. *Quercus* sp.
Willow	Willow	*Salix* sp.
Willow/poplar	Willow/poplar	Salicaceae
Pine	Pine	*Pinus* sp.
Indeterminate conifer	Indeterminate conifer	n/a
Unidentified	Unidentified	n/a
Unidentifiable	Unidentifiable	n/a

3.2.1.2 Palynological data

Woodland compositions were reconstructed for each zone using data from selected pollen sites in each zone (table 10), which were taken to represent the major woodland types in each area, together with regional (see below) and national vegetation summaries (Birks 1989; Edwards 2004; Edwards and Whittington 2003; Tipping 1994). Dominant woodland species differed considerably both spatially and temporally during the Mesolithic on a local, as well as on a regional scale and the table provides a generalised and simplified picture of the vegetation in each zone. The vegetation also changed considerably during the Mesolithic, as different species colonised Scotland, and so the wood species present in each zone have been reconstructed separately for the earlier and later Mesolithic (as with the charcoal analysis, the division between these periods was arbitrarily set as c. 6000 cal BC). The only major difference between this reconstruction and Tipping (1994)'s reconstruction is the abundance of Alder (*Alnus glutinosa* (L.) Gaertn.) in some areas of woodland zones 1 and 2. This is due to the fact that Tipping (1994:11) did not include alder in his woodland type reconstruction because it preferentially grows in wetland habitats close to pollen sampling sites and its frequency may be over-represented in pollen diagrams. Considering this, in this reconstruction, alder is recorded as 'P/D' to indicate its local dominance in the vegetation in some areas of these zones.

For the North-East mainland area of woodland zone 1, the pollen diagram from Warren Field, Crathes (Murray et al 2009:16-20), provides evidence for the local vegetation around this site, but considering its restricted pollen source area, the results from this analysis are probably not representative of the wider Mesolithic vegetation in North-East Scotland (Tipping et al 2009:148). However, with the exception of the pollen diagram from Warren Field, there were few pollen diagrams available in close proximity to the archaeological sites in the North-East lowland mainland area (Tipping 1994:6) and so the pollen diagrams from Braeroddach Loch (Edwards 1979) and Loch of Park (Gunson 1975; Vasari and Vasari 1968) were taken to represent the regional vegetation for the North-East lowland mainland area of this zone. Since several of the West coast archaeological sites with charcoal in this woodland zone were distributed on Colonsay, Oronsay and Islay, local pollen sites at Loch Cholla, Oronsay (Andrews et al 1987), Loch a' Bhogaidh (Edwards and Berridge 1994), Islay and Newton, Islay (McCullagh 1989a) were also chosen to represent the vegetation close to the archaeological sites in the Southern Inner Hebrides and the regional sites at Loch Cill an Aonghais, near Tarbert, Argyll (Birks 1993) and at Loch Meodal, Loch Cleat and Loch Ashik, Skye (Birks and Williams 1983) to represent the general vegetation in mainland Argyll and the Northern

Inner Hebrides. In addition, regional summarises from Gunson (1975), Tipping (2007), Birks (1987), and Edwards (2000b) were also utilised.

For woodland zone 2, several regional pollen sequences from across this woodland zone were selected to represent the vegetation in this area, because of the scattered nature of the archaeological sites in this region and the lack of pollen sites in close proximity to many of the archaeological sites: Black Loch, Fife (Whittington et al 1991), Round Loch of Glenhead (Jones et al 1989) and Loch Dungeon (Birks 1972), Galloway, and Dubh Lochan (Stewart et al 1984) and Loch Lomond (Dickson et al 1978), Stirling/West Dunbartonshire. These regional sequences were used in conjunction with reviews of the vegetation in the area (Ramsay and Dickson 1997; Tipping 1997a, 1997b).

For woodland zone 3, there is an absence of well-dated local pollen sites close to any of the archaeological sites with charcoal in this area and so the following sites were chosen to represent the regional vegetation: Loch Lang (Bennett et al 1990a), Loch Buailaval Beag and Loch a' Phuinnd (Fossitt 1996) in the Western Isles, and Quoyloo Meadow, Crudale Meadow (Bunting 1994) and Scapa Bay (de la Vega-Leinert et al 2007) in Orkney. The regional vegetation summaries by Bennett et al (1997) and Church (2006) were used in conjunction with these specific pollen diagrams to reconstruct the woodlands in this zone.

3.2.1.3 Firewood properties

In order to explore the relationship between the burning properties of different wood species and wood selection in the Scottish Mesolithic, a table of the burning properties of the main species present and/or utilised in Mesolithic Scotland was compiled (table 11) (Barnes and Barnes 2008; Boulton and Jay 1946; Caple 2006:112; Dickson and Dickson 2000; Eco Tree Care & Conservation Ltd; Edlin 1973; Kreuz 1992; Milliken and Bridgewater 2004; Rackham 2003; Taylor 1981:45-55; The Scout Association 1999; Wicks 1975), together with the suckering, coppicing and pollarding properties of the trees (Rackham 2006:12). The most useful firewood species are listed towards the top of the table and the least useful towards the bottom of the table. The assessment of the usefulness of the woods as fuels was based primarily on the burning speeds of the different species, rather than the calorific content/heat production of the different woods, because the burning speed would probably have been more important for varying fire properties to hunter-gatherers using small-scale hearths than absolute fuel values. Indeed, all wood species are capable of producing temperatures of 250°C, which would be suitable for most purposes (Théry-Parisot 2002:244). Woods that burn at a steady rate are more likely to have been used as a main fuel on domestic hearths than those which burn rapidly or very slowly and would have to have been mixed with other woods, unless used for very specific purposes. The use of calorific values to assess the importance of specific woods in the past (e.g. Marston 2009) is based on the unsuitable modern concept that high heat production is of prime importance for domestic fires, as it would have been for heating American 20th century houses (Théry-Parisot et al 2010:144). However, it should be noted that the ranking of the different woods in table 11 broadly corresponds to the fuel values of North American wood taxa determined by experiment, which show that Crab Apple, oak, elm and ash all have high fuel values, whereas, pine (*Pinus* sp.), willow (*Salix* sp.) and poplar (*Populus* sp.) have low fuel values (Marston 2009:2195).

3.2.2 Data analysis

Wood charcoal was much more frequently recovered from Mesolithic sites than edible plant remains and so it was possible to use semi-quantitative methods to establish the relative importance of each wood species in each of the chronological and woodland type categories. In order to standardise the charcoal dataset to take into account the discrepancies in the sampling methods used between different sites, percentage presence analysis was undertaken. For each category, the percentage of sites with each identified wood charcoal taxon was calculated from the number of site blocks containing each taxon and the number of site blocks in each regional or chronological category (Hubbard 1975:198, 1980:53; Pearsall 2000:212; Popper 1988:60-61). Following Hubbard (Hubbard 1980:52) and Popper (Popper 1988:61), sites with only one identified species were excluded from the percentage presence analyses. To increase the reliability of the analyses, only sites where bulk sampling had been undertaken were included and sites with unidentified or indeterminate charcoal only were excluded from the analyses. Sites classed as 'Mesolithic' were excluded from the chronological period analysis, but where included in the geographical area analysis. The data was not analysed using charcoal fragment counts or masses because only 14 site reports detailed the total number of fragments for each taxa and only nine site reports detailed taxa masses and so no meaningful charcoal fragment or mass analyses could have been undertaken. Also, the degree of charcoal fragmentation can vary considerably between different sites and so fragment counts may give an inaccurate picture of the relative frequency of different species between different assemblages (Hubbard and Clapham 1992:119; Pearsall 2000:213; Popper 1988:60; Smart and Hoffman 1988:190). Percentage presence analysis was undertaken on a site block rather than a total sample basis, because the total sample number was not available for all sites and only two sites, where the total sample number was given, had greater than ten samples containing charcoal, which would result in considerably inflated frequency scores for some taxa, especially those with low frequency counts (Popper 1988:63). In order to show the potential species available for exploitation in the Mesolithic and to assess the extent of fuel wood taxa selection, the charcoal ubiquity results were compared to the taxa present in the Mesolithic woodlands in each woodland zone (table 10) and firewood properties (table 11).

3.2.3 Reliability of data analysis

Percentage presence analysis is the most appropriate method for analysing the disparate charcoal data compiled in this chapter because of the differing levels of recording utilised at different sites (Hubbard 1975:198; Pearsall 2000:214). However, sample size may affect the chances of a particular taxa being present in an individual charcoal assemblage (Jones 1991a:64; Pearsall 2000:214). The extent to which this is an issue is an unknown quantity, given that the sample volume was only presented for six of the site blocks included in the review, though considering that some sites sampled single features and others were multi-feature sites, it seems probable that there would be severe discrepancies in the volume of the samples processed between different sites.

The overall assumption inherent in this analysis is that the number of sites with each plant taxon in each of the different woodland and chronological categories is a relative measure of the most commonly exploited wood fuels in Mesolithic Scotland. The results of this analysis do not indicate the absolute importance of any individual taxa i.e. how much wood was burned in any of the chronological or geographical categories, but they do give an indication of how commonly/often each taxa occurs across space or time and therefore how often each taxa was utilised (Hubbard 1975:198; Pearsall 2000:213-4; Smart and Hoffman 1988:190). Given that different numbers of sites were present in each woodland zone and chronological category, the minimum percentage presence of a taxon differed slightly between each category. The minimum percentage presence for a taxa with a count of one was 7% in woodland zone 1, 10% in woodland zone 2, 33% for woodland zone 3, 7% in the earlier Mesolithic and 11% in the later Mesolithic. Therefore small differences in percentage presences in taxa in different categories may be a result of their being different numbers of sites blocks in each category rather than differing frequencies of wood use between different categories.

The main disadvantage of this methodology therefore is that though different taxa with equal or similar percentage presences indicate that these taxa were similarly widely used on Scottish Mesolithic sites, they may not have the same absolute importance as fuels because the occurrence of a single specimen at a site is given equal weight to that of a large charcoal concentration (Hubbard 1975:189, 1980:53). Equally, where large sampling strategies are employed minor components may be overemphasized (Hubbard 1975:198), though considering the small sample sizes and restricted sampling strategies employed on most Scottish Mesolithic sites, this is not an issue with this analysis. Considering all of these factors, the results of this analysis should therefore be considered to indicate general trends rather than absolute differences and small differences between different chronological and geographical categories of less than c. 5% should be interpreted with extreme caution. Differences in percentage presence between different taxa should also be treated carefully. Since the percentage presences of the different taxa in any particular category are not supplementary (i.e. do not sum to 100%) and because equal weight is given to small and large concentrations of a taxa, percentage presences cannot be used to directly compare the absolute importance of different taxa, though they can be used to give an indication of the relative importance of different taxa in the economy (Hubbard 1975:198; Popper 1988:61). This methodology has the advantage that individual taxa percentage presences are unaffected by changes in the percentage presences of other taxa and so each percentage can be considered independently (Popper 1988:61).

3.3 Results

3.3.1 Scottish Mesolithic wood charcoal assemblages

A wide variety of wood species were present in the charcoal assemblages: Alder, Ash (*Fraxinus excelsior* L.), birch (*Betula* sp.), cherry/blackthorn (*Prunus* sp.), Crab Apple, Pomoideae/Maloideae (includes Crab Apple/ pear/ whitebeam/ Rowan/ Hawthorn/ Wild Service), elm, Hawthorn, Hazel, oak, possible Field Maple (cf. *Acer campestre* L.), willow, willow/poplar (Salicaceae) and pine (table 9). However, despite this diversity, the charcoal assemblages were dominated by deciduous woodland taxa and in particular, Hazel and oak. Coniferous species were present on just eight site blocks and pine was the only coniferous charcoal identified to species level. All pine charcoal came from North-East Scotland, except for two fragments, which came from Northton, Harris. Hazel and oak were the main species exploited in Mainland Scotland and the Inner Hebrides, and in the Northern and Western Isles, oak was absent and Hazel was the only dominant utilised taxa (figure 3). There was little change in the species exploited between the earlier and later Mesolithic, except there appears to have been a slight decline in the use of birch and willow in the later Mesolithic; again Hazel and oak were dominant in both periods (figures 4 and 5). The importance of Hazel in the Scottish Mesolithic economy is emphasised by the fact that Hazel was present at 84% of sites as either wood charcoal or nutshell (table 9).

Table 9: Summary of the charcoal species present at Scottish Mesolithic sites; where possible each site is split into chronological blocks (see section 3.2.1.1). The dominant charcoal taxon is highlighted in bold for each site. P: present; A: abundant; +ns: nutshell present; +fs: fruit stone present; +s/f: seed/fruit fragment present. Definitions of each woodland zone category are given in section 3.2.1.1 and site numbers correspond to site locations in figure 1.

Site	Site Number	Woodland Zone	Alder	Alder/Hazel	Ash	Birch	Cherry/Blackthorn	Crab Apple	Crab Apple/ Pear/ Whitebeam/ Rowan/ Hawthorn/ Wild Service	Elm	Hawthorn	Hazel	Field Maple	Oak	Pear	Willow	Willow/poplar	Pine	Indeterminate conifer	Unidentified	Unidentifiable
Earlier Mesolithic																					
Ailsa View	1	2	3			5			**9**	3	+fs	6 +ns		1							
Auchareoch	3	1										+ns								P	
Camas Daraich	6	1				**19**						6 +ns									
Cramond Phases 1-2	11	2										+ns								P	
East Barns	13	2										+ns								P	
Fife Ness	15	2				3						**16** +ns		2		1					
Fordhouse Barrow (E)	16	2										+ns									
Gallow Hill	17	2	P					P				+ns		P		P					
Kinloch	22	1										+ns								P	
Links House G3-5	24	3		1					1			**4** +ns									5
Littlehill Bridge	25	2	P			P						P +ns		P							
Long Howe	27	3										1 +ns									
Lussa Wood	28	1									**3**	+ns	1?								

Site	Site Number	Woodland Zone	Alder	Alder/Hazel	Ash	Birch	Cherry/Blackthorn	Crab Apple	Crab Apple/ Pear/ Whitebeam/ Rowan/ Hawthorn/ Wild Service	Elm	Hawthorn	Hazel	Field Maple	Oak	Pear	Willow	Willow/poplar	Pine	Indeterminate conifer	Unidentified	Unidentifiable
Manor Bridge	29	2				1/7 samples			2/7 samples			**5/7 samples** +ns		1/7 samples		1/7 samples					
Newton	31	1					P		P			P +ns		P		P					P
North Carn	32	1										+ns								P	
Northton 2001	33	3										23 +ns				**25**		2			3
Redkirk Point	34	2								P				P							
Silvercrest circle 1	35	1												P				P			
Silvercrest circle 2	35	1				P												P			
Sketewan	36	2				P								**A**							
Staosnaig F41 &49	40	1										**2/2 samples** +ns									
Warren Field (Other pits)	47	1		2/7 samples								**3/7 samples** +ns					1/7 samples				
Weston Farm (early)	48	2				6						**156** +ns		7		48					

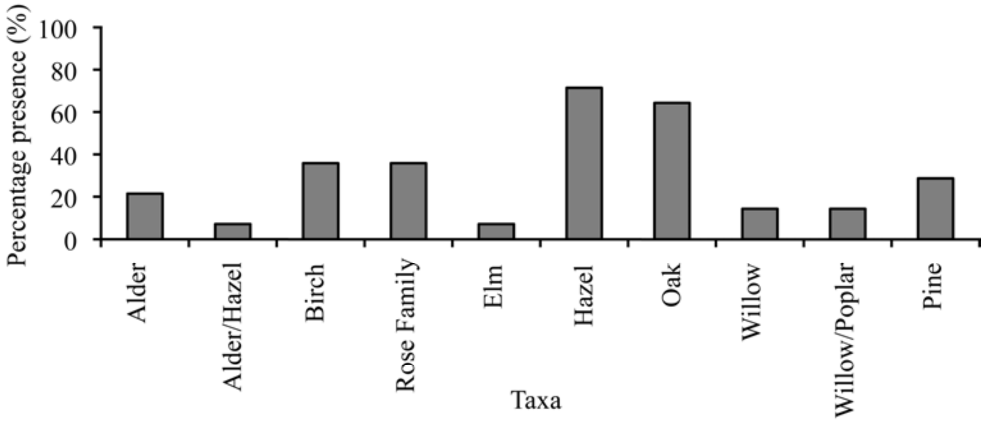
Site	Site Number	Woodland Zone	Alder	Alder/Hazel	Ash	Birch	Cherry/Blackthorn	Crab Apple	Crab Apple/ Pear/ Whitebeam/ Rowan/ Hawthorn/ Wild Service	Elm	Hawthorn	Hazel	Field Maple	Oak	Pear	Willow	Willow/poplar	Pine	Indeterminate conifer	Unidentified	Unidentifiable
Later Mesolithic																					
Aird Calanais	2	3				8						+ns					**21**				
Beattock	4	2							**A**					P							
Biggar Common	5	2												**A**							
Cnoc Coig	10	1	P							P		+ns		P						P	
Daer Valley Site 84	12	2										**50**									
Fordhouse Barrow (L)	16	2										+ns									
Garthdee	18	1										**32**		7							1
Morton B	30	2										P								P	
Skilmafilly	37	1				15						4		**95**							
Smittons	38	2										+ns								P	
Spurryhillock	39	2												**88.9g**							
Staosnaig F30	40	1										+ns									
Summerston	41	2										+ns									
Temple Bay	42	3										+ns								P	

Site	Site Number	Woodland Zone	Alder	Alder/Hazel	Ash	Birch	Cherry/Blackthorn	Crab Apple	Crab Apple/ Pear/ Whitebeam/ Rowan/ Hawthorn/ Wild Service	Elm	Hawthorn	Hazel	Field Maple	Oak	Pear	Willow	Willow/poplar	Pine	Indeterminate conifer	Unidentified	Unidentifiable
Tràigh na Beirigh	43	3										+ns								P	
Tulloch Wood1	44	1												4				**9**			
Tulloch Wood2	44	1												**A**							
Tulloch Wood3	44	1					1					2 +ns						**7**			
Upper Largie	46	1										1		**12**							1
Weston Farm (late)	48	2										**19** +ns		1		2					
Mesolithic																					
Carn Southern	7	1										+ns			+s?					P	
Castle Street	8	1				P			P	P		P +ns						P			
Chapelfield Pit 5	9	2									+fs	0.25g		0.65g				**4.3g**			0.6g
Glenbatrick Waterhole	19	1										+ns								P	
Irish Street	20	2										+ns									P
Kilellan Farm	21	1	**A**			P			P			P		P		P					
Lealt Bay	23	1										+ns								P	

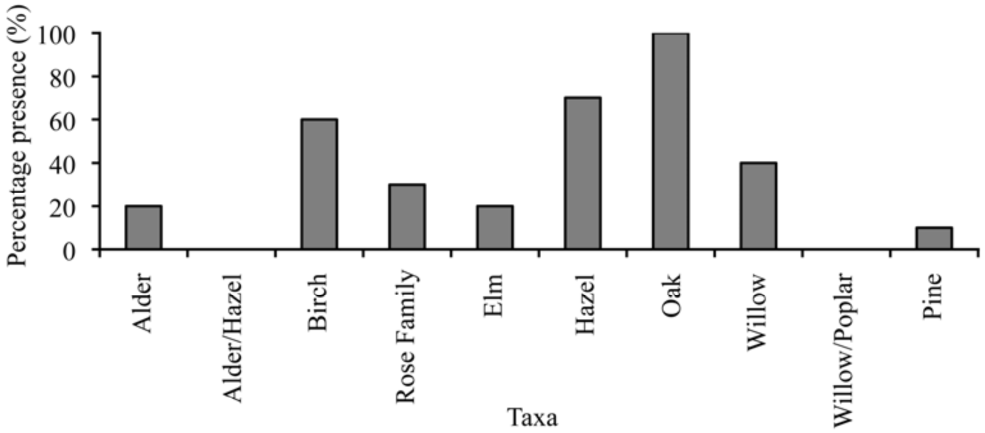
Site	Site Number	Woodland Zone	Alder	Alder/Hazel	Ash	Birch	Cherry/Blackthorn	Crab Apple	Crab Apple/ Pear/ Whitebeam/ Rowan/ Hawthorn/ Wild Service	Elm	Hawthorn	Hazel	Field Maple	Oak	Pear	Willow	Willow/poplar	Pine	Indeterminate conifer	Unidentified	Unidentifiable
Lon Mor	26	1			P?							+ns							P	P	
Morton A	30	2										+ns								P	
Staosnaig F24	40	1						+s/f	5/17 samples			**17/17 samples** +ns									
Ulva Cave	45	1										+ns									
Warren Field (Pit 5)	47	1	1/6 samples			**2/6 samples**						1/6 samples		1/6 samples			1/6 samples				

Figure 3: Percentage presence of wood charcoal species in each woodland zone category, calculated as a percentage of the total number of site blocks in each category.

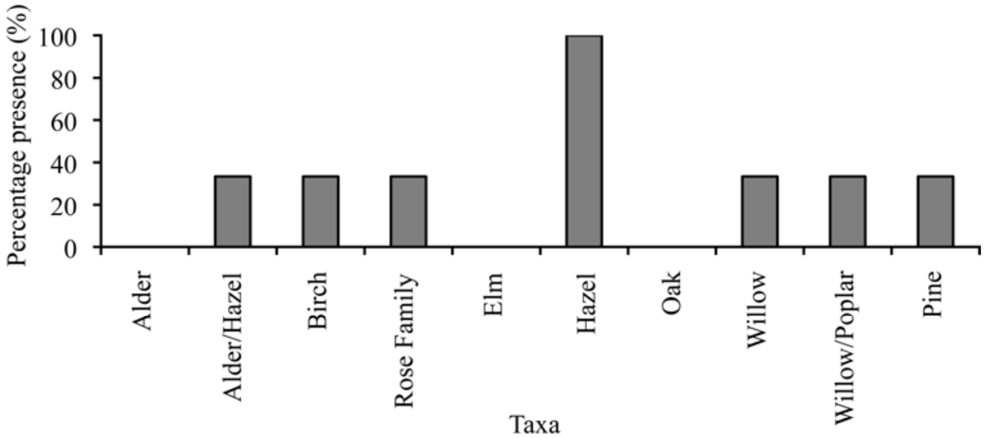
(a) Woodland Zone 1, N=14



(b) Woodland Zone 2, N=10



(c) Woodland Zone 3, N=3



(d) All sites, N=27

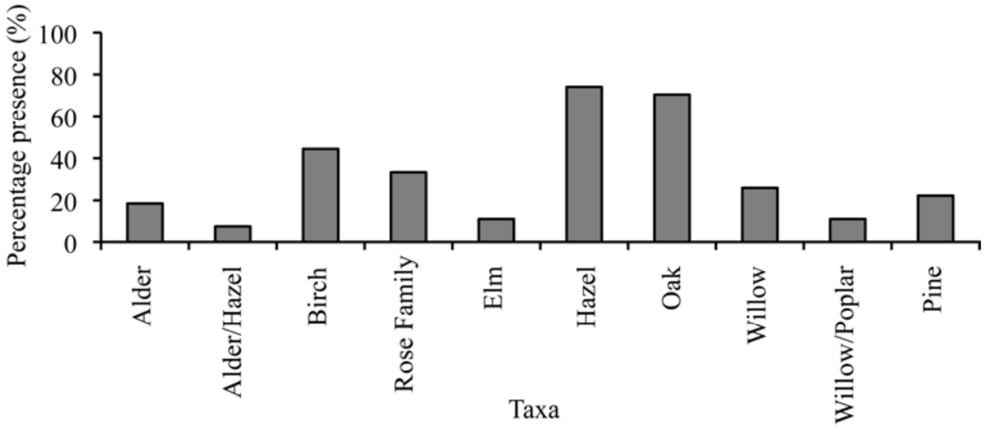
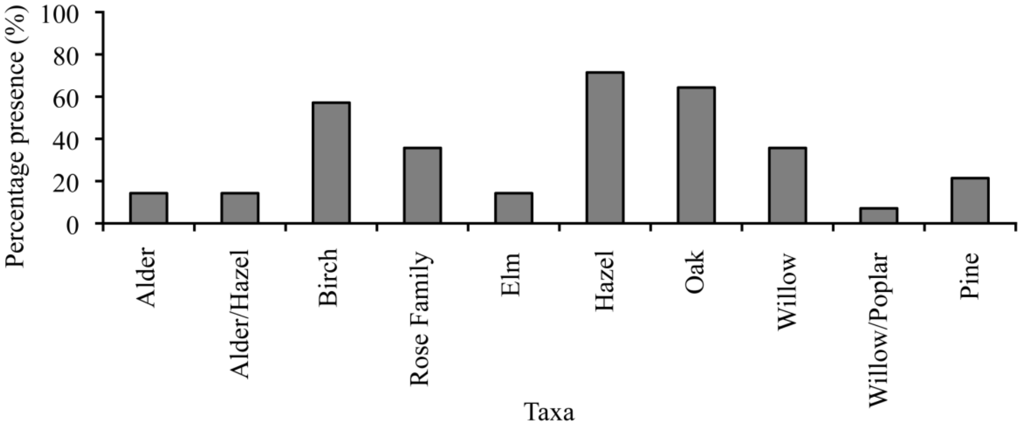
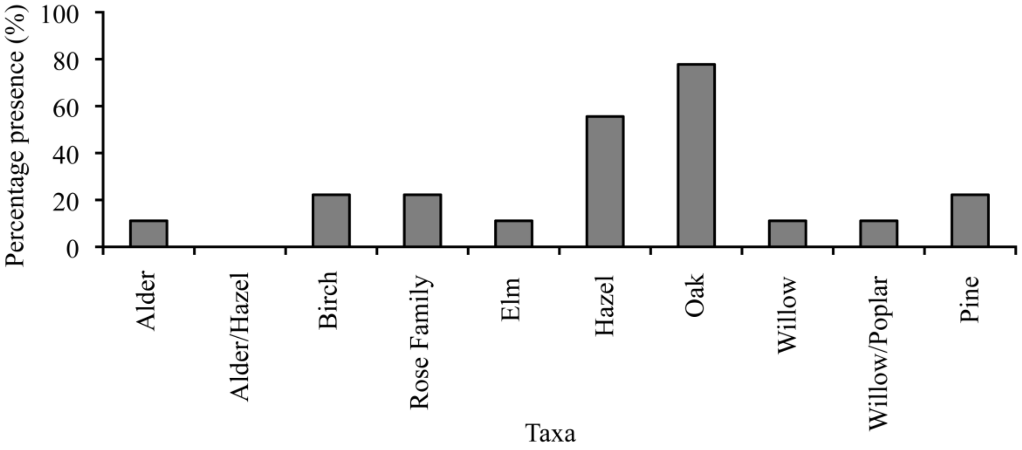


Figure 4: Percentage presence of wood charcoal species in each chronological category, calculated as a percentage of the total number of site blocks in each category.

(a) Earlier Mesolithic, N=14



(b) Later Mesolithic, N=8



(c) All Sites, N=23

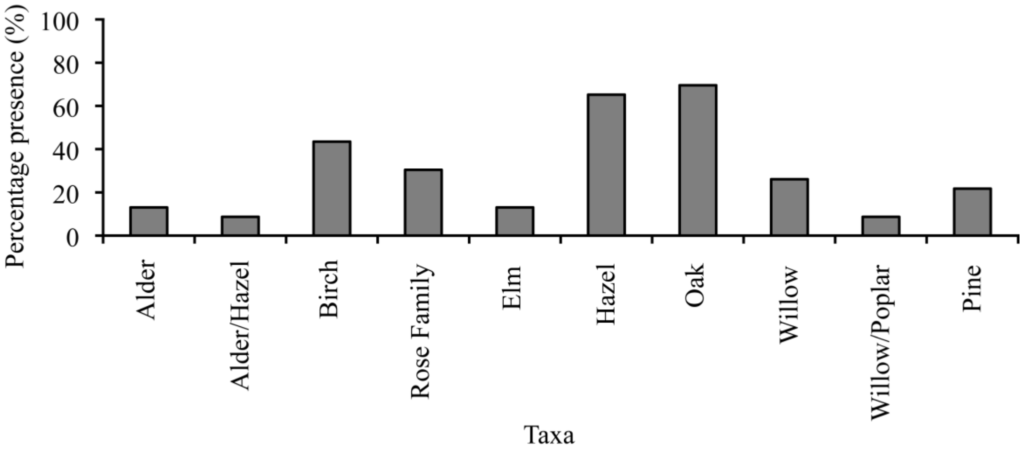
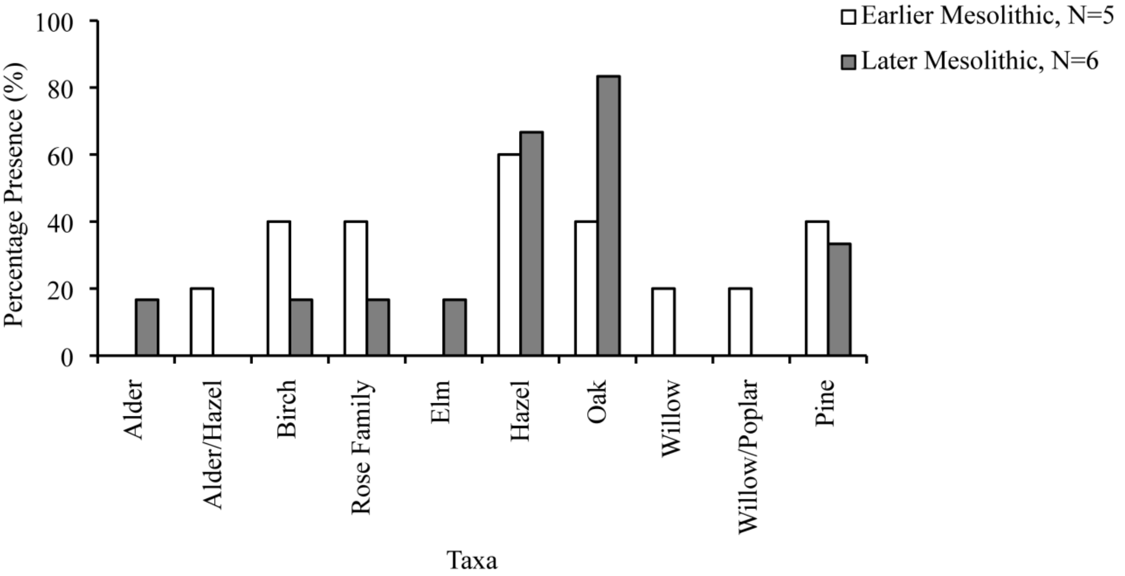
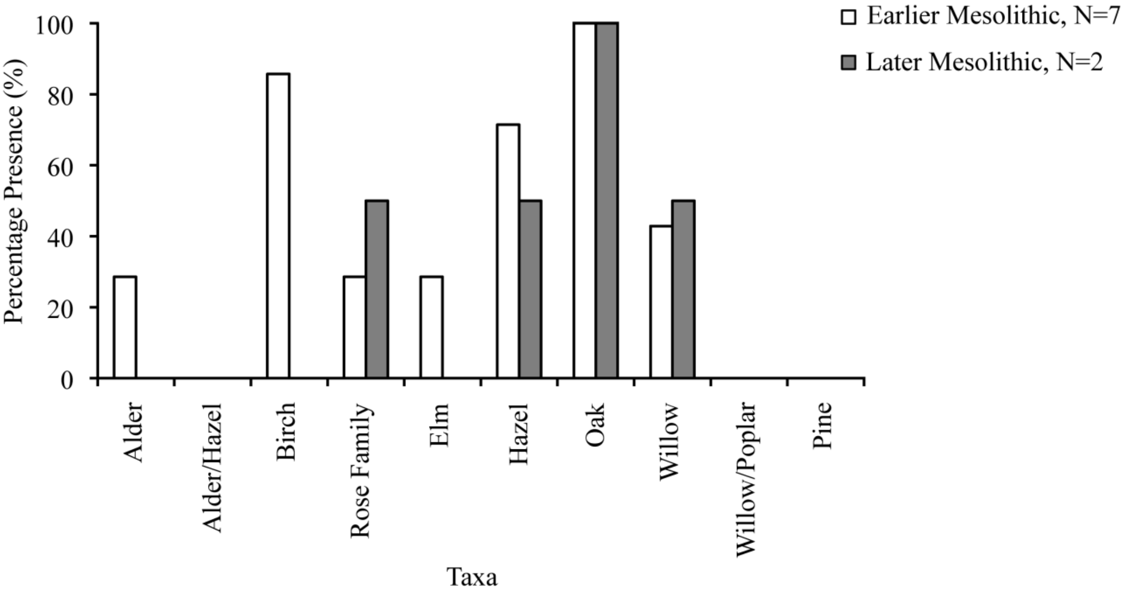


Figure 5: Percentage presence of wood charcoal species in woodland zones 1 and 2 during the earlier and later Mesolithic, calculated as a percentage of the total number of site blocks in each category.

(a) Woodland Zone 1



(b) Woodland Zone 2



3.3.2 Palynological evidence for the composition of Scottish Mesolithic woodlands

Broad woodland distribution maps have been created for Scotland, showing the dominant woodland taxa in each area at the end of the Mesolithic, of which birch, Hazel, pine, oak and elm were of most significance (Tipping 1994, 2004). However, during the Mesolithic, woodland compositions changed considerably as new species colonised different areas of Scotland (table 10). Palynological evidence suggests that whilst, birch and Hazel were already well established in most areas of Scotland prior to the beginning of the Mesolithic, elm, oak, and pine only colonized Scotland during the earlier Mesolithic and Alder from the end of the earlier Mesolithic to the later Mesolithic (Birks 1989; Edwards and

Whittington 2003; Tipping 1994). Though present throughout most of mainland Scotland from c. 9100-8000 cal BC, Hazel may not have become established in North-East Scotland and in some isolated islands, such as Arran and Mull until c. 7500 cal BC (ibid; Boyd and Dickson 1986). Oak colonized Scotland at c. 7600-6700 cal BC, but only became a major woodland component in and north of Aberdeenshire and Skye c. 5000 cal BC, though it may have been locally present prior to this in this area (Birks 1989; Edwards and Whittington 2003; Tipping 1994). Pine was present in some areas of the Northern Scottish Highlands from c. 7600 cal BC, but only expanded throughout the Highlands c. 6400-5700 cal BC (ibid). It was also present outwith the Highlands, in areas such as Galloway from c. 6400-5700 cal BC and may have been locally present elsewhere (ibid). Elm was present throughout most of Scotland from c. 7600-7500 cal BC, but only spread into parts of Caithness and the Northern Isles after c. 7000 cal BC (ibid). The colonisation of Alder was asynchronous, but between c. 6500-6000 cal BC Alder spread into Southern Scotland and by c. 4500 cal BC it had reached the North of mainland Scotland. However, the precise timing of the arrival and expansion of each species into each area was locally divergent and woodlands varied considerably both spatially and temporally on both local and regional scales (Edwards and Whittington 2003:64; Tipping 2004:46-8).

In general, however, birch-Hazel woodlands dominated most of Scotland (outwith the Highland pine-forests region) throughout the Mesolithic, with oak and elm also important species in the end of the earlier Mesolithic and later Mesolithic in Southern and Central Scotland, and the West Coast Mainland. Alder was also locally dominant in some areas of mainland Scotland at the end of the earlier Mesolithic and later Mesolithic. Pine was only locally present or important in some areas outwith the pine-rich forests in the Northern Scottish Highlands, such as Galloway, and in many pollen diagrams pine pollen was probably derived from long distance transport. Scottish Mesolithic woodlands also contained a variable range of other less important species, such as juniper (*Juniperus* sp.), willow, poplar/Aspen (*Populus* sp./*Populus tremula* L.), Ash, Rowan (*Sorbus aucuparia* L.), Hawthorn, Crab Apple and Wild Cherry (*Prunus avium* (L.) L.) (Tipping 1994:11; table 9). The importance of these minor woodland species is difficult to establish, because of the poor pollen production rates of many of these species (Bunting et al 2005; Fossitt 1996:192; Tipping 1997a:18).

Table 10: Summary of the main woody taxa present in each woodland zone. See section 3.2.1.2 for a description of the pollen data included in this table. D: dominant at most sites, P: present at most sites, *: present at some sites, † :pollen may be derived from long distance transport. P/D is used to indicate species which are dominant in some areas/periods of the zone, but not all areas/periods of the zone, and P/ † and */ † are used to indicate species which are present in some areas of the zone, but in other areas the pollen may derive from long distance transport or to indicate a difference of opinion on the native status of particular species by different authors.

Woodland Zone	1a (Inner Hebrides, West Coast Mainland and North-East Scotland)= birch/Hazel dominated woods	1b (Inner Hebrides, West Coast Mainland and North-East Scotland)= birch/Hazel dominated woods (with oak also dominant in some areas)	2a (Southern and Central Scotland) = birch/Hazel dominated woods (with oak also dominant in some areas and Alder locally dominant during the later part of this period)	2b (Southern and Central Scotland) = Mixed deciduous woodlands dominated by oak/Hazel/elm, (with Alder/birch also locally dominant in some areas)	3a (Northern and Western Isles)= open birch/Hazel dominated woods	3b (Northern and Western Isles)= open birch/Hazel dominated woods
Taxon	Earlier Mesolithic	Later Mesolithic	Earlier Mesolithic	Later Mesolithic	Earlier Mesolithic	Later Mesolithic
Birch	D	D	D	P/D	D	D
Hazel	D	D	D	D	D	D
Oak	P	P/D	P/D	D	P	P
Alder	*/ †	P/D	*	P/D	*	P
Elm	P	P	P	D	*/ †	*/ †
Willow	P	P	P	P	P	P
Pine	P/ †	P/ †	P/ †	P/ †	P/ †	P/ †
Ash	*	*	*	P	*/ †	*/ †
Juniper	*	*	*		*	
Poplar/Aspen	*	*	*	*	*	*
Rose Family (includes Crab Apple /pear /Whitebeam /Rowan /Hawthorn/ Wild Service/Wild Cherry/Wild Plum/Blackthorn)	*	*	*	*	*	*

3.4 Firewood selection strategies in Mesolithic Scotland

In contrast to the other archaeobotanical remains discussed in chapter 2, which were predominantly charred accidentally during cooking or processing accidents, the primary assumption in firewood selection studies is that the composition of charcoal assemblages reflects the species deliberately burnt as fuels by humans on domestic hearths (Kreuz 1992:388; Pearsall 1983:122). Therefore, before the possibility of firewood selection can be assessed, it is necessary to consider the on-site depositional contexts of the charcoal assemblages and whether there is any evidence for accidental or off-site vegetation burning (Smart and Hoffman 1988:171).

The charcoal assemblages in this review are derived from a range of different types of features of differing purposes, including pits, postholes, scoops, stakeholes, hearths/fire spots, gullys, old ground surfaces/occupation horizons, shell middens and possible natural features (table 2). In most cases, the wood charcoal probably represents the hearth remnants from a mix of different fires, which accumulated accidentally in secondary contexts during the use of the sites as a result of trampling, or shifts in the location of specific activities (Asouti and Austin 2005:10) or as a result of bioturbation, erosion or post-depositional processes occurring after site abandonment. Wood charcoal may also have been deliberately deposited as a result of the discard of domestic rubbish away from the primary hearth area. In particular, samples from old ground surfaces may represent palimpsests of hearth debris, which accumulated as a result of multiple occupations, perhaps over long periods of time. Having said this, many of the assemblages could represent the remnants from short-term fires, either occurring *in situ* or in the immediate vicinity of pits into which the charcoal was later deposited, and may represent wood collected in a single episode. For example, the assemblages from Beattock, Garthdee, Tulloch Wood, Skilmafilly, Spurryhillock, Daer Valley Site 84, Lussa Wood, Redkirk Point and Chapelfield pit 5 (see table 2) all contain a restricted range of charcoal species (1-3 taxa) (table 9) and are from small single pits, possible hearth contexts or are discrete concentrations of charcoal within larger pit features. Conseqeuntly all of the charcoal in these assemblages may derive from single-use fires, perhaps used for cooking purposes. Against this idea, is the absence of edible plant macrofossils from all of these sites, except Lussa Wood, Chapelfield pit 5 and Skilmafilly, which might suggest a function unrelated to cooking for some of these fires. In contrast, the oak charcoal recovered from the stakeholes at Biggar Common probably represents the remnants of structural oak posts accidentally burnt *in situ* (Crone 1997; Johnston 1997). Though Mercer and Midgley (1997:291) and Carter (1993:231), suggest that the pits at Sketewan and Tulloch Wood containing radiocarbon-dated charcoal, may have been tree throw holes, there is no evidence that the charcoal was derived from trees burnt *in situ*. Therefore, with the exception of Biggar Common, all the charcoal assemblages are assumed to have originated from fuels deliberately burnt on domestic hearths.

The diversity of native woodland species in Mesolithic Scotland is reflected in the charcoal assemblages. All of the woodland species present in the pollen record are represented in the charcoal assemblages, with the exception of juniper, which was relatively rare or absent from the Mesolithic Scottish environment, and perhaps Rowan and poplar, though these may have been present under the identification categories of *Sorbus* sp. and Salicaceae respectively (tables 8 and 9). Overall the charcoal assemblages were dominated by native deciduous species and pine was the only coniferous taxon identified. There was no evidence for the utilisation of non-native driftwood species such as larch (*Larix* sp.) and spruce (*Picea* sp.) (Dickson 1992), but given the availability of wood within the environment, driftwood exploitation would have been unnecessary. Despite the range of deciduous wood species exploited in Mesolithic Scotland, in Southern, Central and North-East Scotland and the Inner Hebrides, oak and Hazel dominated the charcoal assemblages. In the Northern and Western Isles, oak was absent and Hazel was the most frequently recovered species. Yet, considering that this area is represented by only three sites, these assemblages may not be representative of the Mesolithic firewood exploitation strategies in this area.

The abundance of Hazel in the charcoal assemblages is probably a reflection of the dominance of Hazel in the environment in all three areas (table 10), together with its good burning properties (table 11). Interestingly, hazelnuts were also recovered from most of the assemblages dominated by Hazel charcoal (table 9) and there were numerous sites where Hazel was present as nutshell and charcoal. This emphasises the importance of Hazel within the Mesolithic economy and it is possible that the wood and nuts were gathered simultaneously at some sites. If gathered as greenwood, this could suggest deliberate pruning to increase nut production, as has traditionally been undertaken in this country on commercial hazelnut farms (Howes 1948:179; Mason 1996a:2; Pierpoint Johnson 1862:259). The possibility of some accidental gathering of hazelnuts during the gathering of Hazel greenwood cannot be discounted at sites where both are present, but it is unlikely that this accounts for the abundance of hazelnuts in Mesolithic archaeobotanical assemblages because hazelnuts are present on numerous sites lacking Hazel charcoal (table 9).

Table 11: Summary of the burning properties of dry wood for each of the main charcoal species recovered from Scottish Mesolithic sites and the main tree species present in Scottish Mesolithic woodlands, with the most useful fuel woods listed towards the top of the table and the least useful towards the bottom of the table (see section 3.2.1.3 for references).

Species	Firewood usefulness rating	Burning Speed	Burning Properties	Suckers?	Coppices?	Pollards?
Ash	Excellent	Steady	Wood burns very well and produces a good and long-lasting flame and heat. It has a low moisture content and can be burnt when green.	No	Very Well	Very well
Hawthorn	Excellent	Steady	The wood is an excellent fuel, which burns very well even when green, with a good heat and little smoke. Can be burnt when green.	No	Well	Reasonably Well
Crab Apple	Excellent	Steady	Wood burns very well, with little flame but good heat and gives off a pleasant smell; when used to smoke fish and meat, they give it a sweet, distinctive flavour.	No	Reasonably Well	Poorly
Oak	Excellent	Steady	It is an excellent fuel as both wood and charcoal, producing a good heat, but not much flame and little ash. It has been a favoured wood for smoking meat and fish because it produces a thick preservative smoke. An excellent wood for keeping fires lit overnight.	No	Pedunculate oak: Reasonably Well; Sessile Oak: Well	Pedunculate oak: Well; Sessile Oak: Reasonably Well
Maple	Good	Steady	Wood rarely used historically as a fuel in Britain, but burns well with a long-lasting flame and good heat and rarely sparks.	No	Very Well	Very Well
Elm	Good	Steady	Wood burns well if dry (but poorly if fresh due to its high moisture content) and is an excellent wood for keeping fires lit overnight.	Wych Elm: No; English Elm: Well	Wych Elm: Very Well; English Elm: No	Wych Elm: Very Well; English Elm: Very Well
Hazel	Good	Steady	Wood provides a good fuel and produces a good charcoal.	No	Very Well	Poorly

Species	Firewood usefulness rating	Burning Speed	Burning Properties	Suckers?	Coppices?	Pollards?
Birch	Good when mixed with other woods	Fast; burn with slow or steady burning woods	Wood burns well, produces good heat, bright flame and smells pleasant. However, the wood burns quickly due to its high tar content. Can be used for firewood with other species, and as kindling and produces excellent charcoal.	No	Well	Poorly
Cherry	Good when mixed with other woods	Slow; burn with steady or fast burning woods	Wood difficult to ignite but once alight burns well (provided it is dry). Burns slowly, with good heat and a pleasant scent.	Very well	Poorly	No
Rowan/ Whitebeam	Good when mixed with other woods	Slow; burn with steady or fast burning woods	Wood produces a hot fire but it burns slowly. Produces an excellent charcoal.	No	Rowan: Reasonably Well; Whitebeam: Well	Rowan:Well; Whitebeam:?
Alder	Poor	Fast; burn with slow or steady burning woods	Wood burns quickly with a low heat and bright flame, but produces excellent charcoal.	No	Very Well	Reasonably Well
Willow/ poplar	Poor	Slow; burn with steady or fast burning woods	It is a poor fuel that burns slowly (even when well dried) and produces little flame or heat and has a tendency to spark, but it burns without much smoke and produces excellent charcoal.	No	Willow: Very Well; Poplar:Well	Very Well
Scots Pine	Poor	Fast; burn with slow or steady burning woods	It burns hotly, rapidly and with considerable flame due to its high resin content and has a tendency to spark. It is useful for torches and fire-lighting.	No	No	No

The importance of oak in the charcoal assemblages was also clearly influenced by its abundance in the natural vegetation in many areas of mainland Scotland. This is supported by the absence of oak charcoal in the Northern and Western Isles, where oak was a less significant component of the vegetation. However, when considering the percentage presence of oak charcoal in each of the geographical regions as a whole, oak appears to be slightly over-represented relative to its frequency in the environment, especially in relation to birch, which was probably either equally abundant or more frequent in most local woodlands. This may reflect a slight degree of selection in favour of oak, which is an excellent fuel (table 11). Having said this, when the percentage presences in zones 1 and 2 are split chronologically (figure 5), there appears to be no appreciable difference in the importance of oak and birch in the earlier Mesolithic, though given the small number of sites in each category this should be viewed with caution. Indeed, the apparent increase in the importance of oak relative to birch between the earlier and later Mesolithic in these zones may be a reflection of its increasing abundance in the natural vegetation.

In contrast, birch does appear to be under-represented in the charcoal assemblages relative to its importance in the environment, particularly in woodland zones 1 and 3, and to a lesser extent in woodland zone 2 (figure 3). Considering that birch burns well and was a major woodland component of most Scottish Mesolithic woodlands (tables 10 and 11), it is surprising that birch charcoal was not more frequently recovered in the archaeobotanical assemblages. This rarity could be due to the nature of its combustion properties. Although birch burns well, it burns relatively quickly and so when utilised, it would probably have been burnt together with other steady burning woods, such as oak and Hazel or slow burning woods, such as cherry or Rowan. Having said this, when burnt in a green state, birch produces a similar amount of heat energy to oak (Forestry Commission 2010b:5). Furthermore, the frequency of birch in the charcoal assemblages does appear to be influenced by its changing abundance in the natural vegetation to some extent. The decline in the importance of birch in the vegetation in woodland zone 2 between the earlier and later Mesolithic appears to be shown in the charcoal assemblages: whereas birch is present in 6 of the 7 (86%) assemblages in the earlier Mesolithic, it is completely absent from the later Mesolithic assemblages in this area. This also appears to be reflected in the decline in the overall number of sites with birch between the earlier and later Mesolithic (figure 4). Due to the very small number of sites dated to the earlier or later Mesolithic in woodlands zones 1 and 3, it is difficult to evaluate whether there was a decline in birch exploitation specifically in these areas. Overall, therefore, the choice of birch as a fuel was clearly dependent on its availability, but the relative rarity of birch does appear to reflect the fact that other woods were preferred for burning over birch.

Alder also appears to have been avoided as a fuel in the Mesolithic. Although it was locally dominant in many areas of mainland Scotland in the later Mesolithic, it has only been definitely identified on 6 of the 38 site blocks in the review (with an additional 2 site blocks with possible Alder/Hazel identifications) and was completely absent from the later Mesolithic in woodland zone 2, where it would have been most prevalent in the environment. It is possible that none of the Mesolithic sites in the review was specifically located in an area of Alder woodland dominance, and if this is the case then the rarity of Alder in the charcoal assemblages probably reflects its competitive inferiority to most other native woodland species (Tipping 2004:46). Yet, where Alder was abundantly available for exploitation, it would probably have been avoided as a fuel due to its extremely poor burning properties (table 11). If utilised, Alder would have been more likely to be exploited for tool-making due to is soft and easily workable qualities (Caple 2006:98; Taylor 1981:45). This may suggest that human choices rather than availability were influencing the rarity of Alder in the archaeological assemblages.

Likewise elm is virtually absent in archaeological assemblages, despite being a good fuel when dry and major woodland taxa in Southern and Central Scotland in the later Mesolithic (tables 10 and 11). The fact that it is only present on 4 of the 38 site blocks in the review suggests that elm was avoided for burning purposes. This could be a consequence of the fact that elm burns poorly when wet (table 11). Considering that elm is tough and resistant to splitting and decay when wet (Taylor 1981:49), it may have been favoured for construction purposes rather than as a fuel.

Again, pine was rarely selected as a fuel in Mesolithic Scotland. The relative scarcity of pine charcoal can probably be explained by its rarity in Scottish Mesolithic woodlands (outwith the Highland Pine woods), together with its thermal properties. The fact that pine burns very rapidly and at a high temperature suggests that it would probably not have been routinely used as a main fuel source, though it may have been chosen for kindling or mixed with other softwood species, which burn more slowly (table 11).

Another species that is notably rare in the charcoal assemblages is Ash, which was present at just one site, despite its excellent burning qualities (tables 9 and 11). Although Ash was present in many areas of mainland Scotland and the Inner Hebrides (table 10), it was not a major woodland component in any area of Mesolithic Scotland. This suggests that the presence of Ash in the charcoal assemblages was influenced by availability rather than selection. Similarly, the consistent, but low-medium frequency of willow/poplar and Rose family charcoal in all areas is most probably a direct reflection of their more restricted availability in natural environment, although the relatively poor burning qualities of willow/poplar and several species in the Rose family (Rowan/whitebeam/Wild Cherry) probably also further influenced the scarcity of these species in the charcoal assemblages to some extent (table 11).

Several sites have charcoal identifications from species that did not grow within the local vegetation. For instance, the oak charcoal at the earlier Mesolithic site of Silvercrest, in North-East Scotland is interesting, given that the radiocarbon dates from the site predate the expansion of oak into the area (Birks 1989). However, considering that the post-circle has been dated using pine charcoal and that the oak charcoal has not been directly dated, the dating of this oak charcoal should be treated with caution. Another unexpected species in the Mesolithic assemblages was the maple charcoal recovered from the stone settings at Lussa Wood, Jura and dated to 7963 ± 200 uncal BP. The native English species of Maple, the Field Maple (*Acer campestre* L.) is not native to Scotland (Stace 1997:470), and its presence in a Scottish assemblage requires an explanation. Considering the coastal location of the site, one possible reason for the presence of the maple charcoal in Scotland was that it was derived from driftwood from North America. However, given that the radiocarbon sample was derived from a mix of Hawthorn and maple charcoal, of which hawthorn was dominant, the Mesolithic date for the charcoal may not have been reliable. Also, considering that charcoal analysis was still a developing field in the 1970s and that less-sophisticated microscopes were available than at present, it is possible that the charcoal was misidentified. Re-identification and AMS dating would be necessary to resolve this issue.

As discussed in section 3.1.2, it is potentially possible that there may be a taphonomic filter in terms of the preservation of different wood species as charcoal in archaeological deposits. However, whilst depositional and post-depositional processes may have had a major impact on the composition of individual site assemblages, they probably had a very minor impact on the presence of particular species at each site. The percentage presence of poorly preserved species in archaeological assemblages would be reduced, but well preserved species would not be overestimated since the analysis is not based on the quantification of fragment counts or masses.

In fact, it is probable that the on site taphonomy and the sampling strategies employed on each site would have had the greatest taphonomic impact on the results of the analysis. Many of the charcoal assemblages are derived from mixed occupation layers of long duration, in which a range of activities was carried out, and so they may represent a palimpsest of different selection strategies rather than a single strategy (Théry-Parisot et al 2010:145). Also, sites without systematic sampling methodologies or with small numbers or sizes of samples may have produced a much narrower range of species than were actually present on site (Jones 1991a:64; Shackleton and Prins 1992:632; Smart and Hoffman 1988:191). Therefore, it is probable that some important taxa may have been missing from some assemblages.

3.5 Conclusions

Overall, therefore, on the basis of the analysed samples, the data at present suggests that in particular, birch, elm and Alder were deliberately avoided for use as fuels in Mesolithic Scotland. On the other hand, considering the good burning qualities of Hazel, oak and Ash, the importance of Hazel and oak and the rarity of Ash in Mesolithic assemblages can be attributed to the relative abundance of Hazel and oak and the scarcity of Ash in the environment. Thus it appears that species availability had a strong influence on the choice of fuels exploited by Mesolithic people, but that species with poor combustion qualities were deliberately avoided in favour of species with good burning properties. Having said this, it is considered that restricted sampling practices and the mixed nature of the on site taphonomy of many of the sites may have affected the species recovered. Thus, it should be emphasised that all of the above conclusions are preliminary in nature and further work is necessary to validate these suggestions.

Chapter 4: Intensive plant use or management in the Scottish Mesolithic?

4.1 Introduction

4.1.1 Chapter outline

This chapter will assess the complexity of Mesolithic plant use in Scotland, through a consideration of the evidence for intensive plant use and management. The first section will briefly summarise the context of this research, and will then examine the different types of intensive plant use employed by hunter-gatherer societies and how intensive plant use may be recognised in the archaeological record. The archaeobotanical evidence reviewed in chapter 2 will then be considered in more detail to evaluate whether plants were intensively used in Mesolithic Scotland. The second half of the chapter will discuss the possibility of plant management in the Scottish Mesolithic using ethnographic, archaeobotanical and palynological evidence.

4.1.2 Research context

Traditionally, Mesolithic societies were perceived to have had only a passive impact on the environment, causing only minimal and incidental vegetation change (Austin 2000:72-3). However, over the past few decades there has been increasing interest in the importance of the active role of hunter-gatherers in modifying their environment as part of intensive economic strategies (Harris 1989; Rowley-Conwy and Layton 2011; Zvelebil 1994). As discussed in chapter 1, intensive plant use and plant management are extremely difficult to recognise in the archaeological record, but are crucial for understanding the nature of Mesolithic plant exploitation. This chapter will consider some of the possible palaeobotanical evidence for intensive plant use and management in the Scottish Mesolithic.

4.2 Intensive plant use in the Scottish Mesolithic?

4.2.1 Intensive plant use in hunter-gatherer economies

In hunter-gatherer societies utilising plants intensively, Zvelebil (1994:37) proposed that "people would be expected to engage in the conservation of their food resources, in the development of specialised tool kits for plant processing, and in the storage of plant foods." As part of such a strategy, important resources, which were only seasonally available, would have been deliberately targeted for large-scale gathering. In order to maximise the use of plants gathered on a large scale and to prevent wastage of surplus, storage or feasting would have been undertaken. The storage of plants gathered on a large scale would not only have been an important method of preserving surplus foods, but it would also be a way of minimising risk against seasonal and inter-annual food-shortages, would have reduced transportation difficulties between gathering/processing sites and more permanent settlements, and would have provided material for exchange and social display/control of resources (Bonsall 2008:262; Cunningham 2010:24; 2011:137; Mithen 2000:435; Rowley-Conwy and Zvelebil 1989). For instance, since hazelnut productivity varies inter-annually (Cunningham 2011:142), especially with cold and wet weather in April and May during pollination (Mason 1996a:2), hazelnut storage would also be an important way of minimising shortages during years with poor harvests (cf. Rowley-Conwy and Zvelebil 1989). Stored hazelnuts would also have been key resources for winter consumption, when other resources were less abundant (McComb 2009:228) and ethnographic evidence shows that hunter-gatherers frequently stored hazelnuts for winter use (Moerman 1998:181). Though conducted for social and political reasons, feasting – the communal consumption of food, often on a large scale - is another way of dealing with surplus gathered foods (Hayden 2001; Milner 2009:79).

Particular types of plants may also have been targeted for storage on a much smaller scale in the Mesolithic. Small-scale storage would have been an important method of creating portable high-energy foods for transportation or for storage in pits along routes between specialised activity sites and would have aided mobility (Cunningham 2010:25; 2011:3; Kuhnlein and Turner 1991:16). Small-scale storage of surplus may also have taken place in temporary camps to be utilised when the sites were reoccupied at a future date or for short-term storage during the occupation of a temporary settlement (Cunningham 2011:3; Rowley-Conwy and Zvelebil 1989:48). This would have been an important way of ensuring that food was immediately available on the reoccupation of a site and of providing a food supply whilst obtaining further resources (ibid). The storage of foods, such as fruits, on a small scale would also have been a key mechanism of preventing seasonal nutritional deficiencies, by providing vitamins which were unavailable in winter. For instance, the Inuit in West and North-west Alaska traditionally gathered berries in large quantities in autumn for winter consumption (Anderson et al 1998b:231; Burch 1998:208).

4.2.2 Recognising intensive plant use in the archaeological record

Intensive plant use can be recognised in the archaeobotanical record by identifying sites with high-density plant assemblages, which provide evidence for the large-scale collection and processing of particular plants. High-density plant deposits can be created in a number of ways:

1. Accidental/deliberate charring of products/waste products during the large-scale processing and drying/roasting for storage.
2. Accidental charring of products/waste products during the large-scale processing or cooking for feasting.
3. Accidental charring of an *in situ* stored product.

In the archaeobotanical record, feasting deposits would be indistinguishable from high-density plant deposits created during processing for storage. Both types of deposit may be dominated by large concentrations of products or waste products. However, it should be noted that though feasting involving plants occasionally occurs, most ethnographic examples of feasting relate to the increased consumption of meat rather than plant foods (Hayden 2001:41; Rowley-Conwy and Owen 2011:327). Therefore, high-density plant deposits are more likely to represent the preparation of plants for storage rather than feasting remnants. The large-scale processing of hazelnuts has been identified on a number of Mesolithic sites in Europe through the association of large quantities of hazelnuts with possible roasting pits, similar to ethnographic and experimental examples (Holst 2010; Score and Mithen 2000:508). Hazelnut fragment size and preservation data from archaeobotanical assemblages may also be useful in distinguishing hazelnut roasting from the casual consumption and deposition of charred nutshell in domestic hearths: larger and better preserved fragments tend to be produced during roasting compared to nutshell charred in open hearths, because the nuts do not come in direct contact with fire (see section 6.4.6).

Where preservation conditions were favourable, samples recovered from storage contexts should be dominated by plant products, though waste products may also be present if the plant did not require full processing before drying for storage (cf. Hillman 1981b). However, direct stored products are difficult to recognise in the archaeological record. There is little direct evidence for storage facilities in Mesolithic Britain, since pottery is absent and organic containers do not survive in non-waterlogged conditions (Cunningham 2011:135). It is also difficult to identify plant storage pits because they can be used for multiple purposes unrelated to storage and the stored contents of pits would only come in contact with fire in exceptional circumstances (Cunningham 2010:10, 2011:141). Furthermore, considering that most Mesolithic structures were probably fairly small and short-lived (Wickham-Jones 2004b), roof storage of plant products inside structures close to domestic hearths would be less frequent than in later periods (cf. Jones and Rowley-Conwy 2007:401; Rowley-Conwy 2000:44-47). Therefore, there would be much less opportunity for the accidental charring of plant stores in the Mesolithic than in later prehistory.

The small-scale storage of plant foods is even more difficult to recognise, since high-density plant deposits would probably not be created during the preparation of foods for storage on a small scale. However, as discussed in chapter 2, it is possible to infer the existence of small-scale storage by considering the taphonomy of the preserved plant remains. Small-scale storage in hunter-gatherer societies is best recognised through the presence of highly seasonal resources on a large number of sites in a study-area, because without storage, all the sites where a particular resource is identified would have been occupied in the same season.

The identification of moisture-rich foods, such as fruits, roots/tubers and seaweed in archaeobotanical assemblages also provides evidence for small-scale storage. As discussed in chapter 2, the preservation of roots/tubers and seaweed is extremely poor if they are charred when fresh and they are most likely to be identifiable to species if they have been dried prior to charring (Hather 1993:22, 2000a:417; Mason and Hather 2000:417). Therefore, the presence of well-preserved tubers/roots and seaweed in archaeobotanical samples is suggestive of drying for storage.

Similarly, considering that most fruits do not require processing to make them edible, the most probable anthropogenic taphonomic pathway into the archaeological record for fruits and berries was drying for storage (see chapter 2). Storage provides a valuable mechanism for preserving fruits and berries, which are highly seasonal and only remain edible for short time periods and provides the opportunity for the collection of a much greater quantity than could be consumed in a fresh state. Dried fruits and berries would have been a valuable food source for mobile hunter-gatherers, since they have a high calorific content. For instance, 100g of fresh domestic apples contain 52 kcal, whereas 100g of dried apples contain about 243 kcal (United States Department of Agriculture 2011). Also, once dried, they are also easily transportable because of their low mass and volume (Cunningham 2011:140; Kuhnlein and Turner 1991:16). Consequently they would have been important portable, high-energy foods for use during hunting expeditions and long journeys.

4.2.3 Archaeological evidence for intensive plant use

There are several sites which had notably large concentrations of hazelnut shell: East Barns in East Lothian, Weston Farm near Newbigging, Cramond in Edinburgh and Staosnaig on Colonsay (chapter 2, table 4). However, at East Barns though more than 234g of hazelnut shell was recovered, the density of nutshell across the site was not particularly high (c. 1g per litre of soil) because the nutshell was recovered from a range of contexts including pits, an occupation horizon, and the fill of the structure. The largest sample of nutshell contained 25g (c. 2g per litre of soil). Likewise, at Weston Farm, a concentration of hazelnut shell fragments was deposited in a small, shallow pit (834 fragments in c. 25l of soil), which also contained burnt bone, Hazel and willow charcoal and lithics. At Cramond, nutshell was present in most samples across the site and large quantities of highly fragmented hazelnut shell were also found concentrated within two shallow pits together with rare charcoal, burnt bone fragments and lithic material (density information not available). It is difficult to assess the significance of the results from these sites because of the different quantification methods used: the mass was measured at East Barns, fragments counted at Weston Farm and a semi-quantative abundance scale was used for the Cramond assemblage. It is also uncertain how common such concentrations of nutshell were in Mesolithic Scotland due to the lack of the full quantification hazelnut shell on other sites and the fact the sample volume has not been published for most sites (see also chapters 6 and 9 and appendix 2 for further discussion).

However, considering the highly fragmented nature of the nutshell and the absence of hazelnut kernel from all three of these assemblages, there is no evidence that any of the pits were the remnants of hazelnut stores burnt *in situ*. It is possible that nutshell from Weston Farm and Cramond could represent the remains of the pit roasting of hazelnuts, especially considering that the shallow morphology of the pits is similar to roasting pits suggested at other sites (see section 2.4.1). The fragmented nature of the nutshell may also be suggestive of roasting (Hastie 2003e:7; Score and Mithen 2000), but experiments conducted as part of this research suggest that larger fragments are produced during roasting than charring in an open hearth (see section 6.4.6). Considering the presence of the other environmental and artefactual material in these pits, it is also possible that the nutshell represents discarded waste material that was deliberately deposited or naturally accumulated in the pits from the surrounding deposits (Miksicek 1987:226). Of course, it is possible that these hazel nutshell concentrations represent nutshell that was accidentally charred during roasting or drying for storage and were later deposited in the pits. Overall all that can be said is that the quantities of nutshell recovered from these 3 sites clearly attest to the importance of hazelnuts in the economy, but without further analysis of these assemblages, none provides indisputable evidence of the large-scale collection, processing or storage of hazelnuts.

On the other hand, the assemblage from Staosnaig F24 provides clear evidence of intensive plant use. At this site, a large pit contained the fragmented nutshells from an estimated 30-40,000 whole hazelnuts, as well as 1 whole hazelnut kernel and several fragments, 414 Lesser Celandine tubers/bulbils, several charred Crab Apples, occasional carbonised seeds, sparse charcoal fragments and abundant lithics. There are several possible processes that could have resulted in the charring and deposition of the hazelnut shell in this feature. Mithen (2000:434) argues that the plant remains from F24 were not carbonised within the pit itself, due to a lack of clear evidence for *in situ* burning and the infrequent nature of wood charcoal within the pit. Considering this, together with the rarity of whole hazelnuts or nut kernels in the deposits, there is no evidence that the hazelnuts represent an accidentally burnt store. Mithen (2000:434) proposes that the hazelnuts were accidentally carbonised whilst being roasted within the smaller pit features surrounding F24 and were deposited within F24 as a means of rubbish disposal. Given the short duration of deposition within the pit (ibid), the large-quantity of nutshell and the fact that raw hazelnuts are indigestible when consumed in large quantities (Gerarde 1597:1251; Mears and Hillman 2007:26), it is improbable that the nuts would have been eaten raw without cooking. It therefore seems unlikely that the nutshell represents the accidental/deliberate use of cracked nutshells as a fuel after the consumption of the raw nuts. However, it is possible that the nuts were charred accidentally during drying for storage rather than during roasting. Whatever the mechanism of preservation at Staosnaig, hazelnut collection and processing had clearly taken place on a substantial scale. Most importantly, this evidence shows that intensive plant use did take place in Mesolithic Scotland.

Though there are no direct examples of *in situ* burnt hazelnut stores in Mesolithic Scotland (contra Cunningham 2011:141-2), the existence of plant storage in Mesolithic Scotland can be inferred in a number of ways. Firstly, considering the restricted seasonality of hazelnut production and short window of time (usually 2-8 weeks) from

September to October when hazelnuts are available for collection (Hill 1941:41; Holst 2010:2878; Howes 1948:184; Loewenfeld 1957:40; Mabey 2001:122), it is clear that the gathering of large quantities of hazelnuts, such as at Staosnaig, would have required a short, intense period of gathering, drying/roasting and ultimately storage to maximise the harvest and to prevent wastage (Cunningham 2011:142; Holst 2010; McComb 2009:228; McComb and Simpson 1999:7). Secondly, the ubiquity of hazelnuts on Mesolithic sites suggests that hazelnut storage *was* a common practice. If hazelnuts are purely indicators of seasonal collection in the autumn, then 38 of the 56 site blocks discussed in the review (see chapter 2) would have been occupied in the autumn or several seasons including the autumn. More probably, some of the sites were occupied in the autumn, others for repeated visits or periods of time over several seasons and others would have been visited at other periods during the course of the year. Therefore, it is highly improbable that all of the Mesolithic sites where hazelnuts were recovered were occupied in September/October during the short period when hazelnuts would have been available for exploitation (Dark 2004; McComb 2009:230). Thirdly, as discussed in sections 4.2.1 and 2.4.4, since most fruits can be eaten raw, they would only be charred if they were dried for storage. The charred Crab Apple seed and endocarp at Staosnaig and Hawthorn stones from Ailsa View and Chapelfield Pit 5 may have been charred during preparation for small-scale fruit/berry storage.

4.3 Plant management in the Scottish Mesolithic?

4.3.1 Ethnographic evidence for wild plant management

Smith (2011:836) defines several different types of wild plant management strategy, drawing a distinction between generic vegetation enhancement practices and specific practices used to promote particular types of plant resources: “(i) general modification of vegetation communities, (ii) broadcast sowing of wild annuals, (iii) transplantation of perennial fruit-bearing species, (iv) in-place encouragement of economically important perennials, (v) transplantation and in-place encouragement of perennial root crops.”

There is considerable historical and ethnographic evidence, showing that hunter-gatherers commonly undertake these practices (e.g. Anderson 2006:241; Harris 1989:20; McCarthy 1993; Mellars 1976; Rowley-Conwy and Layton 2011:850-51; Smith 1995b:17; 2011; Stewart 1956). For instance, anthropological observations document the fact that during harvesting, native communities in Northern Australia left the upper portion of the long yam (*Dioscorea transversa*) tubers in the soil to re-grow for the following year

(Rowley-Conwy and Layton 2011:850; Smith 1995b:17). Ethnographic and historical records also describe indigenous peoples in Southern Australia and North America expanding the natural habitats of selected tuber species by constructing irrigation channels and dykes and digging and weeding the soil to improve its fertility and to reduce competition from other species (Rowley-Conwy and Layton 2011:851; Smith 2011:842-3). Likewise, many native American communities sowed the seeds of wild edible annuals in fertile, wet, vegetation-free areas around river banks following spring floods, near their settlements or on areas of deliberately burned land, transplanted small berry and fruit producing plants close to settlements, and pruned berry bushes to enhance fruit production (Anderson 2006:256, 262; Smith 2011:839-40).

Woodland coppicing, to produce a regular supply of long straight, flexible branches of a uniform diameter, was also a widespread practice in hunter-gatherer societies past and present worldwide. For instance, in North America hunter-gatherers coppiced a diverse range of trees by burning for the construction of items such as baskets, traps, fish weirs, cordage, arrows, tools and structures (Anderson 2006:210,224). Young coppiced branches of willow and hazel of between 1-2 years were particularly favoured for small items, such as baskets (Anderson 2006:213, 219; Wilkinson and Vedmore 2001:31), whereas larger poles used in construction would be coppiced after greater intervals, such as 4-7 years (Coles et al 1978:24).

Landscape burning is probably the most widespread method of deliberate land management employed by hunter-gatherer societies past and present (Gammage 2011; Lewis 1982; Mellars 1976:16; Moore 2000:131; Rackham 2006:838). Periodic burning of the landscape disrupts the natural succession of plants and increases the diversity of the vegetation by creating zones of vegetation in different successional stages (Anderson 2006:239; Moore 1996:67; Smith 2011:838). This increases the numbers of plants at the beginning of the successional cycle, such as annuals, grasses and herbaceous and shrubby plants, which are of high economic significance (Anderson 2006:238; Smith 2011:838). The burning of natural grasslands or woodland grasslands would have prevented woodland regeneration in specific areas and would have enhanced the growth of small berry producing shrubs, such as Crowberries (*Empetrum nigrum* L.), Bilberries (*Vaccinium myrtillus* L.), Blackberries (*Rubus* sect. 2 Glandulosus Wimm. & Grab.), Raspberries (*Rubus idaeus* L.) and sloes (*Prunus spinosa* L.) (Lewis 1982:50; Mason 2000:142; Moore 1996:67; Stewart 1956:120). Controlled burning could also potentially have increased the growth of edible wild grass seeds, a practice well documented for North American hunter-gatherers (Anderson 2006:262; Bean and Lawton 1993:40; Stewart 1956:120). In woodlands, the burning of ground vegetation and fire-adapted trees may have increased light levels and soil fertility, encouraging the development of shade-intolerant annuals, herbaceous and berry-producing shrubs, as well as the growth of new fire-adapted seedlings, such as pine (Anderson 2006:238; Rackham 2006:54, 56). Several nut- and berry-producing trees, which may have been of economic importance to Mesolithic people, may respond positively to fire, such as Hawthorn, elder (*Sambucus* sp.) and oak (Mason 2000:140-142; McCarthy 1993). Groups of trees may also have been deliberately killed by repeated burning to create supplies of ready-dried firewood, which unlike greenwood, would not require months of drying prior to use (Lewis 1982:50). However, it should be noted that the controlled burning of vegetation may have been undertaken for a range of reasons, not necessarily exclusively to promote nut, berry, seed and firewood production (table 12). It should also be emphasised that medium- to large-scale landscape burning was not necessarily aimed at promoting any single plant or animal species, but was usually used more broadly to increase biodiversity and plant and animal resource diversity by creating mosaics of different vegetation and edge zones (Bird et al 2008; Lewis 1982:51-2; Moore 1996:67; Smith 2011:838).

Table 12: Summary of the main benefits of burning trees, woodland clearings and grasslands for hunter-gatherers (Anderson 2006:238; Kuhnlein and Turner 1991:18, 140; Lewis 1982:49-52; Mason 2000:142; McCarthy 1993; Mellars 1976; Moore 1996:67; Rowley-Conwy and Layton 2011; Smith 2011; Zvelebil 1994:61).

Plant Exploitation	Hunting
- stimulates the growth of new seedlings of fire tolerant tree species	- attracts animals for hunting
- increases growth of edible understory plants, such as herbaceous berry producers and edible wild grasses	- increases growing season, quantity and nutritional quality of food supplies to herbivores which increases herbivore carrying capacity, growth rates and reproductive rates
- creates ready-dried firewood in fire-killed trees (greenwood requires months of drying prior to use)	- improves visibility and mobility in woodlands, which increases hunting success by destroying cover and increasing visibility
- causes a reduction in undergrowth which would facilitate the collection of wild edible plants, such as hazelnuts and acorns	- enables humans to control distribution of food resources, resulting in a reduction in time and energy involved in finding food and in the uncertainty of hunting success
- increases soil fertility and the rate of nutrient recycling within the soil	
- helps to prevent destructive high-intensity fires	
- reduces competition from unwanted species	
- destroys parasites which attack plants	

4.3.2 Archaeological evidence for plant management in Mesolithic Scotland

Considering the widespread evidence for hunter-gatherer land management strategies, it is theoretically possible that Mesolithic hunter-gatherers in Scotland managed plants to enhance wild plant food production or the availability of wood for fuel or construction purposes. As mentioned in chapter 1, although it is extremely difficult to identify such practices in the archaeobotanical record, they may be recognised through the detailed examination of suitable archaeobotanical assemblages of waterlogged wood, charred seeds or wood charcoal.

In Scandinavia, there is abundant evidence for Mesolithic coppicing from waterlogged sites (e.g. Christensen 1997) and there are several Neolithic sites with coppicing evidence from Britain, such as the Sweet Track in Somerset (Orme 1982) and the *in situ* preserved coppice stools discovered at Etton (Taylor 1988:95). However, evidence for Mesolithic coppicing in Britain is lacking, due to a rarity of waterlogged sites. Also, whether as a result of poor sampling or a rarity on Mesolithic sites, there is an absence of suitable seed concentrations in Scottish Mesolithic archaeobotanical samples to look for possible changes in seed dimensions through time and therefore wild seed cultivation (cf. Smith 1995b:187, 2006:12225, 2011:839). There is also a dearth of large assemblages of charcoal from Scottish Mesolithic sites, probably as a result of the lack of large-scale bulk sampling. There are therefore no assemblages, where the age and size distributions of the charcoal fragments have been analysed, though the results of such analyses would be meaningless from small assemblages. However, the absence of evidence is not evidence of absence and the production, analysis and publishing of large archaeobotanical assemblages from Scottish Mesolithic sites is necessary before the possibility of wild plant management can be assessed.

4.3.3 Palynological evidence for plant management in Mesolithic Scotland

Whilst there is at present a lack of archaeobotanical evidence for plant management in Mesolithic Scotland, there is an extensive body of palynological evidence for small-scale, human-woodland manipulation (e.g. Bohncke 1988; Edwards 1996a, 2000b, 2004, 2009; Edwards and Ralston 1984; Edwards and Sugden 2003; Hirons and Edwards 1990; Tipping 1995a, b). Yet, there is not a clear-cut palynological signature for recognising Mesolithic woodland management. Some contend that woodland management is shown in pollen diagrams through the stability of tree species and microcharcoal frequencies over long periods (Mason 2000:146; Moore 1996). For instance, Moore (1996) argues that the maintenance of Hazel and Alder levels together with the continuous presence of charcoal between c. 6910±90 BP and 4870±70 BP at Rhoin Farm in Kintyre provides evidence for a human fire-maintained landscape.

However, most palynologists argue that woodland management can be recognised through the identification of woodland 'disturbance' or 'clearance' phases in pollen diagrams. Such phases are typically recognised by the decline in tree taxa, together with an increase in grasses, sedges (Cyperaceae), heather (*Calluna* sp.) and/or other open ground indicator species such as docks, Bracken (*Pteridium aquilinum)* and cow-wheat species (*Melampyrum* sp.). In some instances all tree taxa are affected during 'disturbance phases', whereas in other cases only certain tree species decline in frequency. For example, a clearance phase is argued to have occurred at Kinloch on Rhum between c. 5950-5700 uncal BP, when there was a sudden decline in Alder and Hazel and an increase in charcoal and grasses (Hirons and Edwards 1990) and at Loch a' Bhogaidh, Rinns of Islay where there was a reduction in Hazel (but not birch) and an expansion in microcharcoal, grasses and sedges at c. 7670-7080 uncal BP (Edwards 2004). At Burnfoothill Moss, anthropogenic woodland disturbance at c. 7800-7700 cal BP was argued to have been indicated by a microcharcoal peak and the presence of cow-wheat species, hawthorn (*Crataegus* sp.) and Ribwort Plantain pollen and bracken (*Pteridium* sp.) spores together with a small increase in grass pollen, but without an associated decline in major woodland taxa (Tipping 1995b).

Clearly, these 'clearance phases' are of long duration (>100 years), as are most such phases recognised in pollen diagrams from Mesolithic Scotland. Unlike the fine resolution pollen analyses that have been undertaken in North Yorkshire (Simmons and Innes 1996), they do not represent single events within a human timeframe. Therefore most 'clearance phases' from Mesolithic Scotland should be viewed as general periods of increased woodland disturbance combined with regeneration phases and probably represent an amalgamation of multiple events occurring at different spatial scales (cf. Rowley-Conwy 1981:86). Whether or not these palynological changes indicate Mesolithic woodland management is open to debate.

4.3.3.1 Were people responsible for 'disturbance phases' in pollen diagrams?

There are several possible causes of short-term woodland 'disturbance phases' in pollen diagrams: (a) natural woodland dynamics, (b) overgrazing by large herbivores, and (c) human woodland manipulation and utilisation, each of which will be considered in turn.

Assessing the nature of 'natural' Mesolithic woodland dynamics in Britain is highly problematic since no modern ecologically comparable environments exist (Moore

2000:126). However, though the extent of 'natural' Mesolithic woodland openness has been much debated in recent years (Mitchell 2005; Rackham 2006:90-101; Vera 2000), the traditional image of a dense and impenetrable 'wildwood' is no longer widely accepted, and most ecologists and palaeoecologists believe that open areas would always have been present within Mesolithic woodlands (Brown 1997:139; Edwards and Ralston 1984:24; Edwards and Whittington 2003:70; Moore 1996:63; Rackham 2006:91; Rowley-Conwy 1982; Tipping 1994:16). Woodlands were extremely dynamic environments, which were constantly changing due to natural processes such as windthrow, disease, flooding, droughts, insect and fungal attack, natural fire and climate change (Brown 1997:141; Edwards and Whittington 2003; Moore 1996:63; Peterken 1996:70; Tipping 1994:16, 2004:48). Also, in some more exposed areas, such as the Northern and Western Isles, woodlands may always have consisted of open scrub rather than closed canopy woodlands (Tipping 1996:43). Therefore indicator species of open environments would be naturally present in pollen diagrams to some extent without human interference and 'disturbance phases' may reflect natural woodland dynamics.

Large terrestrial mammals could also have been responsible for creating clearances within wooded environments. In Mesolithic Scotland, the natural terrestrial fauna included red deer (*Cervus elaphus*), auroch (*Bos primigenius*), wild pig (*Sus scrofa*), beaver (*Castor fiber*), moose/elk (*Alces alces*), roe deer (*Capreolus capreolus*), reindeer (*Rangifer* tarandus) and hare (*Lepus timidus*) (Kitchener et al 2004; McCormick and Buckland 2003), all of which would have impacted on woodlands either by consumption of tree leaves, branches and bark, or by rooting in the soil for roots/tubers (wild boar) or grazing on grasses in natural clearings and preventing tree regeneration (Kreuz 2008:53; Peterken 1996:95). Beavers in particular may have been responsible for creating large clearings of several hectares by tree-felling to make river dams and by consumption of tree bark (Peterken 1996:95 and 340). However, as with the structure of Mesolithic woodlands, the population size and density of the terrestrial fauna is unknown and so the extent of mammal-woodland impact is uncertain (Bradshaw and Mitchell 1999; Mitchell 2005; Rackham 2006:103).

The final possibility is that humans were responsible for creating clearances in woodlands. Mesolithic hunter-gatherers would have required considerable amounts of wood for fuel and construction, and it is possible that they created clearings as a result of the exploitation of woodlands for these purposes. Indeed, clearances could indicate areas of over-exploitation, rather than deliberate management practices. In recent years, in line with current ideological, political and economic concerns over human impacts on the environment (Stern 2007:575), there has been a tendency to view hunter-gatherers as ecologically skilled woodland managers, in contrast to Neolithic farmers and modern western societies, which are seen as ecologically damaging (Austin 2000; Warren 2005:69). Mesolithic hunter-gatherers are therefore rarely considered to be responsible for large-scale destruction or mis-management of woodlands. However, it is possible that in some instances, Mesolithic people over-exploited plant resources. For instance, palynological evidence from Loch Cholla, Colonsay, suggests that the intensive exploitation of Hazel nuts and wood evident at the Mesolithic site at Staosnaig resulted in a substantial decline in birch-Hazel woodlands on the island at c. 7044-6534 cal BC (Mithen 2000:437). Yet, given the lack of herbaceous species indicative of clearances, the apparent woodland decline may simply have been a statistical consequence of the increase in grasses, heather and sedge percentages as a result of the increased local growth of these species in the basin (Andrews et al 1987:66; Edwards 2000a:127).

Woodland clearances may also have been undertaken as part of management strategies to increase the production and control of economically important plant and animal species. As discussed in section 4.3.1, there is a substantial ethnographic literature showing that hunter-gatherers past and present managed the landscape using fire. Whilst direct analogies should be treated with caution (Hodder 1982), this evidence suggests that Mesolithic hunter-gatherers in Scotland would certainly have had the technological capacity to manage their environments in this manner. Alternatively, woodlands may also have been cleared by felling using antler mattocks (Saville 2004:200) or by ring barking (Edwards and Ralston 1984:25). Though experiments have shown that antler mattocks can cut wood and fell trees (Jensen 2001), the extent to which they would have been effective in creating clearances in closed canopy woodlands is open to question: tree felling experiments showed that antler mattocks required resharpening after 5 minutes of cutting (ibid) and it certainly seems unlikely that it would have been an easy task to cut down large numbers of mature trees with antler mattocks. Ring barking, perhaps followed by burning of specific trees, would have been a more practical mechanism of tree clearance for Mesolithic hunter-gatherers.

However, it is highly questionable whether microcharcoal peaks in pollen diagrams are indicative of anthropogenic woodland burning practices. It is a misconception that it is easy to burn deciduous woodlands in Britain (Edlin 1972:85; Peterken 1996:101; Rackham 2006:56). Fires, and in particular crown fires, are extremely rare in deciduous woods because they grow in moist habitats, their foliage has a high moisture content and they lack highly flammable resins present in coniferous species (Moore 1996; Murgatroyd 2002:3; Peterken 1996:101; The Scottish Government 2011:5). Whilst it may be possible to burn the surface vegetation (leaf litter, shrubs, bracken, brambles) and young tree saplings, it is very difficult to burn broad-trunked mature deciduous trees (Edlin 1972:86; Peterken 1996:101; Rackham 2006:58; The Scottish Government 2011:5). Indeed, today British woodlands are classed as a low fire risk within the European Union, due to the lack of a regular dry season (Murgatroyd 2002:1). North American woodlands provide poor ecological analogies for the woodlands in Mesolithic Britain, because of their differing tree species and climates (Edlin 1972:85; Rackham 2006:58). At any rate, most vegetation burning by North American hunter-gatherers involved firing grasslands or naturally cleared areas within woodlands rather than trees, and where woodlands were burnt, individual fires were usually lit beneath the tree trunks to kill the trees, which then fell at a later date (see section 4.3.1; Lewis 1982:50; Moore 2000:131). Therefore, if fire was used to manage woodlands, this would mostly likely have been conducted on a small scale – with particular trees selected for burning. Arguably such fires would be indistinguishable from the microcharcoal signal produced from domestic fires.

In fact, it is possible that most microcharcoal was derived from the burning of wood on domestic hearths rather than from large-scale woodland burning (Bennett et al 1990b; Edwards and Ralston 1984:25; Edwards and Whittington 2003:71). Despite advances in recent years (e.g. Blackford 2000; Clark and Royall 1995; Patterson et al 1987; Peters and Higuera 2007), microcharcoal taphonomy is still not well understood, and it is possible that microcharcoal peaks could reflect changing patterns and intensity of domestic settlement in the source area of pollen sampling sites (Bennett et al 1990b).

Microcharcoal peaks may also reflect an increase in climatic dryness in the Mesolithic, which could have resulted in a rise in naturally occurring forest fires (Tipping 1996, 2004:50). Yet, whilst, the environment would have been more susceptible to fire during drier periods (ibid), considering the low combustibility of deciduous woodlands and the association of rain with lighting strikes in Britain (Peterken 1996:103 and 335), it seems unlikely that the frequency of natural fires would have increased significantly enough to produce the sustained periods of woodland reduction and charcoal peaks evident in many Mesolithic phases of pollen diagrams from Scotland. Ecological evidence suggests that even in coniferous forests in North-West Europe, lightning induced-fires are relatively rare, occurring approximately once every 80 years (Peterken 1996:103).

Another possibility is that microscopic charcoal increases reflect grassland or heathland conflagrations. It is widely accepted by palynologists and ecologists that grasses, bracken and heather in Britain are readily combustible due to their fine branches/stems and lower moisture content, and that they are fire-responsive taxa (Edlin 1972:86; Rackham 2006:58; The Scottish Government 2011:5). There are a number of sites in Scotland where there is an association between microcharcoal and heathland expansion in the Mesolithic and later periods (Edwards et al 1995; Froyd 2006). Therefore it seems possible that heathlands and/or grasslands may have been burnt as part of land management practices in Mesolithic Scotland, similar to some of the ethnographic examples discussed section 4.3.1.

Considering these arguments, if humans were involved in creating clearance phases in pollen diagrams, it is more probable that they maintained or enlarged existing woodland clearings that had been created by herbivores or natural woodland dynamics (Brown 1997) or burned areas of grassland or heathland (Edwards et al 1995) rather than burning woodlands. This could be viewed as part of a management strategy to encourage wild game for hunting or to increase understory berry production, or it could simply reflect people taking advantage of naturally open areas for settlement. Indeed in light of the fact that Mesolithic anthropogenic 'disturbance phases' in pollen diagrams in Scotland come from a range of different environments, clearances were most probably created as a result of a number of different human activities occurring at different temporal and spatial scales (Tipping 1997b:156). Given the association of precipitation with lightning strikes in Scotland, the inflammability of Scottish woodlands and the frequency of microcharcoal in Mesolithic phases of pollen diagrams, microcharcoal is probably an indicator of the frequency of anthropogenic fire in the landscape, though much of it may have derived from fires lit for domestic activities rather than to create or maintain woodland clearings or burn heathland or grassland. However, since microcharcoal frequency decreases into the Neolithic in some areas of Scotland (Edwards 1988:262, 1998:74; Tipping 1997b:156), it seems most likely that some landscape level burning of grassland/heathland was taking place in the Mesolithic.

4.3.3.2 Is there any palynological evidence for the use of fire to manage Hazel?

During the 1970-90s several palynologists proposed that Mesolithic people in North-West Europe were responsible for accelerating the spread of hazel and/or for increasing its abundance through anthropogenic fires (Boyd and Dickson 1986; Huntley 1993:214; Iversen 1973:62; Smith 1970:83). There are several key problems with these arguments. Firstly, post-glacial tree colonisation is now widely regarded to have occurred as a result of natural processes, with rates of expansion varying between species as a result of seed dispersal rates, distances from late-glacial woodland refugia locations, environmental factors, such as climate and soils, and chance factors (Birks 1989; Tipping 1994:9, 2004:46). Secondly, whilst it is at least theoretically possible that Hazel was deliberately spread to some of the more remote areas of Scotland, such as the Hebrides through human agency (Boyd and Dickson 1986), there is no archaeobotanical evidence to support this hypothesis. Hazel was already well established in most of Scotland prior to the Mesolithic and in areas where Hazel was late to colonise, such as Arran and Mull (ibid), there is no evidence for the presence of hazelnut shells in archaeobotanical samples prior to Hazel colonisation. Considering the probable key importance of hazelnuts in Mesolithic diets (see section 2.5), it is more likely that human populations followed the natural spread of the productive Hazel woods across North-West Europe than vice versa (Huntley 1993).

Furthermore, palynologists and ecologists do not unanimously accept that the native British Hazel is a fire-responsive or tolerant species, which would have increased in frequency in the more open environments created by landscape burning practices. Whilst Rackham (2006:356) argues that Hazel is not a fire responsive species, Smith (1970:83) states that "There is no doubt that the European *Corylus avellana* is fire resistant, springing up again readily from burnt stumps" and Jacobi (1978:83) argues that Hazel could "survive burning and take over areas cleared by fire from birch, pine, oak and lime depending on the ability of its burnt stump to send out side shoots and low down on the root stock." Huntley (1993:212) is more cautious, but proposes that Hazel was "probably also relatively fire-tolerant." In North America, hunter-gatherers burned Hazel bushes to ground level to increase nut production (Kuhnlein and Turner 1991:18,140) or coppiced them by burning dead leaves which had been piled into the branches (Anderson 2006:222). However, the North American Hazel is a different species than the British *Corylus avellana* L. (Rackham 2006:356) and though the British Hazel coppices well, it does not have the ability to sprout ('sucker') from below ground level (Rackham 2006:12). At any rate, if Hazel management was undertaken to further increase the production of hazelnuts then this could have been achieved by pruning or cutting particular branches, as has traditionally been undertaken in this country on commercial hazelnut farms (Howes 1948:179; Mason 1996a:2; Pierpoint Johnson 1862:259), and burning would have been unnecessary. Furthermore, Edwards (1990) has shown that there is no clear correlation between the increase in Hazel pollen and microcharcoal curves in Mesolithic Scotland. Therefore, it is unlikely that the deliberate burning of Hazel or landscape burning would have increased Hazel frequency or productivity.

It is probable that the abundance of Hazel in the Mesolithic relates to the climatic conditions in the early Holocene, which favoured the spread of Hazel, but delayed the expansion of other canopy-forming taxa (Huntley 1993). Before the arrival of shade-producing species, it is likely that Hazel would have grown as a canopy-forming species, rather than as an understory shrub (Birks 1989:511; Coppins and Coppins 2010; Holst 2010:2876; Rackham 2006:80). The abundance of Hazel in Mesolithic phases of pollen diagrams would also be exaggerated slightly by the fact that Hazel is a low pollen producer when it is shaded by other trees, but produces more pollen when it is unshaded due to increased flowering (ibid; Huntley 1993:214). The apparent marked rise in Hazel pollen may be explained by the possible presence of non-flowering Hazel trees in the environment, before the amelioration in climate favouring Hazel productivity (Tallantire 2002). Therefore, the changing climatic conditions were responsible for the sharp rise and abundance of Hazel in the Mesolithic environment.

Since Hazel dominated the landscape in most areas before the arrival of shade-producing species (Birks 1989:511; Rackham 2006:80), arguably there would be no need to increase Hazel frequency artificially (Simmons and Innes 1996:191). In these conditions, it seems likely that Hazel would have been much more productive than it is at present, where (outwith areas of coppice) it usually grows an understory shrub. It is probable that the spacing of Hazel trees and the lack of competition with other trees were the most important factors which affected nut production, and although small-scale pruning of Hazel branches increases nut production (Howes 1948:179; Mason 1996b:2; Pierpoint Johnson 1862:259), it is not certain to what extent coppicing enhances nut production in the British Hazel (Mason 1996b:3). Thus, Hazel was undoubtedly a key component of the Scottish Mesolithic economy, but the palynological record provides no clear evidence that humans inadvertently or deliberately contributed to the spread or increase of Hazel. As Birks (1989:508-11) argues,

“Hazel nuts were important in the diet of Mesolithic people…but this does not, of course, prove that the presence or abundance of hazel resulted from human activities, only that humans took advantage of the 'endless nut groves, a Garden of Eden where one could reap without having sown' (Iversen, 1973).”

4.4 Conclusions

Thus, the presence of a high-density hazelnut deposit at one of the few sites where a large-scale sampling strategy was implemented shows that intensive plant use did take place in Mesolithic Scotland. Moreover, though there are no *in situ* burnt plant storage pits in Mesolithic Scotland, the restricted seasonal availability of hazelnuts, the ubiquity of nutshell on Mesolithic sites and the archaeobotanical taphonomy of fruit, root and nut remains on Mesolithic sites suggests that plant storage was probably taking place in Mesolithic Scotland. Though there is considerable ethnographic evidence for hunter-gatherer plant management past and present, there is at present an absence of archaeobotanical evidence for the management of wild plants in the Scottish Mesolithic, and the palynological evidence for plant management remains equivocal.

Chapter 5: Cereals, fruits and nuts in the Scottish Neolithic

5.1 Introduction

5.1.1 Chapter outline

The majority of this chapter was published in the *Proceedings of the Society of Antiquaries of Scotland* (Bishop et al 2009), with the research undertaken as part of this PhD. This chapter assesses the use of plants in the Scottish Neolithic economy using the archaeobotanical evidence from 75 sites. The first section will provide a theoretical background to this review, with a discussion of past approaches to the Neolithic economy in Britain and will outline the specific research aims for this chapter. The methodologies employed to compile and analyse the Scottish Neolithic archaeobotanical dataset will then be described, before a brief summary of results is provided and the reliability of the data analysis is considered. The next section will then consider the taphonomic processes that affect the composition of Neolithic archaeobotanical samples in Scotland and the problems in establishing the relative importance of wild and domestic plants in the Neolithic economy. The following sections will discuss the geographical, social and temporal differences in the exploitation of wild and domestic plants and arable crops, taking into account the potential taphonomic biases.

5.1.2 Research context

In Britain, the nature of Neolithic subsistence strategies has been rigorously debated. While some have favoured the idea that settled agriculture was the main form of subsistence (Barclay 2003a; Cooney 1997; Noble 2006:22; Rowley-Conwy 2000, 2002, 2004; Sheridan 2007:381; Warren 2004), others have argued that Neolithic communities lived in temporary settlements, focusing on the use of wild resources (Armit and Finlayson 1992, 1996; Barrett 1994; Moffett et al 1989; Thomas 1996, 1999, 2003, 2004, 2007c:434; Whittle 1999). Others have taken a middle position, favouring geographical diversity and viewing mainland populations as semi-mobile or transhumant farmers (Brophy 2006). This debate has developed for a number of interrelated reasons.

Firstly, assumptions concerning the extent to which social or economic factors were responsible for driving change in the past have resulted in differing interpretations of the available archaeological evidence. Consequently, while some have assumed that the development of a monument-building society in the Neolithic required a prior shift to agriculture (e.g. Rowley-Conwy 2004), others have viewed the transition to agriculture as a secondary development contingent upon social and cultural change (e.g. Hodder 1990; Thomas 1999, 2003). Conversely, others have downplayed the level of social change that was necessary prior to the adoption of agriculture, suggesting that hunter-gatherers adopted agricultural practices to some extent within existing social systems (Armit and Finlayson 1992:671).

Secondly, the settlement and archaeobotanical evidence from Neolithic Britain is highly ambiguous. In contrast to later periods, many archaeobotanical assemblages from Neolithic England contain significant quantities of hazelnut shell with relatively insubstantial quantities of charred cereal grains, which has led some researchers to suggest that wild rather than domestic resources were of greater importance in Neolithic plant subsistence strategies (Moffett et al 1989; Robinson 2000; Thomas 1996, 1999, 2003, 2004:120, 2007c:434). However, it is very difficult to determine the scale of cultivation because taphonomic processes may have resulted in an overrepresentation of wild plants in the archaeological record (Jones 2000b; Jones and Rowley-Conwy 2007; Rowley-Conwy 2004). Likewise, while there is evidence that substantial stone and timber built structures existed in Neolithic Britain, much of the settlement evidence is highly ephemeral, consisting of scatters of pits, artefacts and stakeholes that suggest temporary rather than permanent settlement (Thomas 1996). The domestic status of the large timber hall-like structures has also been questioned, with some arguing that they represent ritual focuses for an otherwise mobile society (Thomas 1996:12, 2003:71, 2004:123, 2007c:434, 2008b:32; Topping 1996:166) or structures providing a central social focus for semi-mobile communities (Brophy 2006:35, 2007:89; Noble 2006:59).

However, despite these detailed debates, most discussions about the Neolithic economy in Britain have remained essentially theoretical, have failed to collate or analyse much of the available archaeobotanical evidence and have instead focussed on a narrow range of published and outdated archaeobotanical reviews of English sites. While there have been some detailed reviews of Neolithic archaeobotanical evidence in some parts of Britain (Brown 2007; Jones and Rowley-Conwy 2007; Moffet et al 1989; Robinson 2000), much of the evidence for Neolithic plant use in Scotland has been ignored in debates about the British Neolithic economy. For example, the most recent and comprehensive review of British Neolithic plant remains by Jones and Rowley-Conwy (2007), only included 14 Scottish sites and Brown's (2007) analysis of the radiocarbon dates from British Neolithic sites with cereals totalled just 28 Scottish sites.

To some extent this situation can be seen as a result of the great expansion in the number of archaeobotanical studies undertaken on Scottish Neolithic sites in the last ten years, as a result of the large increase in developer funded archaeology in Scotland, and the absence of a detailed regional review of plant remains written by specialists on Neolithic Scotland. As a result, general discussions about the Scottish Neolithic economy (e.g. Barclay 2003a; Boyd 1988b; Dickson and Dickson 2000; Kinnes 1985; Noble 2006), have understated the available published archaeobotanical data, despite the fact that by 2000 there were at least 28 published sites (table 13) available for comparison and synthesis. This has contributed to the impression that little archaeobotanical evidence actually survives in Neolithic Scotland and that a broad-brush approach can be applied to the Neolithic economy of Britain as a whole.

Moreover, this reluctance to incorporate Scottish archaeobotanical evidence into discussions about the British Neolithic economy can be seen as a result of a number of more general theoretical misconceptions. Traditionally, the Scottish Neolithic economy has been regarded as marginal and the availability of productive arable land in Neolithic Scotland has often been underestimated due to inaccurate reconstructions of the Neolithic environment – dividing Britain into a productive 'Lowland' and unproductive 'Highland' - which has been portrayed as being largely unsuitable for agricultural settlement (Barclay 2001:8-9, 2004:31-33). There has also been an anglocentric focus on the South of England in the writings about the *British* Neolithic economy, with the exclusion or piecemeal inclusion of evidence from the other constituent parts of the British Isles that have been erroneously considered as peripheral and insignificant (Barclay 2001, 2004, 2009; Cooney 1997:23).

Given the lack of evidence for substantial buildings and cereal assemblages in Southern England - the 'core' area of Britain - it has been assumed that this situation was the same in the more 'peripheral' areas of Britain (Barclay 2004:35, 2009:2; Cooney 1997:23; Sheridan 2003:3, 2007:465). Considering the increasing acceptance that subsistence practices in Neolithic Britain were not uniform (Fairbairn 2000:110; Thomas 1999:7, 2004:120, 2007c:425), it seems simplistic to assume that the English evidence can be extrapolated to stand for the economic practices in the whole of Britain. Unlike the situation in England, there are now at least four large Neolithic timber longhouses in mainland Scotland (Richardson and Kirby 2006:14), numerous stone-built settlements in Orkney and Shetland (Card 2005a:48; Whittle et al 1986) and consistent evidence for smaller-scale permanent settlement in mainland Scotland (Barclay 1996, 2003a, 2003b; Brophy 2006:18). While it is recognised that the 'Scottish Neolithic' as an entity probably never existed and that it is simply an arbitrary division reflecting modern political boundaries (Kinnes 1985:16), it is clear that the nature of the Scottish Neolithic economy cannot be assessed on the basis of the English archaeobotanical evidence.

This review seeks to show that a diversity of subsistence practices existed within Neolithic Scotland, through the detailed analysis of the archaeobotanical data from 75 Scottish Neolithic sites. The overall research aims of this chapter are:

- To assess the relative importance of wild and domestic plants in Scottish Neolithic palaeoeconomies.
- To assess the relative importance of wheat, oats and barley in Scottish Neolithic palaeoeconomies.

5.2 Methodology

5.2.1 Data selection

A database of 75 Neolithic sites with archaeobotanical remains was compiled using published data obtained from major journals and other relevant publications, together with some unpublished data obtained from archaeological units (table 13). The abundance of each plant taxon in each assemblage was recorded and the sample sizes and sampling methodologies employed were noted. Background information about each site was also recorded to aid comparison between different sites. Only sites where sampling and flotation for Neolithic remains was undertaken were included, to ensure the data was representative of the plant remains present on site (Jones 2000b:79; van der Veen 1984:193). As a result the database includes archaeobotanical remains recovered after 1970 only, when flotation became common on British archaeological sites.

Table 13: Description of each site in the review. For a description of the site type classifications see section 5.2.2. EN: early Neolithic; ELNT: early-late Neolithic transition; LN: late Neolithic; N: Neolithic; NE: North East Scotland; S: Southern Scotland; A: Atlantic Scotland. The location of the sites are shown in figure 6.

Site	Site Number	Area	Period	Site Type	Site Description	References
Abernethy Primary School	1	NE	ELNT	5	1 fire pit	Conolly 2004; Hastie 2004b
Achnasavil	2	NE	EN	6	cultivation (charcoal spreads in colluvium)	Boardman 1992b; Carter and Tipping 1992
Allt Chrisal	3	A	EN	2	postholes, gullies, stone walls, open hearths, occupation deposits (remains of timber and stone structures)	Boardman 1995a; Branigan and Foster 1995
Allt Chrisal	3	A	LN	2	remains of stone settings, hearths, occupation layers, a platform	Boardman 1995a; Branigan and Foster 1995
Balbridie	4	NE	EN	1	large rectangular timber structure	Fairweather and Ralston 1993
Balfarg	5	NE	EN	5	pit	Barclay and Russell-White 1993; Fairweather and Smith 1993
Balfarg	5	NE	LN	4	ritual timber structures, ditched enclosures	Barclay and Russell-White 1993; Fairweather and Smith 1993
Barnhouse	6	A	LN	2	stone-built domestic settlement	Hinton 2005; Richards 2005
Beckton Farm	7	S	LN	3	small stake-built structures, 4-post structures, pits	Boardman 1992c, 1997; Pollard 1997
Bellfield Farm	8	NE	LN	3	small circular structure, a group of pits	Jones 2009; Timpany 2009
Bharpa Carinish	9	A	LN	3	3 stone-built hearths, 5 shallow pits and half a dozen postholes, spreads of ash and charcoal (remains of domestic structure)	Boardman 1993b; Crone 1993
Biggar Common 1	10	S	EN	4	ritual bonfires	Boardman Unpublished a; Boardman and Pelling 1997; Johnston 1997
Biggar Common 2	10	S	EN	3	fires, postholes, stakeholes, possible structures	Boardman Unpublished a; Boardman and Pelling 1997; Johnston 1997

Site	Site Number	Area	Period	Site Type	Site Description	References
Braes of Ha'breck	11	A	LN	2/3	timber and stone built oval domestic structures, midden deposits	Plant remains = RB's own analysis; Site info = Thomas 2007a, 2008a, 2009, 2010, 2011, Thomas and Lee 2012
Boghead	12	NE	EN	3	pit, hollows, stakeholes = possible windbreaks, black layer, no clear hearths	Burl 1984; Maclean and Rowley-Conwy 1984
Bookan	13	A	LN	4	chambered cairn	Alldritt 2005; Card 2005b
Cairnwell	14	NE	ELNT	5	pits outside stone circle, stone circle socket	Holden 1997a; Rees 1997
Carding Mill Bay	15	A	EN	7	shell midden	Boardman 1992a; Connock et al 1992
Carsie Mains	16	NE	LN	1/4	rectilinear timber structure and timber circle	Brophy and Barclay 2004; Miller and Ramsay 2004b
Castle Menzies	17	NE	EN	5	posthole	Halliday 2002; Hastie and Wilson 2000
Carzield	18	S	EN	5	a single pit	Boardman 1993a; Maynard 1993
Chapelfield	19	NE	EN	3	group of pits and small oval stake-built structures	Alldritt 2002; Atkinson 2002
Chapelfield	19	NE	LN	3	a pit, 2 circular stake-built structures	Alldritt 2002; Atkinson 2002
Claish Farm	20	NE	EN	1	large rectangular timber structure	Barclay et al 2002; Miller and Ramsay 2002
Cowie Road	21	NE	EN	4	a pit-defined enclosure	Holden 1996a, 1997b; Rideout 1997
Cowie Road	21	NE	LN	4	a post-defined enclosure	Holden 1996a, 1997b; Rideout 1997

Site	Site Number	Area	Period	Site Type	Site Description	References
Crossiecrown	22	A	LN	2	midden deposits	Downes and Richards 2000; Miller and Ramsay Forthcoming; Richards et al 2000, 2001
Culduthel	23	NE	EN	5	pits	Haston 2008; Murray 2008
Culduthel	23	NE	LN	5	pits, ditch	Haston 2008; Murray 2008
Deer's Den	24	NE	EN	5	group of pits	Alexander 2000; Holden 2000
Dubton Farm	25	NE	EN	5	large pits and small pit clusters, scoops, fire-pits	Cameron 2002; Church 2002a
Eilean Domhnuill	26	A	N	2	small rectilinear boulder and possibly turf/earth built buildings with floors and hearths	Grinter and Mills 2000; Mills et al 2004
Embo	27	A	N	4	chambered cairn	Henshall and Wallace 1964; Johnson 1964
Eweford	28	S	EN	4	earth mound, with later earth mound and wood/stone structures built on top, isolated pits	Lelong and Macgregor 2007; Miller and Ramsay 2007d
Eweford	28	S	LN	5	isolated pits	Lelong and Macgregor 2007; Miller and Ramsay 2007d
Fochabers to Mosstodloch Bypass	29	NE	EN	3	pits	Hastie 2008; Suddaby 2008
Forest Road 1/2/3	30	NE	EN	3/4/5	mound surrounded by segmented ditches, pits, working hollow - pit and stakeholes	Cook and Dunbar 2008; Holden et al 2008
Forest Road 2/3	30	NE	N	3/5	possible structure, pits	Cook and Dunbar 2008; Holden et al 2008
Garthdee	31	NE	EN	3	oval building: post-pits, floor deposit, hearths, artifact concentration	Murray and Murray Forthcoming; Timpany 2008b

Site	Site Number	Area	Period	Site Type	Site Description	References
Geirisclett	32	A	N	4	chambered cairn	Church and Cressey 2003; Dunwell et al 2003
Hillend	33	S	LN	5	3 pits	Armit et al 1994; Coles and Boardman 1994
Hill of Tarvit pit 1	34	NE	ELNT	5	pit	James and Duffy 2001; Miller and Ramsay 2001a, Unpublished
Holywood	35	S	EN	4	postholes in cursus monument	Clarke 2007c; Thomas 2007b
Inchture	36	NE	EN	5	alignment of 4 pits	Miller and Ramsay 2004a; Rees 2004
Isbister	37	A	LN	4	chambered tomb	Hedges 1983; Lynch 1983
Kinbeachie	38	NE	ELNT	3	pits and postholes, rectangular timber structure	Barclay et al 2001; Holden and Hastie 2001
Knap of Howar	39	A	N	2	two stone-built houses and associated midden deposits	Dickson 1983; Ritchie 1983
Knowes Farm	40	S	ELNT	5	line of 12 pits	Lelong and Macgregor 2007; Miller and Ramsay 2007c
Knowes of Trotty	41	A	LN	2	stone-built rectangular house	Alldritt 2003, 2006, 2007a; Card et al 2006, 2007c; Card and Downes 2002;
Lairg site 0870	42	A	LN	5	pit	Holden 1994, 1998; McCullagh and Tipping 1998
Lairg buried soil	42	A	EN	6	cultivated soil beneath a cairn	Holden 1994, 1998; McCullagh and Tipping 1998
Lamb's Nursery	43	S	N	3	groups of pits and postholes and a circular structure or curvilinear windbreak	Cook 2000; Rankin 2000

Site	Site Number	Area	Period	Site Type	Site Description	References
Larkhall Academy	44	S	EN	3	ditch, pits and postholes	Dutton and Atkinson 2006; Gillis and Franklin 2006
Lockerbie	45	S	EN	1	large rectangular timber structure	Hastie 2011; Kirby 2006; Richardson and Kirby 2006
Loudoun Hill	46	S	EN	5	2 pits	Alldritt 2000; Atkinson 2000
Maeshowe	47	A	LN	4	passage grave	Hinton 2005
Maybury Park	48	S	EN	3	pits and hollow - possible shelter	Hastie 2006; Moloney and Lawson 2006
Meldon Bridge	49	S	N	4	pits and timber enclosure	Griffiths and Roberts 1999; Speak and Burgess 1999
Midmill	50	NE	LN	3	pits, hearth, ard marks	Timpany and Masson 2009
Milton of Leys	51	NE	LN	3	cluster of small pits, hearths and postholes	Conolly and MacSween 2003; Hastie 2003d
Mountcastle Quarry	52	NE	LN	5	pit	Kimber 2008; Timpany 2008a
Ness of Brodgar	53	A	LN	2	large oval/cruciform stone structures	Alldritt 2007b; Card 2004; Card et al 2007a, 2007b; Card and Cluett 2005; Card and Sharman 2007
North Straiton	54	NE	LN	5	pit alignment	Carter 1996; Holden 1995
Overhailes	55	S	LN	3	pits, postholes, stakeholes	Lelong and Macgregor 2007; Miller and Ramsay 2007a
Parks of Garden	56	NE	LN	7	small wooden platform	Ellis et al 2002

Site	Site Number	Area	Period	Site Type	Site Description	References
Pencraig Hill	57	S	EN	4	low mound and timber mortuary structures surrounded by a timber palasade	Lelong and Macgregor 2007; Miller and Ramsay 2007b
Pitlethie Road	58	NE	EN	5	pit	Cook 2007; Hall and Inglis 2007
Pool	59	A	EN/LN	2	low mound of tip-like deposits, structural features	Bond 2007a; Hunter et al 2007
Ratho Quarry	60	S	EN	5	3 pits	Holden and Rankin 1995; Smith 1995a
Scord of Brouster	61	A	ELNT/LN	2	2 stone-built houses	Ballin 2005; Milles 1986a; Whittle et al 1986
Silvercrest	62	NE	EN	5	pits	Cressey and Lyons Forthcoming; Cressey and Suddaby 2002
Skara Brae	63	A	LN	2	10 stone houses, midden deposits	Childe 1931; Clarke 1976b; Rowley-Conwy Forthcoming
Stonehall	64	A	LN	2	stone-built houses, midden deposits	Downes and Richards 2000; Miller and Ramsay Forthcoming; Richards et al 2000, 2001
Stoneyburn Farm	65	S	ELNT	4	pits and postholes beneath a cairn	Banks 1995; Dickson 1995
Stoneyhill Farm	66	NE	LN	5	pit	Hastie and Cressey Forthcoming; Suddaby and Ballin Forthcoming
The Howe	67	A	LN	4	chambered tomb	Ballin Smith 1994; Dickson 1994
Tinto Sands and Gravel Quarry	68	S	LN	5	pits	Conolly 2003; Hastie 2003c
Titwood	69	S	EN	5	pit	Johnson et al 2003; Hastie 2003a

Site	Site Number	Area	Period	Site Type	Site Description	References
Tofts Ness	70	A	LN	2	stone domestic structure and midden, cultivated soils	Bond 2007b; Dockrill et al 2007
Upper Forth Crossing	71	NE	LN	3	pits, postholes	Jones and Atkinson 2006; Timpany 2006b
Wardend of Durris	72	NE	EN	3	slot, postholes (possible timber structure)	Boardman 1995b, Unpublished b; Russell-White 1995
Warren Field	73	NE	EN	1	large rectangular timber structure	Hastie 2004a; Lancaster 2009b; Murray 2005; Murray et al 2009; Timpany 2006a, c
West Flank Road	74	S	ELNT	3	pits and postholes (remains of a structure)	MacGregor and Cullen 2003; Miller and Alldrit 2003
Wideford	75	A	LN	2/3	3 timber and 1 stone structure, midden deposits	Miller and Ramsay Forthcoming; Richards 2007

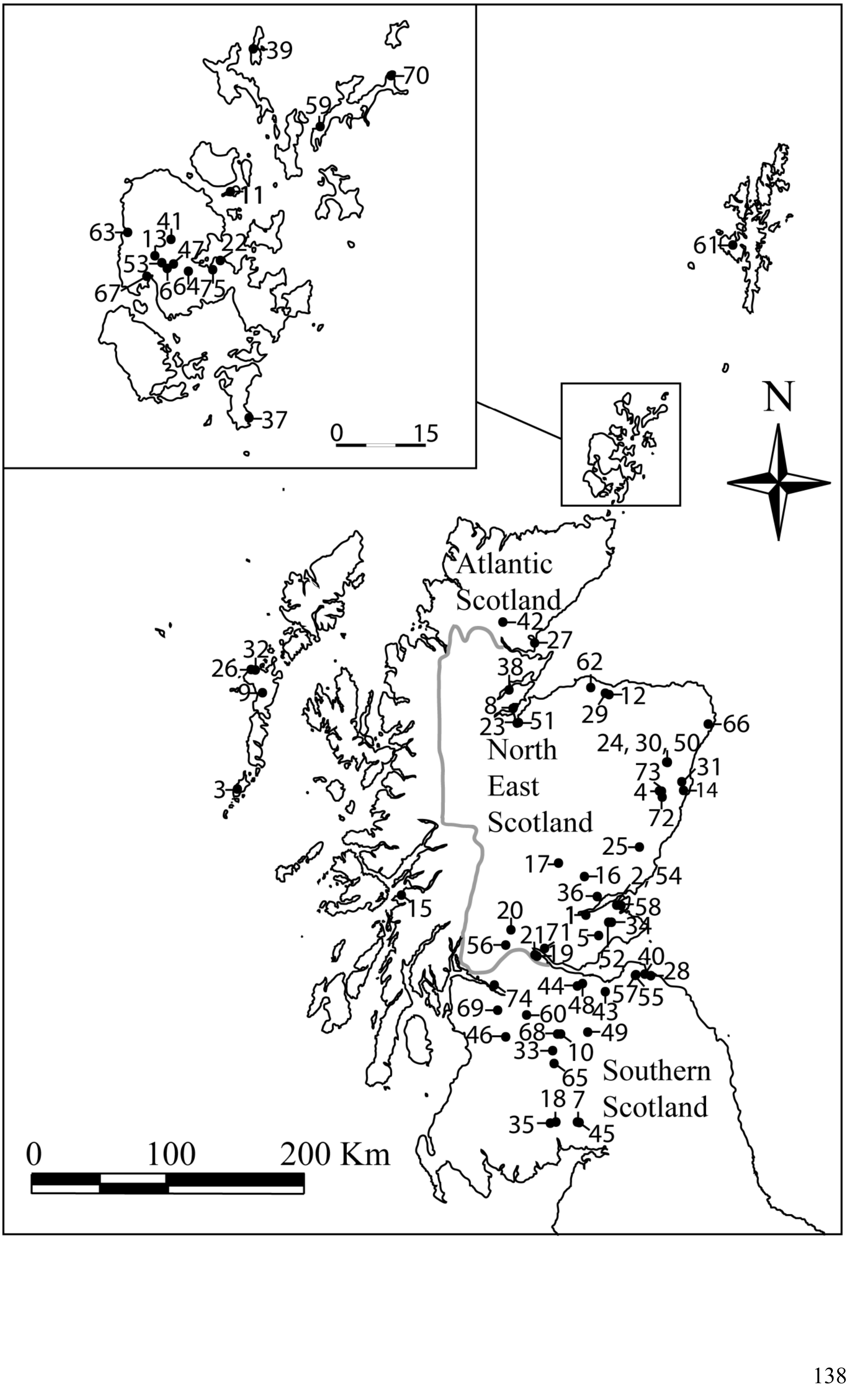
5.2.2 Geographical, chronological and site classifications

Before data analysis was undertaken, each context at each site included in the review was classified, following accepted chronological ranges for the Neolithic in Scotland (e.g. Barclay 2005:29; Bradley 2007:27; Brophy 2006:9; Noble 2006:15), into early Neolithic (c. 4000-3300 cal BC), late Neolithic (c. 3300-2500 cal BC) or early-late Neolithic transition (c. 3500-3000 cal BC). These chronological classifications are based on the site stratigraphy and radiocarbon dating evidence where possible and structural morphology and artefactual evidence where no radiocarbon dates are available. In some instances the chronological resolution was insufficient to allow this classification and so some sites were simply recorded as 'Neolithic' (c. 4000-2500 cal BC); the data from these sites were not included in the comparative statistical analyses based on temporal changes through time. While it is recognised that Neolithic Orkney has its own chronology, separate from mainland Scotland (Card 2005a:47), the Orkney sites were still divided into early/late Neolithic strictly by the radiocarbon dates (and not by structural or artefactual associations) to allow a temporal comparison with the rest of Scotland. However, in order to provide an indication of the chronological change between the Orkney early Neolithic (c. 3500-3000 cal BC) and Orkney late Neolithic (c. 3000-2000 cal BC), the Orkney sites were also classed into these categories in a further separate analysis (table 15). Since the chronological range of this study is 4000-2500 cal BC Orkney Neolithic sites dating to 2500-2000 cal BC, were not included in this analysis. The evidence from Orkney will be discussed in more detail in chapter 7.

The sites were further divided into the categories of Atlantic Scotland, North-East Scotland and Southern Scotland (figure 6). These regional categories were based on Piggott's (1966) division of Scotland, but with the Solway-Forth and Tyne-Forth regions combined into the single category of Southern Scotland. These categories were chosen because they broadly correspond to the differing topographic and climatic regions of Scotland (Armit and Ralston 2003:170).

Additionally, each site was classified into one of seven different categories to attempt to ascertain whether the type of site had an effect on the economy (see table 13): (1) large rectangular timber structures, e.g. Balbridie and Warren Field; (2) stone domestic structures and/or domestic midden material, e.g. Skara Brae and Stonehall; (3) small/ephemeral rectangular/oval/round timber structures and concentrations of pits, postholes, stake-holes and hearths found together, which were probably of a 'domestic' nature (Ashmore 1996:59; Barclay 2003b:81; Brophy 2006:22), e.g. Beckton Farm and Kinbeachie; (4) 'ritual' sites - such as cairns, timber/stone circles and enclosures,

Figure 6: Map of Scotland showing regions and site locations. Numbers correspond to those shown in table 13.



e.g. Isbister and Carsie Mains timber circle; (5) isolated pits/postholes and groups of pits not associated with structures and of no clear function, e.g. Dubton Farm and Abernethy Primary School; (6) cultivation evidence: Achnasavil and Lairg; (7) and the two remaining sites, which do not fit into any of these categories: Carding Mill Bay (a shell midden) and Parks of Garden (a working platform). Sites with contemporary samples derived from very different context types/functions, were separated to allow a more reliable analysis of the relationship between function and plant species to be established.

5.2.3 Data analysis

The abundance of each plant taxon present within each assemblage was recorded numerically where possible and on a scale of ‘present’ (‘P’), absent (blank), or ‘abundant’ (‘**A**’) when plant components were not numerated in the archaeobotanical reports. To summarise the archaeobotanical species identifications made at each site, the cereal species were grouped as indet. cereal (cerealia indet. and *Triticum*/*Hordeum* sp.), oat (*Avena* sp.), indet. barley (*Hordeum* sp.), hulled barley (*Hordeum* hulled symmetric and asymmetric), naked barley (*Hordeum* naked symmetric and asymmetric), indet. wheat (*Triticum* sp. and *Triticum dicoccum* Schübl./*spelta* L.), Emmer Wheat (*Triticum dicoccum* Schübl.), Bread wheat (*Triticum aestivum* L. and *Triticum aestivo-compactum* Schiem.), Spelt Wheat (*Triticum spelta* L.), Rye (*Secale cereale* L.), Flax (*Linum usitatissimum* L.), hazelnut (*Corylus avellana* L.) and Crab Apple (*Malus sylvestris* L. Miller). Totals for cereal chaff pieces, wild edible seeds and seeds of other wild plants were also complied. Except where otherwise stated, in this thesis, the term “chaff” is used to refer to all non-grain components (including glumes, rachis, culm nodes and culm bases) from domestic and wild grasses. In this chapter, culm bases and nodes were not included in the cereal chaff totals because of the difficulty of distinguishing wild grass from cereal culm nodes and bases and because these taxa were rarely distinguished in the archaeobotanical reports. A full list of each plant species and component is given in table 14. Plant species classed as ‘cf.’ were added to the definite species identifications e.g. grain identified as *Triticum* cf. *dicoccum* Schübl. was classed as Emmer Wheat in the table 15. Quantification in table 15 was based on the numerical counts of plant components presented in the archaeobotanical reports, rather than the mass of specific plant identifications.

Multivariate statistical techniques have been widely employed in archaeobotanical research in the past few decades to explore the variation in composition between different archaeobotanical samples and assemblages (e.g. Bogaard 2004; Jones 1984, 1987, 1991a; van der Veen 1992). For instance, exploratory pattern searching techniques, such as

Table 14: Common and scientific names of plant components included in each plant group in table 15.

Plant group	Common name	Latin name	Plant Part	Wild/domestic?
Cereal indet.	Indeterminate cereal	Cerealia indet.	Grain	Domestic
Cereal indet.	Indeterminate cereal	*Triticum*/*Hordeum* sp.	Grain	Domestic
Oat	Oat	*Avena* sp.	Grain	Domestic
Oat	Oat?	cf. Avena sp.	Grain	Domestic
Barley	Barley	*Hordeum* sp.	Grain	Domestic
Barley	Barley?	cf. *Hordeum* sp.	Grain	Domestic
Barley	Twisted barley	*Hordeum* sp. asymmetric	Grain	Domestic
Barley	Straight barley	*Hordeum* sp. symmetric	Grain	Domestic
Hulled barley	Twisted hulled barley	*Hordeum* hulled asymmetric	Grain	Domestic
Hulled barley	Straight hulled barley	*Hordeum* hulled symmetric	Grain	Domestic
Hulled barley	Twisted hulled barley?	*Hordeum* cf. hulled asymmetric	Grain	Domestic
Hulled barley	Straight hulled barley?	*Hordeum* cf. hulled symmetric	Grain	Domestic
Hulled barley	Hulled barley	*Hordeum* hulled	Grain	Domestic
Hulled barley	Hulled barley?	*Hordeum* cf. hulled	Grain	Domestic
Naked barley	Naked barley	*Hordeum* naked	Grain	Domestic
Naked barley	Twisted naked barley	*Hordeum* naked asymmetric	Grain	Domestic
Naked barley	Straight naked barley	*Hordeum* naked symmetric	Grain	Domestic
Naked barley	Naked barley?	*Hordeum* cf. naked	Grain	Domestic
Naked barley	Straight naked barley?	cf. *Hordeum* naked symmetric	Grain	Domestic
Wheat	Wheat	*Triticum* sp.	Grain	Domestic
Wheat	Emmer/Spelt wheat	*Triticum dicoccum* Schübl./*spelta* L.	Grain	Domestic
Wheat	wheat?	cf. *Triticum* sp.	Grain	Domestic
Emmer Wheat	Emmer Wheat	*Triticum dicoccum* Schübl.	Grain	Domestic
Emmer Wheat	Emmer Wheat?	*Triticum* cf. *dicoccum* Schübl.	Grain	Domestic
Bread Wheat	Bread Wheat	*Triticum aestivum* L.	Grain	Domestic
Bread Wheat	Bread Wheat	*Triticum aestivo-compactum* Schiem.	Grain	Domestic
Bread Wheat	Bread Wheat?	*Triticum* cf. *aestivum* L.	Grain	Domestic
Spelt Wheat	Spelt Wheat	*Triticum spelta* L.	Grain	Domestic
Rye	Rye	*Secale cereale* L.	Grain	Domestic
Flax	Flax	*Linum usitatissimum* L.	Seeds	Domestic
Flax	Flax?	cf. *Linum usitatissimum* L.	Seeds	Domestic
Hazelnut shell	Hazelnut	*Corylus avellana* L.	Nutshell, whole nuts	Wild
Crab Apple	Crab Apple	*Malus sylvestris* (L.) Mill	Pips and pericarp	Wild

Plant group	Common name	Latin name	Plant Part	Wild/domestic?
Other wild fruits and nuts	Bearberry	*Arctostaphylos uva-ursi* (L.) Spreng.	Seeds	Wild
Other wild fruits and nuts	Billberry/Blaeberry	*Vaccinium myrtillus* L.	Seeds	Wild
Other wild fruits and nuts	Blackberry	*Rubus fruticosus* L. agg.	Seeds	Wild
Other wild fruits and nuts	Blackberry/Raspberry	*Rubus* cf. *fruticosus* L. agg./*idaeus* L.	Seeds	Wild
Other wild fruits and nuts	Cowberry	*Vaccinium vitis-idaea* L.	Seeds	Wild
Other wild fruits and nuts	Cranberry	*Vaccinium oxycoccos* L.	Seeds	Wild
Other wild fruits and nuts	Crowberry	*Empetrum nigrum* L.	Seeds	Wild
Other wild fruits and nuts	Hawthorn	*Crataegus monogyna* Jacq./ *Crataegus* sp.	Fruit stones	Wild
Other wild fruits and nuts	Strawberry	*Fragaria vesca* L.	Seeds	Wild
Other wild fruits and nuts	Sloe	*Prunus spinosa* L./*Prunus* sp.	Fruit stones	Wild
Cereal chaff	Wild Oat	*Avena fatua* L.	Floret base	Not included
Cereal chaff	Small/Black/Bristle oat	*Avena strigosa* Schreb.	Floret base	Not included
Cereal chaff	6-row barley	*Hordeum vulgare* L. emend. Lam.; *Hordeum* sp. 6-row	Rachis, internodes	Not included
Cereal chaff	Barley	*Hordeum* sp.	Awn fragments, rachis internodes, rachis fragments, floret base	Not included
Cereal chaff	4-row barley	*Hordeum* cf. naked – 4-row	Rachis	Not included
Cereal chaff	Naked barley?	*Hordeum* cf. naked	Rachis	Not included
Cereal chaff	Wheat	*Triticum* sp.	Glume base, spikelet fork, rachis internodes, chaff	Not included
Cereal chaff	Bread Wheat	*Triticum aestivum* L.	Glume fragment	Not included
Cereal chaff	Emmer Wheat	*Triticum dicoccum* Schübl.	Glume base, spikelet fork, rachis, spikelet/glume base, chaff	Not included

Plant group	Common name	Latin name	Plant Part	Wild/domestic?
Cereal chaff	Emmer Wheat?	cf. *Triticum dicoccum* Schübl.	Glume base, spikelet fork	Not included
Cereal chaff	Spelt/Emmer Wheat	*Triticum spelta* L./*dicoccum* Schübl.	Spiklet/glume base, chaff	Not included
Cereal chaff	Spelt/Emmer Wheat?	cf. *Triticum spelta* L. /*dicoccum* Schübl.	Spiklet/glume base	Not included
Cereal chaff	Einkorn/Emmer Wheat	*Triticum monococcum* L./*dicoccum* Schübl.	Spikelet fork	Not included
Cereal chaff	Cereal	Cereal indeterminate	Rachis segment	Not included
Cereal chaff	Cereal	Cereal indeterminate	Internodes	Not included
Other seeds	All other seeds not listed in 'other wild fruits and nuts' category	All other seeds not listed in 'other wild fruits and nuts' category	Seeds	Not included

coorrespondance analysis and principal components analysis, have been used to identify the potential variables responsible for the observed patterns in data sets (Jones 1991a). However, since many of the assemblages compiled in this review were quantified on a presence/absence basis or had a small number of archaeobotanical remains (< 50 identified cereals or wild and domestic remains), most of the sample and site assemblages were unsuited to multivariate analysis. Consequently, in this chapter, descriptive statistics were chosen as the main method of analysis, to provide a summary of the main features of the data set. However, future research could develop this approach further, using multivariate techniques to analyse the data from a more restricted number of sites or samples from this review. This could potentially help to further highlight differences between different site blocks, periods and regions.

The percentage of each assemblage made up of wild (fruits and nuts) and domestic plants (cereal grain and flax seeds), as well as the main cereal species (wheat, oat and barley) were calculated for each site, where possible. Cereal chaff was not included in these percentages due to the low frequency of chaff remains, the differences in quantification criteria evident from the archaeobotanical assemblages, and the differential preservation of grain and chaff (Boardman and Jones 1990). These percentages were used to establish the mean percentages of wild and domestic species and the main cereal species present in each site type, chronological and geographical category. The use of percentages provides a standardisation that removes the discrepancies between assemblages of different sample sizes, and allows a direct comparison between different sites (Jones 1991a:69; van der Veen 1992). Sites with less than ten cereal grains were excluded from the calculations involving the proportions of different cereal species at different sites, as were sites with less than ten wild/domestic plant remains from the wild and domestic plant calculations, to prevent low frequencies of particular species being overestimated in the overall calculations. While it would have been preferable to only include sites with over 100 (rather than over ten) cereal grains/wild and domestic plant remains in these calculations, this would have restricted the number of sites available for consideration and the range of interpretations possible from the data. However, it is not considered that the inclusion of sites with small numbers of remains has significantly affected the general conclusions made because very few sites had less than 50 plant components in each of the geographical, chronological and functional categories (e.g. three Atlantic Scottish sites, two North-East Scottish sites and three Southern Scottish sites had less than 50 wild/domestic plants). Also the percentages calculated from these sites fit within the general spread of the data (see below). Sites with between one to ten cereal grains were included in the calculation of the proportions of wheat, oats and barley in the early to late Neolithic transition and late Neolithic categories in Southern Scotland due to the absence of any sites with greater than ten cereal grains in these categories. Again, while it would have been preferable to avoid this, the calculated percentages are considered to be reliable because of the absence of wheat and the extreme rarity of oat in either of these categories. Sites where the number of hazelnut fragments had not been quantified were not included in the calculations of the proportions of wild and domestic plants. Where minimum numbers of remains were recorded at certain sites, these were used as the actual number of components identified of a particular species. While this may have led to a slight underestimation of the importance of a particular species, it has probably not greatly affected the overall proportions of species at these sites.

5.3 Results

This section presents the results of the survey of 75 Scottish Neolithic sites with plant remains, split into 94 separate chronological and functional site blocks, to take into account multiple functions of features and periods at a single site. Of these 94 site blocks, 39 were early Neolithic, 39 late Neolithic, eight early-late Neolithic transition, and eight were classed as Neolithic. 30 site blocks were located in Atlantic Scotland, 42 in North-East Scotland and 22 in Southern Scotland. There were five large rectangular timber structures, 18 stone domestic structures and/or domestic midden material, 24 small/ephemeral domestic sites, 17 ritual sites, 26 isolated or groups of pits/postholes, two cultivation sites, one shell midden and one working platform. However, due to the low frequency of remains in many assemblages a smaller number of sites was available for analysis – the numbers of sites included in the percentage calculations are shown in brackets after each chronological, geographical and site category in each figure.

The primary conclusion is that domestic species dominated the assemblages during all three chronological periods, although hazelnut shell was present at most sites (figure 7a; table 15). Flax was present on three sites. Fruit and berry seeds were present in just 25 of the site block assemblages (table 16). While domestic species made a far more significant contribution to the assemblages in Atlantic Scotland and North-East Scotland, Southern Scottish plant assemblages were mostly composed of wild plants throughout the Neolithic (figures 7b, 8b, 9). There appears to be an increase in the use of wild plants in the later Neolithic in North-East and Southern Scotland, and an increase in the use of domestic plants in Atlantic Scotland (figure 8b). Domestic plants remained dominant in both the Orkney early and late Neolithic.

Overall the stone and timber structures contained a higher proportion of domestic species than the other site types (figure 7c). The shell midden had the greatest proportion of wild species, while the ritual sites, ephemeral structures and pit sites had a roughly equal quantity of wild and domestic plants. Although it appears that the samples from the rectangular timber structures contained a similar percentage of domestic species to the pit sites, this is not a true reflection of the compositions of the assemblages from the timber structures. Since the exact numbers of hazelnut shell fragments from Balbridie and Lockerbie have not been published, these sites could not be included in the calculations. However, it is known that Balbridie contained a substantial carbonised cereal assemblage (Fairweather and Ralston 1993:316) and consequently the proportion of domestic species at these sites should have been more similar to the frequencies at the stone structures. Claish Farm was the only rectangular timber structure at which there were more hazelnut shell fragments than cereal grains.

In Scotland, there are four main patterns in the proportions of cereal species in the assemblages (table 15; figures 8a, 10 and 11). Firstly, considering the arable economy in Neolithic Scotland as a whole, barley was the main cereal crop, though some individual assemblages contained more wheat than barley. Of the 55 site blocks that included barley identifiable to variety, 42 contained more naked than hulled barley grain. Emmer Wheat was the main wheat crop, though Bread Wheat was significant at a few sites. Oat, Spelt Wheat, Rye and cereal chaff were rare at all sites in all periods. Naked barley was thus the dominant cereal crop cultivated in Neolithic Scotland, with Emmer Wheat also important at some sites.

Secondly, there is a significant increase in the use of barley and a decrease in the use of wheat between the early and later Neolithic periods in Southern and North-East Scotland (figure 8a, 10a and 11). All 11 sites (Balbridie, Biggar Common 2, Claish Farm, Cowie Road, Deer's Den, Dubton Farm, Holywood, Inchture, Larkhall Academy, Lockerbie Academy and Warren Field) with more wheat than barley were dated to the early Neolithic period and are located in Southern and North East Scotland (figure 12).

Thirdly, barley was far more prevalent at the Atlantic Scottish sites than at the North-East and Southern Scottish sites (figures 8a, 10b and 11). All of the assemblages from the Atlantic Scottish sites contained more barley than wheat. There was no change in the proportions of cereals between the Orkney early Neolithic and the Orkney late Neolithic assemblages, which contained over 94% barley grain in both periods.

Finally, only the assemblages from the early Neolithic rectangular structures contained considerably more wheat than barley (figure 10c). The only other site types with significant concentrations of wheat were early Neolithic pit sites and early-late Neolithic ephemeral structures (table 15).

Despite these general trends in the data set, it is clear that the calculation of mean proportions of plant remains in each of the chronological, geographical and site type categories masks some of the variability in the data set (table 15; figures 9 and 11). In fact, a diversity of subsistence practices existed in North East and Southern Scotland; some sites had plant economies based mainly on the collection of wild plants or cereal cultivation, and at other sites these practices seem to have been equally important. Also, though a clear chronological divide exists between the early and late Neolithic arable economy, there was considerable variability in the importance of wheat and barley in the assemblages in Southern and North East Scotland. In contrast, only 2 of the 21 sites in Atlantic Scotland had plant economies based mainly on wild plants and the proportions of cereals in the Atlantic Scottish assemblages were extremely uniform, with barley dominant in all assemblages.

5.3.1 Reliability of data analysis

The interpretation of mean percentages based on small numbers of sites must be undertaken with caution. The apparent decline in the use of domestic plants in North East Scotland and the increase in domestic plants in Atlantic Scotland in the late Neolithic (figure 8b) are probably a function of the low number of assemblages in the early Neolithic of Atlantic Scotland and the late Neolithic of North East Scotland. Taking together the variability in the proportions of wild and domestic plants in the early Neolithic of North East Scotland (figure 9b) and the fact that one of the two sites in the late Neolithic of North East Scotland contains 100% domestic plants and the other contains 100% wild plants (table 15), there is no clear evidence for any change between the early and late Neolithic in this area. Likewise, the presence of only one site with greater than 20% wild plants in the early Neolithic of Atlantic Scotland (figure 9a) suggests that in this area there was no real change between the early and late Neolithic. In contrast, the near absence of domestic plants in the later Neolithic in Southern Scotland (figure 9c) shows that the apparent decline in domestic plants in Southern Scotland in the later Neolithic (figure 8b) is a real trend, and not a result of the small number of sites available for analysis.

Despite the fact that there are only three assemblages in the early Neolithic of Atlantic Scotland, two in the late Neolithic of North East Scotland, five in the early Neolithic of Southern Scotland and four in the late Neolithic of Southern Scotland, all of the above trends in arable economy can be considered to be reliable. This is because wheat is almost completely absent from the early Neolithic Atlantic Scottish assemblages and the late Neolithic North East and Southern Scottish assemblages (figures 8a, 11). Consequently, the greater importance of barley in Atlantic Scotland than elsewhere and the apparent decline in wheat between the early and late Neolithic are not the result of the calculation of mean percentages using small numbers of assemblages.

Equally, the results of mean percentages based on sites with small numbers of remains must also be considered critically. With the absence of any sites with greater than ten cereal grains in the late Neolithic and early-late Neolithic transition in Southern Scotland, six sites with less than ten cereal grains were analysed, and a number of sites with fewer than 100 plant remains were included in the rest of the analysis (figures 9 and 11). However, it is not thought that the inclusion of these sites in the mean calculations has significantly affected the calculated averages because the results from these sites fit within the general spread of the data, and in the case of the late Neolithic and early-late Neolithic transition sites in Southern Scotland, wheat was absent and oat extremely rare and so the calculated mean proportions (figure 8a) can be considered to be reliable (figures 9 and 11).

Table 15: Summary of the plant remains present at Scottish Neolithic sites; each site is split into chronological and site type blocks (see section 5.2.2). The dominant cereal group is highlighted in bold for each site. For a description of the site type classifications see section 5.2.2. P: present; A: abundant; NE: North East Scotland; S: Southern Scotland; A: Atlantic Scotland; OEN: Orkney early Neolithic; OLN: Orkney late Neolithic.

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Early Neolithic																				
Achnasavil	NE	6	3		**1**									1				3	4	16
Allt Chrisal	A	2	12		17		**56**								12		6	116	85	33
Balbridie	NE	1		2		c.98	3550		**15950**	c.400			P	>48	P	>12	P	P	20000	
Balfarg	NE	5				**15**												2	15	
Biggar Common 1	S	4	1		**1**										>714			P	2	
Biggar Common 2	S	3			1			4	**17**	4					P			P	26	
Boghead	NE	3	68				**305**		38						14			119	411	1000
Carding Mill Bay	A	7													737		1	19		217
Carzield	S	5	2				**3**		1						128				6	
Castle Menzies	NE	5													P				0	
Chapelfield	NE	3													65		2	57	0	
Claish Farm	NE	1	60		11	1		7	**19**	2					>855	7		29	100	
Cowie Road	NE	4							1	**2**								8	3	2130
Culduthel	NE	5					**A**								P			P	P	
Deer's Den	NE	5			1				**2**				1		P			1	3	10
Dubton Farm	NE	5	142	8	61	20	82	69	**191**	13			524		381	>252	2	4688	586	>155
Eweford	S	4	31		36	12	**47**		2						84			3	128	

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Fochabers to Mosstodloch Bypass	NE	3	P				P	P							P				P	
Forest Road 1	NE	4		4	**168**	47	64											5	283	
Forest Road 2	NE	3			**386**	11	232		158		10				52				797	
Forest Road 3	NE	5		>2	>4	P		**25**	>4				P		P				35	
Garthdee	NE	3	43				**60**		2	13					82		1	2	118	
Holywood	S	4	1					**5**							19			5	6	
Inchture	NE	5	159		99	2	74	450	**810**				126					163	1594	
Lairg buried soil	A	6		1	P														P	
Larkhall Academy	S	3	P	P	1				**A**	**A**					P			P	P	
Lockerbie	S	1	125	4	20		5	44	**50**	1			3	43	P			2	249	411.5
Loudoun Hill	S	5	1		**2**										P			8	3	
Maybury Park	S	3													P				0	
Pencraig Hill	S	4	4		**4**		1	3							7		1		12	
Pitlethie Road	NE	5			**c.100**			**c.100**	P		P							1	P	
Pool (OEN)	A	2	86		**25**	2	**25**								5			166	138	55
Ratho Quarry	S	5	33	2	**12**	5	1			1								2	54	80
Silvercrest	NE	5			**1**										P			P	1	
Titwood	S	5													P				0	0.1

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Upper Forth Crossing	NE	3					**A**		P						P				P	
Wardend of Durris	NE	3	2	5	**9**	2	1								69			6	19	34.8
Warren Field	NE	1	211	1	2		119		8	**237**					112			6	578	
Wideford 1 (OEN)	A	3	3226		**1778**		1590	15										6	6609	
Early-Late Neolithic Transition																				
Abernethy Primary School	NE	5		P			P												P	
Cairnwell	NE	5	9		**329**		32		2						2		1	2	372	98
Hill of Tarvit	NE	5													P				0	
Kinbeachie	NE	3	217		**168**	3	41	11	11						>22		1	10	451	169
Knowes Farm	S	5													161				0	
Scord of Brouster house 2	A	2	208		**371**	**A**	P	2					1					350	581	165
Stoneyburn Farm	S	4			1		1								1				2	
West Flank Road	S	3			**5**										P			P	5	

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Late Neolithic																				
Allt Chrisal	A	2	6		20	2	**26**						2				8	196	54	
Balfarg	NE	4	P	P	P										P	1	2	1	P	
Barnhouse (OLN)	A	2	21	1			**227**						2		30	4	17	5002	249	864.9
Beckton Farm	S	3					**c.6**								>220			1	6	
Bellfield Farm	NE	3	P				**A**								P			P	P	
Bharpa Carinish	A	3	8		7	2	**33**	10	11						733	8		20	71	92.5
Bookan (OLN)	A	4																	0	30.5
Braes of Ha'breck * (OEN)	A	2/3	P	P		P	**A**								P				P	
Carsie Mains rectangular structure	NE	1	7		27		**42**											62	76	
Carsie Mains timber circle	NE	4													2		5	10	0	
Chapelfield	NE	3													11			16	0	
Cowie Road	NE	4	1		**3**														4	30
Crossiecrown midden (OLN)	A	2																2	0	
Culduthel	NE	5													P			P	0	
Eweford	S	5			**2**										16				2	
Hillend	S	5													264.5		1	P	0	c. 32kg
Isbister (OEN)	A	4	6		24		**32**		1								8	232	63	200kg

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Knowes of Trotty (OEN)	A	2	2		**21**		6										2	108	29	1173.8
Lairg	A	5			1158		**1980**		408				275					12	3546	15
Maeshowe (OLN)	A	4																39	0	
Midmill	NE	3					**A**								40.6g				P	
Milton of Leys	NE	3		P			P								P				P	
Mountcastle Quarry	NE	5													1				0	
Ness of Brodgar (OLN) **	A	2	57	11	**33**	3	12										5	59	116	
North Straiton	NE	5													3			3	0	
Overhailes	S	3	4	1	2										160				7	
Parks of Garden	NE	7													P				0	
Pool (OLN)	A	2	306		83	**141**	99	9	5				10		1		67	2821	643	325
Scord of Brouster house 1	A	2	20		85	**A**	P						9					440	105	123.11 and 12.2kg
Skara Brae (phase 1) (OLN)	A	2	16			4	**307**		28				2						355	
Skara Brae (phase 2) (OLN)***	A	2															877	29961		>14240

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Stonehall (OEN & OLN)	A	2	124		**120**	1	43										9	361	288	
Stoneyhill Farm	NE	5	1		1		**823**								0.8g				825	19
The Howe (OLN)	A	4																P	0	
Tinto Sands and Gravel Quarry	S	5	1		**1**										P				2	
Tofts Ness (OLN)	A	2	302		257	**364**	137						18				1	927	1060	271
Upper Forth Crossing	NE	3	P				**A**		P	P		P			P				P	
Wideford 1 (OEN)	A	3	146		**157**		91											2	394	
Wideford 2 (OEN)	A	2	15		**15**		7												37	
Neolithic																				
Eilean Domhnuill	A	2	159		**1372**	225	12			6			178		>123		2	290	1774	>67.5
Embo	A	4															2		0	
Forest Road 3	NE	5		3	**602**	113	11	3	23	3			6					4	758	
Forest Road 2	NE	3			**31**	**31**													62	
Geirisclett	A	4													4			13	0	22.5

Site	Area	Site type	Cereal indet.	Oat	Barley	Hulled barley	Naked barley	Wheat	Emmer Wheat	Bread Wheat	Spelt Wheat	Rye	Cereal rachis	Flax	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Cereal grain total	Total volume of samples (l)
Knap of Howar (OEN)	A	2	22				**10**								1				32	
Lamb's Nursery	S	3			**A**	P			P	P					P			P	P	
Meldon Bridge	S	4													P				0	
Total			5868	45	7635	1104	10193	757	17742	682	10	P	1157	92	5091.5	284	1021	46361	43834	21849
Total Identified Remains																				141877

* NB not included in data analysis in this chapter, see chapter 7 for more detailed results and analysis.

**NB: based on 2004-6 samples only: excavation and analysis of samples is on-going.

***NB: not included in data analysis because the sample composition suggests that the whole assemblage from phase 2 is derived from turf/peat burning (Rowley-Conwy forthcoming).

Table 16: Fruits and nuts present on Scottish Neolithic sites. Each site is split into chronological and site type blocks. P: present.

	Bearberry seed	Billberry/Blaeberry seed	Blackberry seed	Blackberry/Raspberry seed	Cowberry seed	Crab Apple fruit	Crab Apple pip	Cranberry seed	Crowberry seed	Hawthorn seed	Sloe stone	Strawberry seed	Whole hazelnuts	Total volume of samples (l)
Early Neolithic														
Allt Chrisal		2			4									33
Balbridie						>6	>6	P						
Biggar Common 2													1	
Carding Mill Bay				1										217
Chapelfield											1			
Claish Farm						6	1							
Dubton Farm	1				1	>127	125						68	>155
Garthdee			1											
Pencraig Hill										1				
Early-Late Neolithic Transition														
Cairnwell				1										98
Kinbeachie											1			169
Late Neolithic														
Allt Chrisal												8		
Balfarg			1				1				P			
Barnhouse							4		17					864.9
Bharpa Carinish							8						3	92.5
Carsie Mains timber circle			5											
Hillend											1		26	c. 32kg
Isbister									8					200kg
Knowes of Trotty									2					1173.75
Ness of Brodgar **									5					
Pool									67					325
Skara Brae (phase 2)									243			634		>14240
Stonehall									9					
Tofts Ness									1					271
Neolithic														
Eilean Domhnuill	2												1	>67.5
Embo		2												

Figure 7: Mean proportion of wild and domestic plants in each (a) period, (b) region and (c) site category. The number of sites is indicated in brackets after the class on the x-axis.

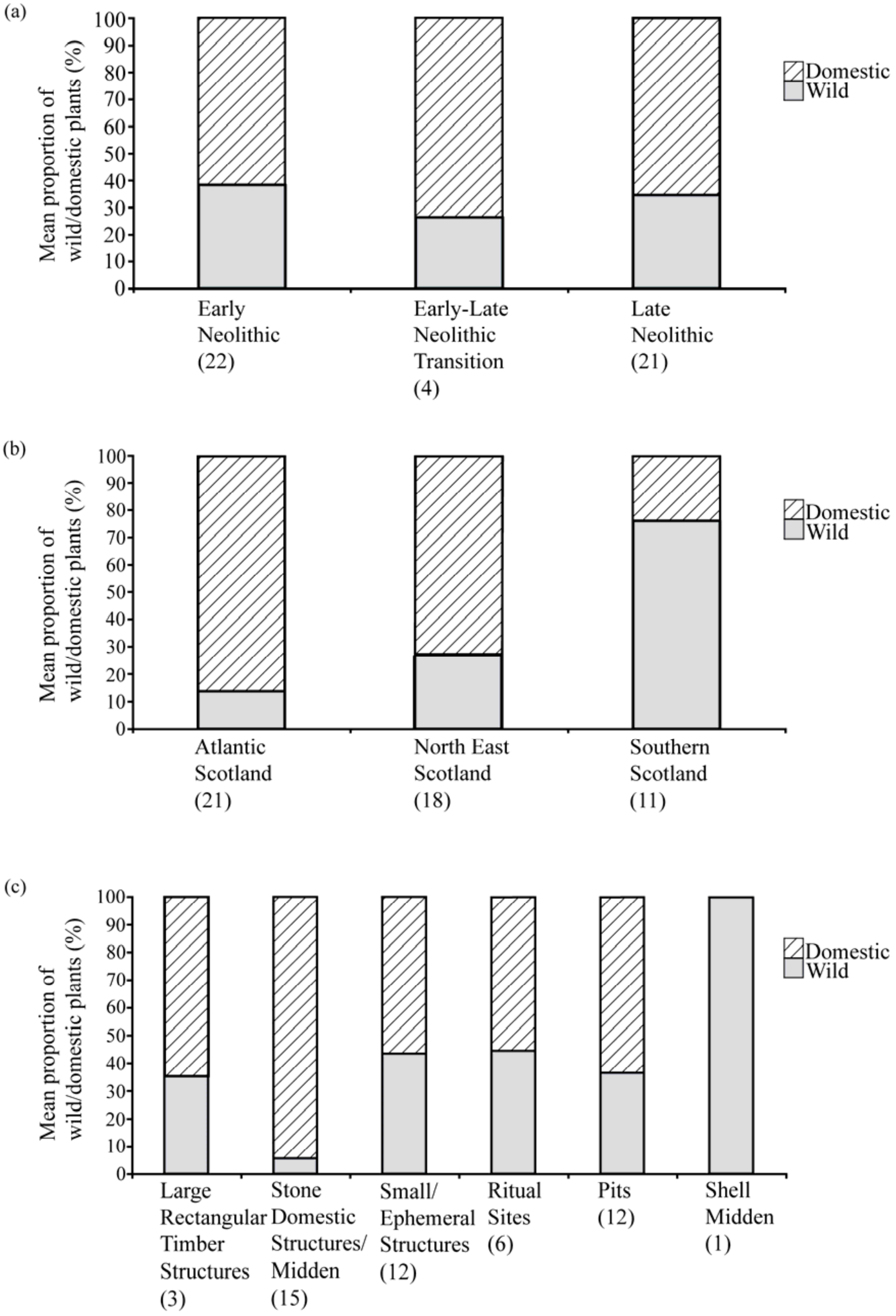
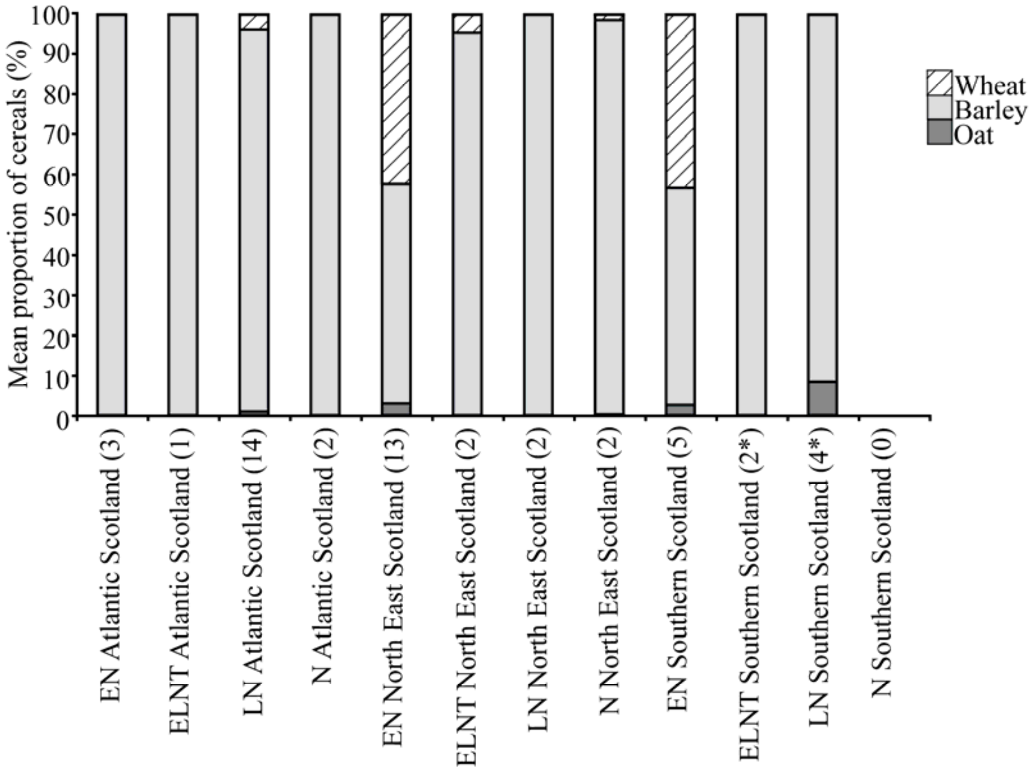


Figure 8: Mean proportion of (a) cereals and (b) wild and domestic plants, divided into each period and region. The number of sites is indicated in brackets after the class on the x-axis. * indicates class incorporating sites with fewer than 10 identified plant remains.

(a)



(b)

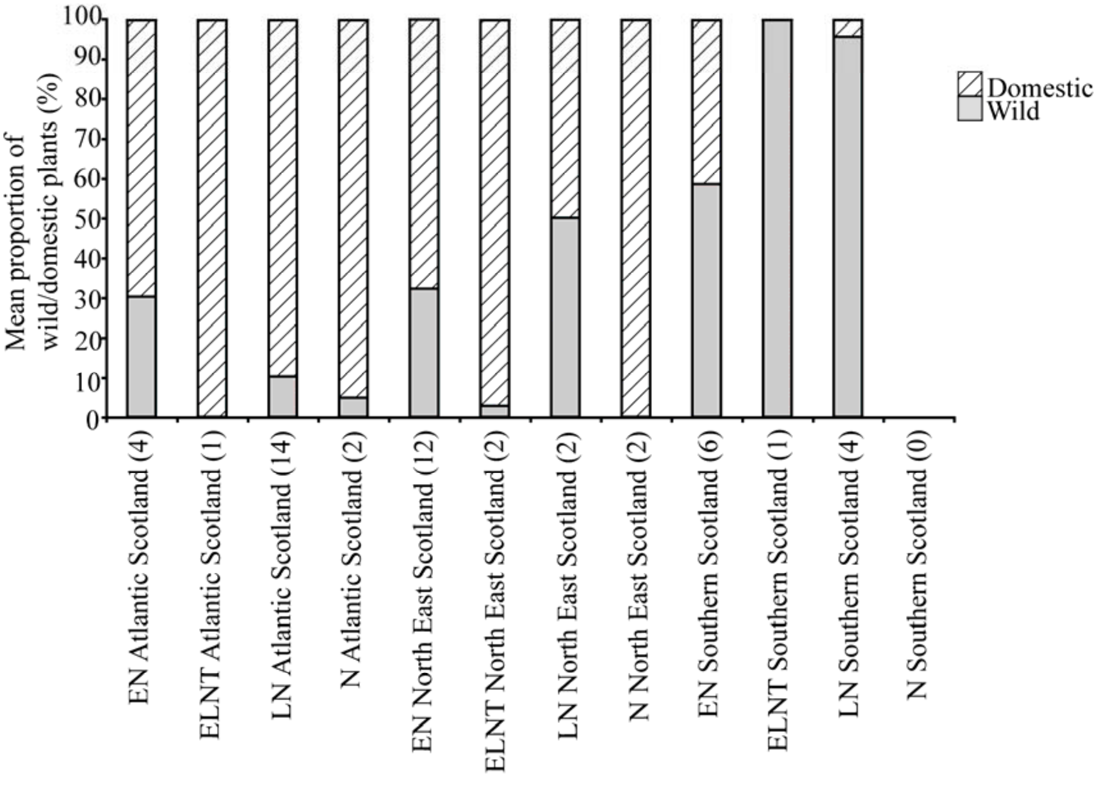


Figure 9: Proportion of wild and domestic plants in (a) Atlantic Scotland, (b) North East Scotland and (c) Southern Scotland assemblages, with the number of plant remains in each assemblage (10-49, 50-99 and 100+) indicated. Grey symbols denote EN sites and black symbols denote ELNT, N and LN sites. The number of sites in each of the assemblage size groupings (10-49, 50-99 and 100+) is indicated in brackets in the legend.

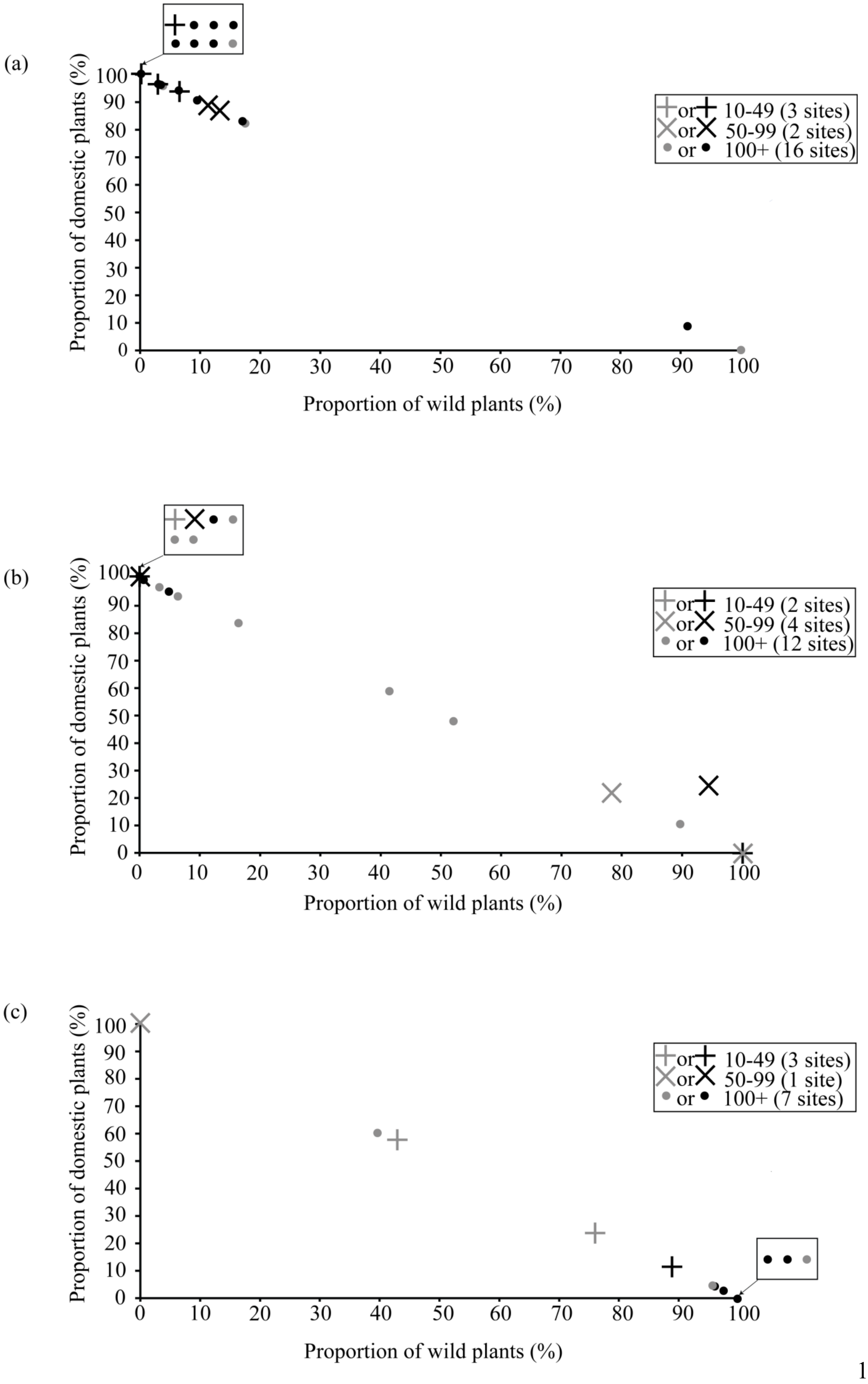


Figure 10: Mean proportion of cereals in each (a) period, (b) region and (c) site category. The number of sites is indicated in brackets after the class on the x-axis.

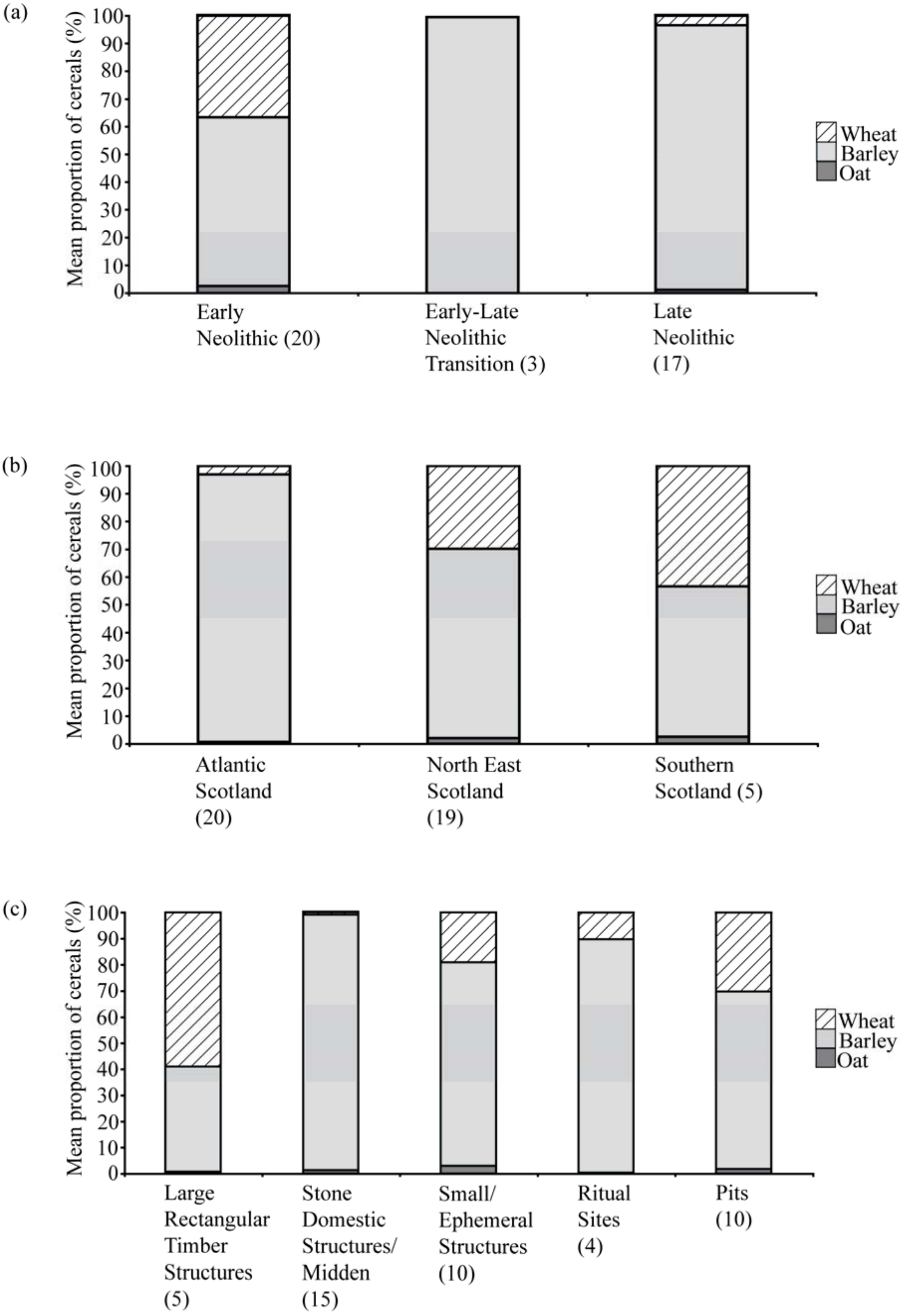


Figure 11: Proportion of wheat and barley in (a) Atlantic Scotland, (b) North East Scotland and (c) Southern Scotland assemblages, with the number of plant remains in each assemblage (<10, 10-49, 50-99 and 100+) indicated. Grey symbols denote EN sites and black symbols denote ELNT, N and LN sites. The number of sites in each of the assemblage size groupings (<10, 10-49, 50-99 and 100+) is indicated in brackets in the legend.

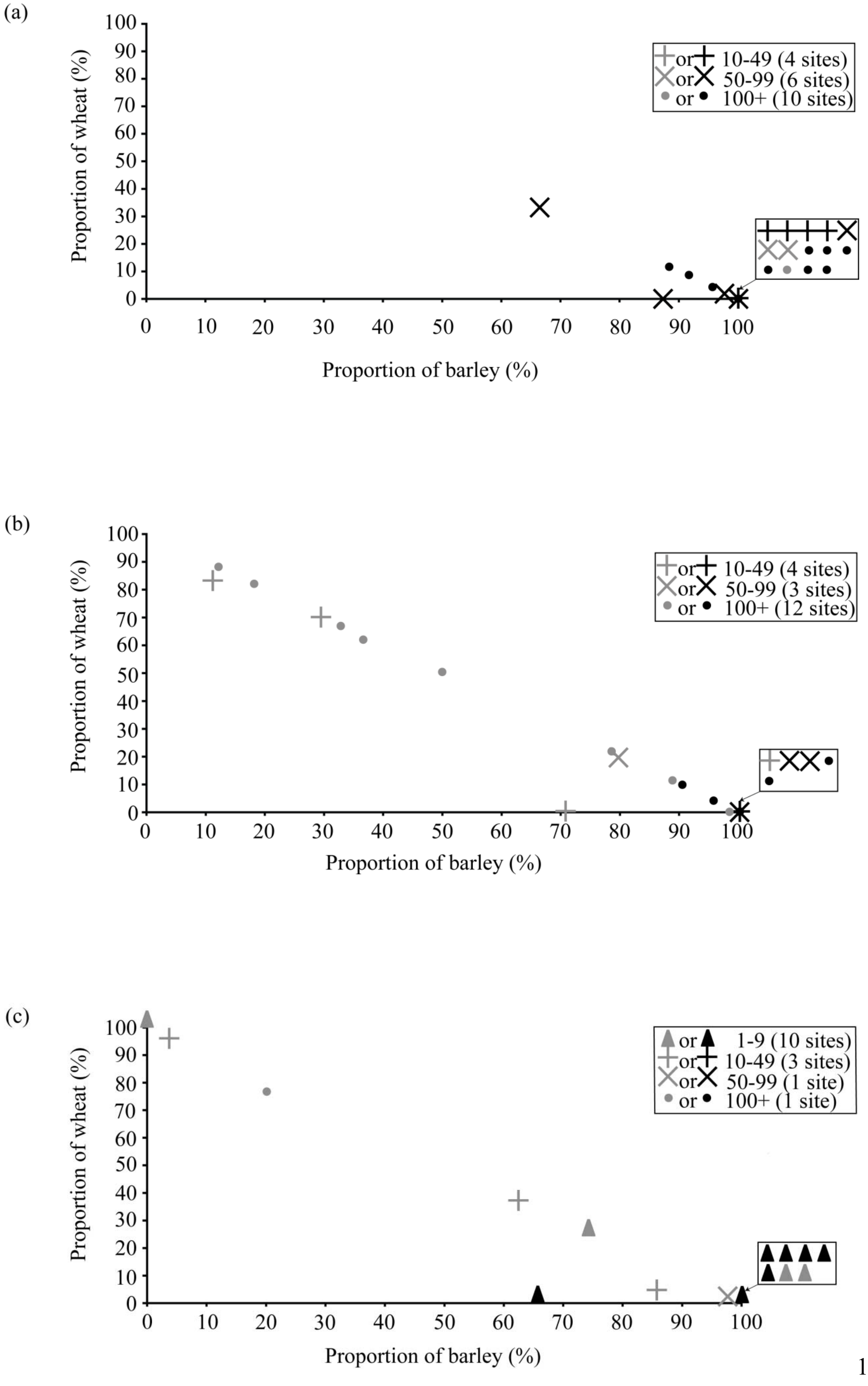
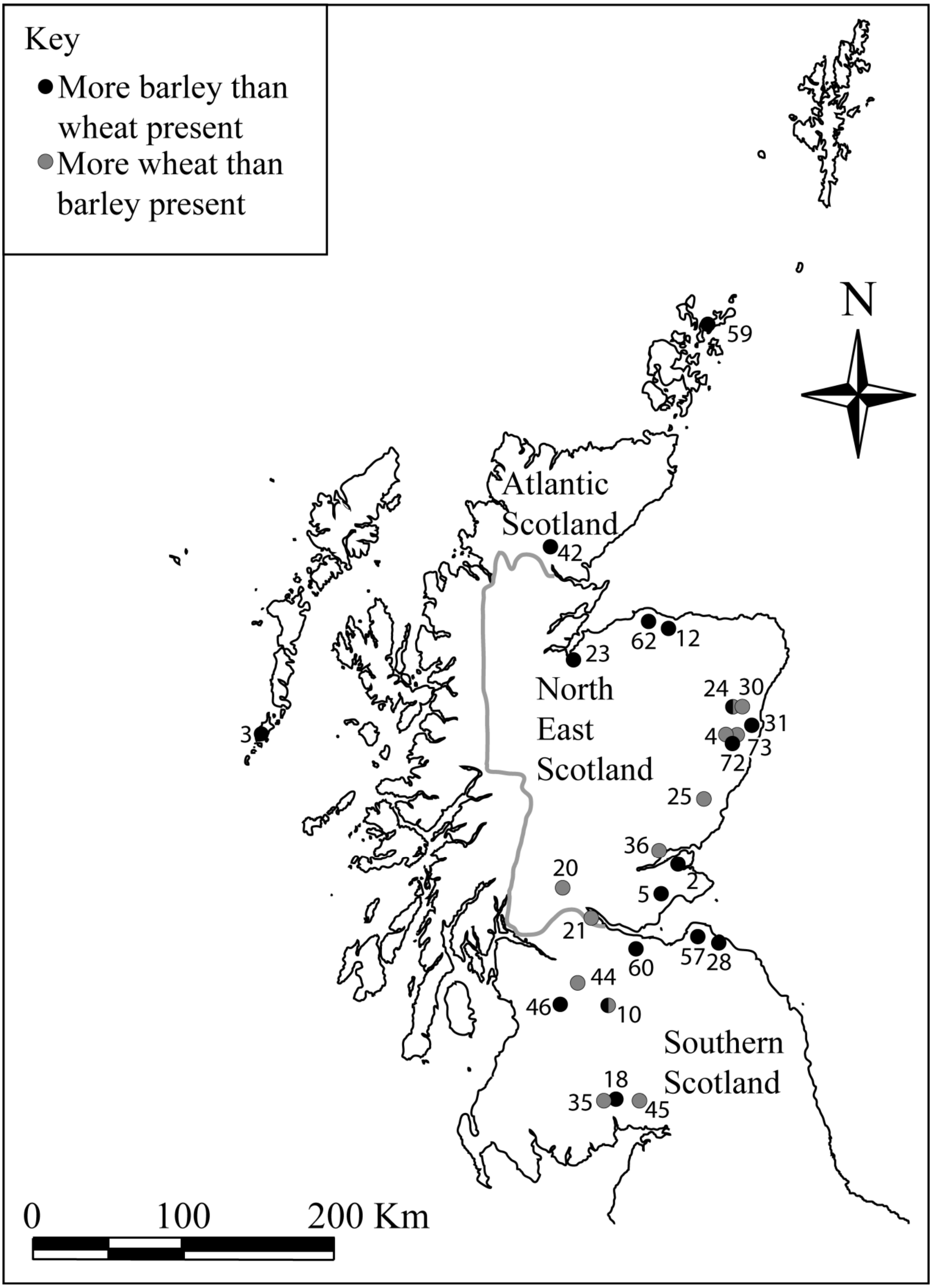


Figure 12: Map of Scotland showing early Neolithic site blocks (see table 15) showing the predominance of wheat or barley.



5.4 Taphonomy

5.4.1 Taphonomy and species abundance

Assessing the relative importance of wild and domestic plants in the Scottish Neolithic is extremely problematic because taphonomic processes will have significantly affected the apparent abundance of different species in archaeobotanical assemblages. The frequencies of hazelnut shell fragments, fruit remains, cereal grains and Flax seeds are not directly comparable, and this must be taken into account in the interpretation of this data.

Firstly, each species differs in its likelihood of exposure to fire and subsequent carbonisation. Hazelnut shell is the unwanted waste product of consumption, which would either be deliberately discarded – often onto domestic fires – or used as kindling (Jones 2000b:80; Jones and Rowley-Conwy 2007:400; Rowley-Conwy 2004:90). On the other hand, cereal grains, which were intended for consumption, would only be charred accidentally and so even in societies dependent on cereals, charred grains are relatively rare (Jones 2000b:80; Jones and Rowley-Conwy 2007:400). Fruit seeds would normally be consumed with the fruits (Boardman 1992a:M100) and neither the seeds nor the fruit itself would come in close contact with fire unless the fruit was being dried for future consumption, in which case carbonisation would be accidental. Both Crab Apples and sloes are bitter before drying and so these species may have been dried before consumption (Dickson and Dickson 2000:247 and 281); Crab Apples may also have been dried for winter storage (Renfrew 1973:139). Most fruits, however, would probably have been consumed raw and may never have come into close contact with fire (Boardman 1995a:152). Also, Flax processing for linen production does not necessitate close contact with fire (Bond and Hunter 1987:176) and Flax seeds would only be burnt accidentally, for example if the stems were hung up to dry near a fire after the retting process (Dickson and Dickson 2000:254). However, the absence of linen production material culture at any of the three sites where Flax was recovered suggests that the seeds were used for the production of oil, so they may have become accidentally charred on domestic hearths during pressing (ibid). Therefore, hazelnut shell has the highest chance of becoming charred.

Secondly, the different plant species have vastly differing probabilities of preservation once exposed to fire. Hazelnut shell is dense, and so is likely to become charred, while the considerably lighter cereal grains, fruit and Flax seeds are likely to be burnt to ash (Hillman 1981a:189; Jones 2000b:81; Jones and Rowley-Conwy 2007:400;

Rowley-Conwy 2004:89; Wilson 1984). Hazelnut shell therefore has a greater chance of carbonisation. Having said this, experiments have also shown that only about 20-25 percent of hazelnut shell will become charred during roasting and survive, and so even hazelnut shell frequencies in archaeobotanical assemblages are severe underestimates of the quantities originally present (Score and Mithen 2000:512).

Thirdly, recovery and quantification biases distort the apparent abundance of wild and domestic plants in archaeobotanical assemblages. It is likely that sites where judgement sampling, rather than a total sampling strategy (Jones 1991b:57), was undertaken will have a greater chance of hazelnut shell recovery than cereal grains, because nutshell is far more visible during excavation (Jones and Rowley-Conwy 2007:400; Rowley-Conwy 2004:89). Also, hazelnut shell breaks easily into many fragments (Score and Mithen 2000:511) and so a single piece of hazelnut shell does not equate to a single hazelnut. Arguably therefore, Neolithic groups utilising hazelnuts even in relatively small quantities, would produce assemblages dominated by nutshells.

Therefore, cereal grains, fruit and Flax remains were probably underrepresented in the archaeobotanical record compared to hazelnut shell. Since hazelnut shell is the most significant wild plant species in the assemblages, it is arguable that taphonomic biases are responsible for its high frequency at some sites. Consequently, it is difficult to be sure whether assemblages with more wild than domestic plant remains necessarily indicate an economy based on wild plants. It is therefore highly significant that such a large number of sites should contain more domestic than wild species, and it seems probable that these sites accurately reflect a plant economy based on domestic rather than wild plants.

However, it should also be noted that a wide diversity of other wild plant species – such as leafy green vegetables and edible roots - were probably utilised. These would be virtually archaeologically invisible (Hillman 1981a:189; Zvelebil 1994:48). Considering that the leaves of wild plants would have been harvested before they set seed, it is very unlikely that seeds of these species would become carbonised and preserved (Boardman 1995a:152; Dickson and Dickson 2000:51). The seeds of edible green plants, such as Fat-hen and cabbage (*Brassica* sp.), have been recovered from many Scottish Neolithic sites, but many of these plants are also common weeds of cultivation and so they may represent crop processing waste rather than foodstuffs. Tubers and roots may also have represented a significant source of food, because they are high in carbohydrates and are available all year round (Hardy 2007). However, roots and tubers have rarely been recognised by archaeobotanists since they cannot be identified using conventional methods (Hather and Mason 2002:2; Mason et al 1994:55; Zvelebil 1994:48), though they have frequently been found in European assemblages analysed appropriately (Hather and Mason 2002:5; Mason et al 2002:195). Consequently, there is at present very limited evidence for edible tubers on Scottish Neolithic sites. Possible Pignut (*Conopodium majus* (Gouan) Loret) and False Oat-grass (*Arrhenatherum elatius* (L.) P. Beauv. Ex J. & C. Presl Var. *bulbosum* (Willd.) St-Amans) tubers have been recovered from Barnhouse (Hinton 2005:341) and some tuber remains have been recovered from Pool (Bond 2007a:198) and Skara Brae (Dickson and Dickson 2000:53-4; Rowley-Conwy forthcoming), though some of these may represent non-edible tubers accidentally gathered with turf collected as fuel (ibid). Perhaps the significance of tubers and leafy plants in Neolithic palaeoeconomies has been greatly underestimated.

Comparing the proportions of different cereal species between different types of sites is far less problematic. While there probably was a difference in the deposition, preservation, recovery and quantification of cereals from different sites, these factors probably did not affect wheat and barley cereal grains differently. It seems probable that the differing proportions of these species provides a reasonably reliable indication of the relative importance of these species in each of the site, chronological and geographical categories.

5.4.2 Taphonomy and inter-site comparison

Taphonomic processes will have affected each assemblage differently. For instance, different storage methods may account for the variations in the frequencies of cereal grains at different sites. The large concentration of grain recovered from Balbridie may relate to the indoor storage of grain within the structure (Rowley-Conwy 2000:51, 2004:90). In contrast, it is likely that grain was stored outside many of the more ephemeral structures due to lack of suitable storage-space in the roofs (Jones and Rowley-Conwy 2007:401; Rowley-Conwy 2000:47) and grain may have had a lower chance of carbonisation. Alternatively, perhaps little cereal storage took place on many sites, with cereals mostly being consumed in the autumn soon after processing (Stevens 2007:383). The short duration of occupation of many Neolithic sites may also account for the low frequency of cereals, compared to later prehistoric assemblages recovered from sites that may have been occupied for several generations (ibid:379). It does not necessarily follow, therefore, that people living in less substantial houses were not reliant on cereals.

Likewise, heterogeneous preservation conditions on the different sites may have been responsible for the variation in the proportions of wild and domestic species. Cereal grain preservation is affected by the context of deposition and preservation (Church

2002c:71; Renfrew 1973:10), the type of fuel utilised on the hearth (Church and Peters 2004:110), the ripeness of the grain on charring (Hubbard and al Azm 1990:105; Renfrew 1973:11), the length of time the remains were exposed to heat and the temperature of the fire (Boardman and Jones 1990). These factors probably differed from site to site. Since hazelnut shell is better preserved in fires than cereal grains, it is probable that cereal grains are under-represented relative to hazelnut shell in the more poorly preserved samples.

In addition, there is no standardised hazelnut shell quantification methodology (see appendix 2). While some sites may have quantified all of the hazelnut shell regardless of how small the fragments were, on other sites only the larger fragments may have been counted. Generally this information was not detailed in archaeobotanical reports, and so the extent to which different quantification methods have been employed is unknown. Equally, on many sites hazelnut shell fragment frequencies were not quantified at all, and simply recorded as a level of abundance or estimated rather than counted (table 15). Consequently, assessing the relative abundance of hazelnut shell between different sites is very difficult.

5.4.3 Taphonomy and site function

The function of the Neolithic timber 'halls' in Scotland (Balbridie, Claish, Warren Field, Lockerbie, Carsie Mains) has been much disputed. Some favour the view that they were permanent houses (Jones and Rowley-Conwy 2007:404; Rowley-Conwy 2002), or structures providing a central social focus for semi-mobile communities (Brophy 2006:35, 2007:89); others argue that they represent ritual structures (Noble 2006:59; Thomas 1996:12, 1999:25, 2003:71, 2004:122, 2007c:34, 2008b:72; Topping 1996:166), perhaps acting as 'specialised storage, consumption or redistributive locations' (Thomas 1999:25). Given the detailed discussions elsewhere, the arguments for and against the domestic function of these sites will not be reiterated again here. However, one important point must be made regarding the rarity of chaff in the large rectangular structures: cereal chaff was rare on *all* sites in Neolithic Scotland, not just the timber 'halls'. Chaff was only present on 14 of the 75 sites; only four sites had over 20 chaff fragments. It is highly improbable that all of these sites had a non-domestic function. If all of these sites contained fully processed crops, then cereal processing and/or deposition of processing waste must have been taking place elsewhere (Jones and Rowley-Conwy 2007; Stevens 2007:379); or the chaff and straw was used as fodder or building materials (Jones 2000b:80), with only clean grain being brought to domestic habitation sites (Bogaard and Jones 2007:66). Alternatively considering that chaff is the least well preserved cereal component in fires (Boardman and Jones 1990), poor preservation may have been responsible for the dearth of chaff on Scottish Neolithic sites. This idea is supported by the poor preservation of many of the assemblages included in the review. Of the 34 plant macrofossil reports that commented on the state of preservation of the archaeobotanical remains, only four described the cereal assemblage as being well preserved. Therefore, the rarity of chaff at the timber 'halls' cannot be used as an indicator of the function of these sites.

5.5 Hunter-gathering or agriculture in Neolithic Scotland?

5.5.1 Cereal cultivation and wild plant collection

Overall, domestic species dominated throughout Scotland in both the early and late Neolithic (figure 7a). 72 of the 94 site blocks contained cereals (table 15). Considering the taphonomic factors discussed above, this suggests that cereals did indeed form a more significant part of Neolithic subsistence strategies than the collection of wild plants for most groups. While some individual sites either lacked cereals altogether or contained more wild than domestic species, many of these sites, such as Cowie Road, Geirisclett, Maeshowe, Embo and Bookan had a non-domestic function. Also, though many of the pit sites, such as Deers Den, contained few cereal remains, these sites may have been places of structured deposition (Richards and Thomas 1984) rather than domestic settlements (Alexander 2000:66; Speak and Burgess 1999:105). Consequently, the types of activity that would result in the preservation of domestic economic evidence probably did not take place at these sites (Church and Cressey 2003:22). Equally, given the differential preservation of hazelnuts and cereal grains (see above) it is uncertain whether these proportions really do indicate economies based on wild plant gathering at all. Therefore, many of the sites with very low concentrations of cereals were not representative of the Neolithic domestic economy as a whole.

Moreover, the recovery of 20,000 cereal grains from Balbridie indicates that arable production was undertaken on a substantial scale in Neolithic Scotland (Cooney 1997:27; Rowley-Conwy 2000:51, 2004:90). Further support for this is the presence of significant numbers of Flax seeds at Balbridie and Lockerbie. This indicates a considerable level of agricultural sophistication, because the cultivation and processing of Flax requires greater levels of management than other crops (Bond and Hunter 1987). Furthermore, the substantial evidence for field systems (Barber 1997:144-5; Barclay 2003a:142; McCullagh

1989a:48; Noble 2006:37-8; Whittle et al 1986:45), ard marks (Ashmore 1996:73; Clarke and Sharples 1990:73; Guttmann et al 2004:55; Haggarty 1991:67; Hunter et al 2007:65; McCullagh and Tipping 1998:115; Noble 2006:170; Romans and Robertson 1983), and soil amendment practices (Clarke and Sharples 1990:73; Dockrill et al 2007:36; Guttmann 2005; Guttmann et al 2004, 2006; Ritchie 1983:45; Romans 1986) in Neolithic Scotland shows a considerable investment in the arable component of the economy and the existence of developed and stable agricultural systems. This is supported by pollen evidence for widespread cereal agriculture across Scotland (Edwards and Whittington 2003; Tipping 1994).

Yet it is clear that the collection of wild plants remained an important part of the Neolithic economy in many parts of Scotland. Hazelnut shell was found on the majority of sites, and 28 sites contained more wild than domestic species (table 15). The occurrence of wild fruit remains of Crab Apple, sloe and various berry species on 24 sites (table 16) is very significant considering how unlikely these species are to become preserved (Hillman 1981a:189). Crowberry was the most frequently present species, with seeds found on eight sites - all in late Neolithic Orkney. While Crowberry may represent a deliberately harvested food stuff, it is equally possible that it was gathered along with peat and turf which was commonly burnt as a fuel in the Northern Isles by this period (see also chapter 7; Church et al 2007b; Dickson 1998; Dickson and Dickson 2000:52-3; Fenton 1978:217-232; Hinton 2005:342; Rowley-Conwy forthcoming). The abundance of other wild plant seeds in the plant assemblages from Orkney (table 15) may also be a reflection of this practice (ibid).

There appears to be an increase in the use of wild plants in the later Neolithic in Southern Scotland (figure 8b). The reasons for this increase are uncertain, but this may be a result of the taphonomic problems discussed above. Another possibility is that in the later Neolithic there may have been some abandonment of the more permanent settlements introduced in the earlier Neolithic. This is supported by the presence of small stake-built structures in the late Neolithic at Becton Farm associated with a plant assemblage composed almost entirely of hazelnut shell, and located in close proximity to the earlier Neolithic timber ‘hall’ at Lockerbie Academy, which had a larger cereal assemblage (see figure 6 for site proximities).

5.5.2 Geographical and social differences in plant exploitation

The Scottish Neolithic economy was far from uniform (table 15; figures 9 and 11). The close proximity of ephemeral structures and pit sites, which were dominated by wild species to more permanent settlements where agriculture was more important, such as Claish Farm to Chapel Field, and Deer's Den to Warren Field and Balbridie (see figure 6 for site proximities), suggests that there were differences between contemporary groups living in close juxtaposition.

At a broader level, it is probable that agriculture was more prevalent in some areas of Scotland than others (Barclay 2003b:81). Archaeobotanical data indicate that there was regional variation in plant subsistence practices, with a much greater reliance on wild species in Southern Scotland than in North-East and Atlantic Scotland (figures 7b, 8b, 9). This may be a reflection of the fact that there are fewer sites with archaeobotanical remains available for analysis in Southern Scotland than elsewhere, and perhaps more sites will be found in the future which contradict this pattern. Alternatively, it is possible that more settled agricultural communities existed in North East and Atlantic Scotland than in Southern Scotland. With the exception of the timber structure at Lockerbie, all of the sites in Southern Scotland are either small/ephemeral domestic sites (seven sites), ritual sites (six sites) or pits (eight sites), which tend to have lower frequencies of domestic plant remains present. In contrast a larger proportion of the sites from Atlantic and North-East Scotland were either large timber rectangular structures or stone structures, which had consistently high frequencies of cereals.

Indeed, many sites in mainland Scotland showed a considerable continuity with the preceding Mesolithic way of life, in both structural forms and subsistence strategies. The small circular structures and the concentrations of pits, postholes and hearths that characterise many Neolithic sites have clear parallels with earlier Mesolithic structures (Alexander 2000:65; Armit 1996:281; Armit and Finlayson 1992:668) and appear to represent short-term occupations of mobile or transhumant populations (Armit and Finlayson 1992:670; Brophy 2006:25; Noble 2006:59). There is an association between these ephemeral structural types and wild plant foods – though domestic plants also formed part of the economy of these sites (figure 7c; table 15). Also, it is arguable that many of the pit sites, which contained few cereal remains, were indicative of transient domestic settlement (Alexander 2000:65; Ashmore 1996:59). This suggests that wild plant collection was still a common aspect of the subsistence strategy in some parts of Neolithic Scotland and may support Sharple's (1992:329) suggestion that indigenous Mesolithic inhabitants may have adopted aspects of the Neolithic package in South-West Scotland.

There may also be a functional division between the pit sites and domestic settlements. Many of the pit sites may actually represent specialised plant processing sites, perhaps used on a seasonal basis by communities occupying the timber 'halls' and ephemeral domestic sites. In particular the site of Dubton Farm, in North-East Scotland provides the clearest evidence for a specialised plant processing site. The largest concentration of cereal chaff, Crab Apple remains and whole hazelnuts, together with the third largest concentration of weed seeds in Neolithic Scotland, was recovered from pits at this site. The cereal chaff and weed seeds indicate cereal processing; the Crab Apple remains and whole hazelnuts may have become charred during drying for storage. The composition of the assemblage was also very similar to the timber halls in the area: mostly Emmer Wheat (43%), some naked barley (19%), and a little Bread Wheat (3%), together with Crab Apples and hazelnuts (compare figures 13 and 14a). Considering this and the fact that the site is contemporary with the rectangular timber structures, Dubton Farm may represent an initial processing area for food used within one of the timber ‘halls’. In support of this is the fact that apart from the timber structures and stone structures, cereal chaff is only present at pit sites (table 15). There are no pit sites in the Northern and Western Isles and it seems likely that cereal processing occurred in the vicinity of domestic settlements on these islands. It should be noted though, that chaff was still scarce on domestic settlements in this region, and it is unlikely that a significant amount of processing occurred within domestic structures (see chapter 7 for further discussion).

Figure 13: Proportion of cereals at the large rectangular timbers structures. The dating classification and the number of grains is indicated in brackets after the class on the x-axis.

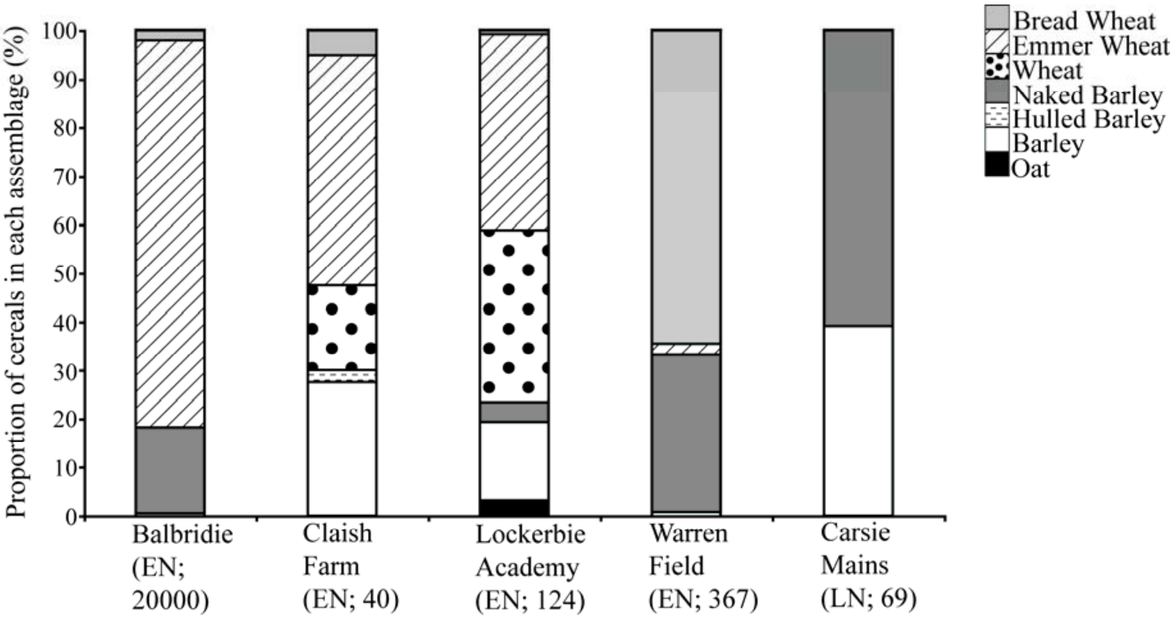
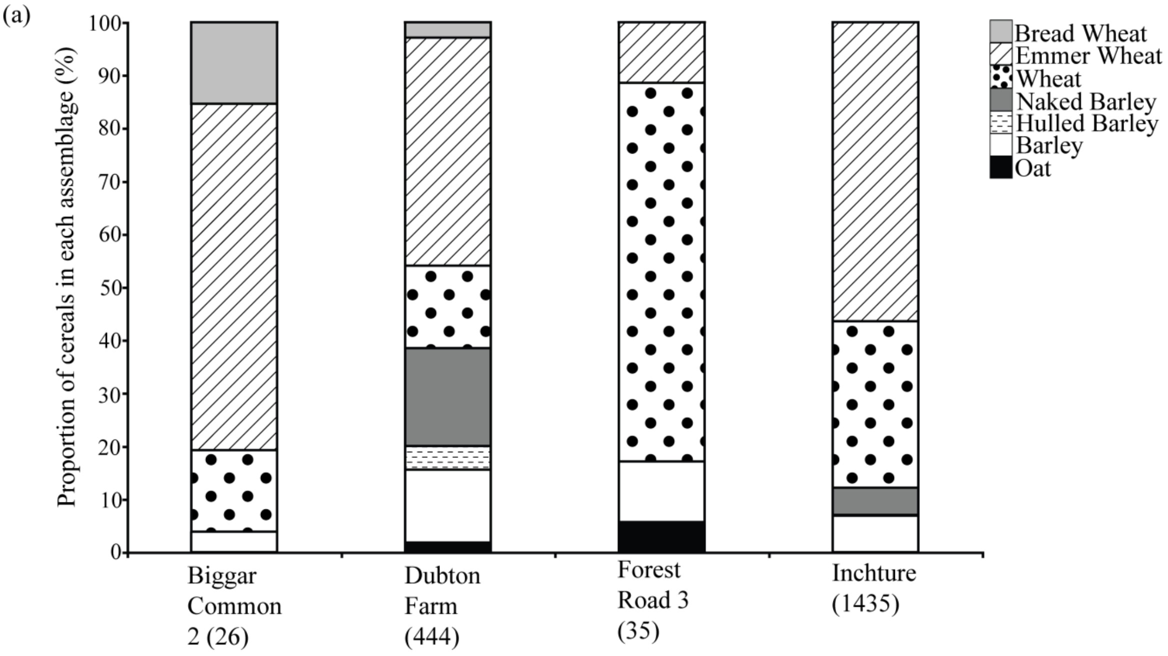
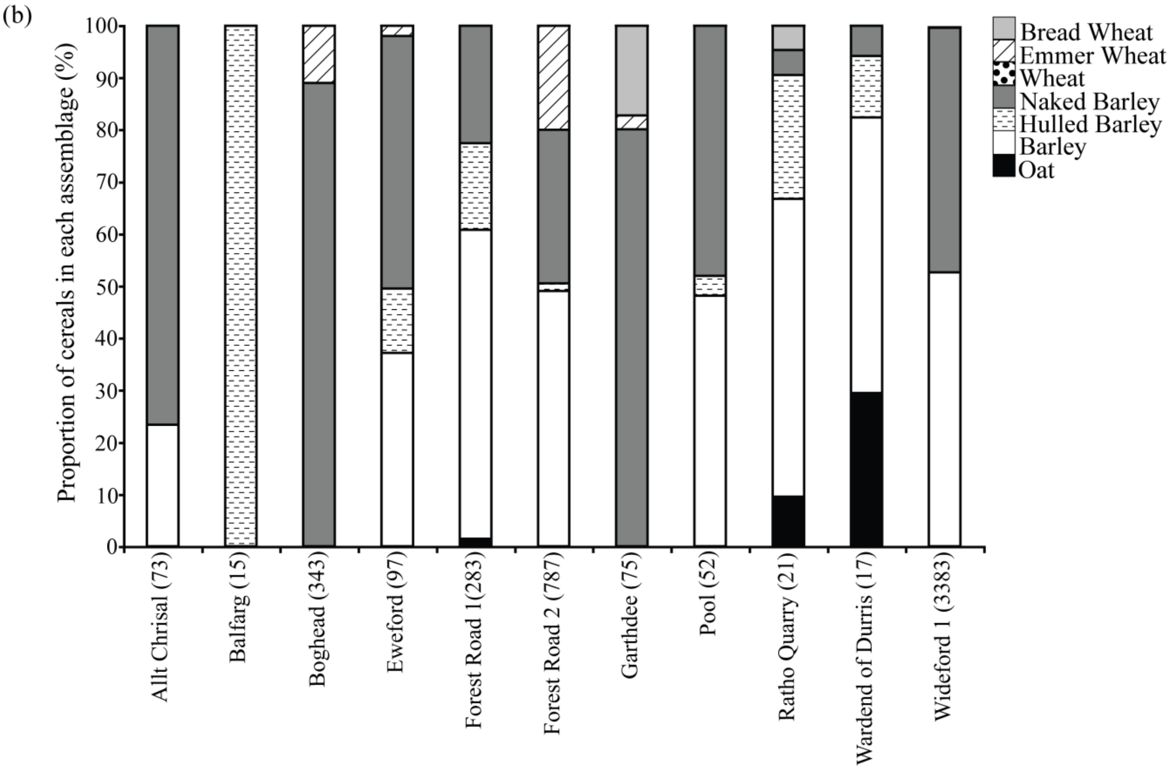


Figure 14: Proportion of cereals at early Neolithic sites (excluding large rectangular timber structures shown in figure 13), (a) sites with more wheat than barley, and (b) sites with more barley than wheat. The number of grains is indicated in brackets after the class on the x-axis.





The mainland Scottish Neolithic sites clearly contrast with the permanent stone settlements in Orkney, Shetland and the Outer Hebrides, where settled agricultural communities appear to have been present, and where plant assemblages were almost entirely composed of cereals (figures 7b, 7c and 9a). Interestingly, even the ephemeral circular timber structures at Wideford, Orkney lacked wild plants remains (table 15). The scarcity of hazelnut shell in the Northern Isles assemblages also contrasts with the mainland Scottish assemblages. Hazelnut shell was only present at four sites in Orkney (Braes of Ha'breck, Knap of Howar, Pool and Barnhouse). This is not surprising given that Hazel was probably relatively scarce in Neolithic Orkney - as a result of both natural decline and anthropogenic clearances (Bunting 1994; Davidson and Jones 1990:25-6; de la Vega Leinert et al 2000; Keatinge and Dickson 1979). Also, though the productively of Hazel in the Northern and Western Isles in the Neolithic is uncertain, considering that Hazel only produces nuts in some years in the Western Isles under current conditions and not at all in Orkney (Dickson and Dickson 2000:258), it seems likely that Hazel may have been less productive than elsewhere due to the more exposed environmental conditions. The preferential preservation of hazelnut shell in archaeobotanical assemblages compared to cereals, together with the presence of Hazel charcoal in assemblages containing cereals but lacking hazelnut shell, such as Wideford and Stonehall (Miller and Ramsay forthcoming) suggests that hazelnuts were a relatively unimportant food source for most social groups in Neolithic Orkney (see also chapter 7). While the settlement evidence from the Outer Hebrides may suggest that settlement was not as permanent as in the Northern Isles (Armit 1992:319), the archaeobotanical evidence suggests that there was no significant difference in subsistence practices between these two areas, since only one of the three settlements in the Western Isles had a greater proportion of wild than domestic plants.

However, in contrast to other areas of Atlantic Scotland where numerous stone-built structures are present, it appears that there was considerable continuity in economic practices between Mesolithic and Neolithic communities in the West Coast of Mainland Scotland and the Inner Hebrides. There are no known examples of cereal grain in the Neolithic of this area (table 15), and there is evidence for the continued occupation of Mesolithic shell middens into the Neolithic period (Armit and Finlayson 1992, 1996; Mithen et al 2007:516-7; Sharples 1992:327; Telford 2002:300). For example, the shell midden at Carding Mill Bay, near Oban, contained only wild plant species and artefacts normally associated with the Mesolithic period, but the radiocarbon dates place this activity within the Neolithic period (Connock et al 1992:36). However, it is also possible that the small number of sampled sites in this area is responsible for this pattern.

While most Atlantic Scottish communities focused on domestic plants and some Southern Scottish/North-East Scottish groups were more focused on wild plants, it is probable that a mixed plant subsistence economy based on both gathering and agriculture was the predominant subsistence pattern in many areas of mainland Scotland (Barclay 2003a:148; Boardman 1993b:376; Stevens 2007:382). Hunter-gathering and agriculture are not mutually exclusive strategies and many societies have mixed economies (Armit and Finlayson 1992:670, 1996:274; Layton et al 1991:260). In mainland Scotland, there is consistent evidence for the cultivation of cereals and the gathering of wild species on most sites (table 15). As Barclay (2003a:148) contends, a 'model of a small scale, intensive, subsistence economy utilizing a wide range of resources may be more helpful than comparisons with later prehistoric agricultural systems in Wessex.'

5.6 The Scottish Neolithic arable economy

The two main crops cultivated in Neolithic Scotland were naked barley and Emmer Wheat, although hulled barley outnumbered naked barley in a number of specific assemblages. Many assemblages contained a mix of both naked and hulled barley. This was perhaps a reflection of the mixed nature of the imported crop and of the ability of the naked and hulled varieties to interbreed – the naked trait is controlled by a single recessive gene (Zohary and Hopf 2000:60). On the basis of the Pool and Tofts Ness assemblages, Bond (2007a:183, 2007b:157) has suggested that the transition from naked to hulled barley, which generally occurred sometime during the Bronze-Iron Age in Britain (Hillman 1981b:124; Miller and Ramsay forthcoming; van der Veen 1992:74), occurred in the Neolithic period in Orkney. Against this idea is the predominance of naked barley at several Neolithic (Barnhouse, Isbister, Knap of Howar, Ness of Brodgar, Skara Brae, Stonehall, Wideford) and Bronze Age sites (e.g. Crossiecrown, Ness of Gruting) in Orkney and Shetland (table 15; Miller and Ramsay forthcoming; Milles 1986b). Considering the high proportion of indeterminate cereal grains and grains identified as barley at Pool and Tofts Ness (table 15), the proportion of naked:hulled barley grain is difficult to assess, and it is not possible to be certain whether there was an increase in hulled barley from the early to later phases of Pool. Consequently, it seems that hulled barley was only to become dominant in the Bronze Age or later in Orkney, as in the rest of Scotland.

All other cereal species were rare in Neolithic Scotland and probably represent contaminants of the Emmer Wheat and naked/hulled barley crops or small-scale experimentation with new crop types. Though cultivated oat was present in 18 of the 94 site blocks, it was only present in very small quantities and was probably never grown as a crop in its own right. Spelt Wheat was only present at two sites and Rye at just one site (table 15). Apart from these examples, grain of these species has only been recovered from the late Bronze Age onwards in Britain (Barclay and Fairweather 1984; Boyd 1986; Godwin 1975:406, 413, 415; Helbaek 1971:268; Renfrew 1973:83; van der Veen 1992:75), and Rye may not have become an important crop until the Medieval period and possibly later in Scotland (Barclay and Fairweather 1984; Boyd 1988b:105; Dickson and Dickson 2000:236-7). Also, none of the Spelt Wheat or Rye grains have been radiocarbon dated and it remains possible that these grains represent intrusive material.

It seems likely that the shift from wheat to barley in mainland Scotland in the later Neolithic was a result of environmental factors. Towards the later Neolithic, climatic conditions were wetter in Scotland (see also section 7.1.4.3; Anderson 1998; Anderson et al 1998a; Bonsall et al 2002; Tipping 1995a; Tipping and Tisdall 2004:76). Therefore conditions were less favourable for the cultivation of wheat, which prefers drier soils (Coppock 1976:55; Renfrew 1973:65 and 81) and is more sensitive to changes in soils and climate (Zohary and Hopf 2000:68). It is probable that Neolithic farmers observed this natural selection against wheat, and that as the climate grew wetter, the more successful species - barley - was chosen as the dominant crop. Equally, the more marginal environmental conditions in Atlantic Scotland were probably far less favourable for wheat production than elsewhere in Neolithic Scotland, due to high winds and rainfall (Coppock 1976:14-16; Davidson and Jones 1990:19). Modern agricultural maps show that the northern economic limit of wheat is around the Dornoch Firth (Coppock 1976:55) - which is at the northern extent of the North-East Scotland geographical category in this review. Wheat would therefore have been better adapted to the conditions in Southern and North-East Scotland (Church 2002a:61; Coppock 1976:55; Dickson and Dickson 2000:67; Maclean and Rowley-Conwy 1984:71; Milles 1986a:119). The decline in the size of Emmer Wheat grains between the early Neolithic site of Boghead and the later Neolithic site of Skara Brae supports this conclusion (Maclean and Rowley-Conwy 1984:70). Indeed, considering the low proportions of wheat in the assemblages from Orkney and Shetland throughout the Neolithic, it seems likely that wheat was just a contaminant of the barley crop in these areas (Bond 2007a:183; Milles 1986a:119; Miller and Ramsay forthcoming).

These environmental factors do not however explain the variation in the proportions of wheat and barley at the different site types. Not only were all of the assemblages from the early Neolithic rectangular structures composed almost entirely of wheat, but there was also a remarkable similarity in the composition of these assemblages (figure 13). The samples from Lockerbie, Balbridie and Claish Farm were dominated by Emmer Wheat (40-80%), together with slightly lesser amounts of naked/hulled barley (18-30%), and low frequencies of Bread Wheat and oats (<5%). The structure at Warren Field, on the other hand, contained more Bread Wheat (*c.* 65%) than Emmer Wheat (*c.* 2%), but similar levels of naked/hulled barley (33%). Bread Wheat is a rare find on Scottish Neolithic sites and it is only present in ten of the other site blocks. In contrast, the plant macrofossil assemblage from the Carsie Mains structure was composed entirely of barley. This is probably a consequence of the late Neolithic date of this site, though it may be a reflection of the fact that it was an unroofed and possibly non-domestic structure, which may differentiate it from the other large timber halls (Brophy 2007; Brophy and Barclay 2004:19). Overall, the proportions of cereals from the early Neolithic timber 'halls' were extremely unusual for Neolithic Scotland.

Other rare and unusual finds at these sites were Crab Apple remains and Flax seeds. Crab Apple was present at just four other Scottish Neolithic sites. Flax was present at both Balbridie and Lockerbie, forming the two largest concentrations of Neolithic Flax in Scotland. Only one other possible Flax fragment has been found in the whole of Neolithic Scotland, at Achnasavil in Kintyre. Flax is also a rare discovery in Neolithic England, with the remains coming from Windmill Hill, Wiltshire (Godwin 1975:167), Lismore Fields, Buxton (Jones and Rowley-Conwy 2007) and from The Stumble, Essex (Grieg 1991:300).

To some extent the abundance of wheat in the cereal assemblages from the timber 'halls' can be accounted for by their early Neolithic date and Southern/North-East Scotland distribution. However, this does not fully explain the unusual compositions of these assemblages because not all of the early Neolithic sites located in these areas conform to the same pattern.

One possibility is that these timber rectangular structures served a ritual rather than domestic purpose (Noble 2006:59; Thomas 1996:12, 2003:71; Topping 1996:166) and that the cereals were specifically chosen for use within ritual contexts. Alternatively, it is possible that these structures were high-status domestic sites and that the unusual compositions of plants may relate to the importance of these species within Scottish Neolithic society (Miller and Ramsay 2002:95). The association of the rare and more labour-intensive Flax with timber hall sites in Britain (Balbridie, Lockerbie, Lismore Fields) could support both these suggestions. However, these arguments seem less plausible since similar combinations of cereals have been recovered from several other early Neolithic sites of different function. These sites include an ephemeral structure and domestic evidence at Biggar Common, the groups of pits from Dubton Farm, Forest Road and Inchture (figure 14a), and ditches, pits and postholes from Larkhall Academy (table 15). None of these sites provides evidence for clear ritual activity and all of these sites can be interpreted as having a relatively low-status domestic function.

A further possibility is that this suite of cereals was introduced together by a group of culturally similar people during the same phase of colonisation. This idea is supported by the similarities in the structural form of the timber ‘halls’ and the associated artefactual evidence (e.g. carinated bowl pottery) with continental material (Ashmore 1996:32-3; Fairweather and Ralston 1993; Sheridan 2004:12, 2007). This may represent either the introduction of a specific method of cereal cultivation that had been successful elsewhere, or the acquisition of cereal grain by indigenous peoples from a specific group at a similar period of time. While the artefactual evidence from Warren Field suggests that this particular site may not have been the first settlement of incoming farmers (Murray et al 2009:66-7), this suite of introduced plants may have continued to be used by descendents of the first farmers using this range of plants. The fact that there appears to be another group of early Neolithic Scottish sites with a very different combination of cereal species supports this suggestion (figure 14b). These site assemblages all contain over 80% barley, with only small concentrations of Emmer/Bread Wheat. This second group could represent another phase of colonisation, or indigenous acquisition of cereals from a different cultural group. However, caution must be exercised when using archaeobotanical remains in isolation when interpreting the nature of Neolithic colonisation and society.

5.7 Conclusions

The most common plant subsistence strategy in Neolithic Scotland was the cultivation of naked barley, supplemented by the collection of hazelnuts and some wild fruits. However, plant exploitation was geographically, socially and chronologically diverse. Though naked barley was the main barley crop, many plant assemblages contained a mixture of hulled and naked barley, and hulled barley was the most significant cereal in a number of specific assemblages. Emmer Wheat was also an important crop on many early Neolithic sites in Southern and North-East Scotland, but was probably only ever a contaminant of the other crops in Orkney and Shetland, due to the more marginal environment in this area. Wheat was no longer a significant crop in the late Neolithic, and was probably only a crop contaminant by this period. The wetter climate in the later Neolithic was probably responsible for this, because wheat is less tolerant of wet conditions than barley. Bread Wheat was only found on 14 sites and was represented by a few grains only at each site, except at the large rectangular timber structures where larger concentrations were present. These early Neolithic timber 'halls' were associated with a distinct suite of plant material: mostly Emmer Wheat, some naked barley and bread wheat, together with Flax, hazelnuts and Crab Apples. Five other early Neolithic sites had a similar range of cereal species to the timber 'halls', and this suite of plants may have been introduced during the same phase of colonisation.

The relative importance of wild and domestic plants in the Scottish Neolithic economy was very variable. The permanent stone settlements in Orkney, Shetland and the Western Isles were associated with plant assemblages composed almost entirely of cereals and seem to represent settled agricultural communities. Hazelnut shell was very rare in Neolithic Orkney and Shetland despite the presence of Hazel charcoal at some sites, suggesting that wild plants were an insignificant part of the economy in this area.

In contrast, in most of mainland Scotland, a mixed plant subsistence economy based on both wild plant collection and cereal cultivation was the predominant pattern. Hazelnuts were present at the majority of sites in this area. Additionally, ephemeral structures, pit sites and ritual sites included a mixture of both wild and domestic plants, but considering the preferential survival of hazelnuts in archaeobotanical assemblages it is difficult to be certain whether wild or domestic plants were of greater significance. However, it appears that wild species made a far more significant contribution to the assemblages in Southern than in North-East Scotland. There also appears to have been a continuation of a Mesolithic subsistence strategy on the West coast of mainland Scotland and the Inner Hebrides, though it is also possible that the small number of sampled sites in this area is responsible for this pattern. On the local scale, however the picture is more complex, with some apparently contemporary groups living in both larger timber structures and growing crops on a large-scale, and other groups living in smaller more ephemeral structures and focusing on wild resources.

Chapter 6: Case study 1: Mesolithic plant exploitation in the Western Isles

6.1 Introduction

6.1.1 Chapter outline

This chapter will explore the nature of plant exploitation in the Mesolithic of the Western Isles of Scotland, through a consideration of the archaeobotanical data from a Mesolithic site (Northton, South Harris, Western Isles) newly excavated by a team from Durham University directed by the author and Dr Mike Church. The key archaeobotanical research themes and aims of this project will first be detailed, before the environmental and Mesolithic archaeological background to the Western Isles are outlined. The excavation sequence, sampling strategies and archaeobotanical methodologies will then be described, in order to provide contextual information for the analysis of the archaeobotanical results. The archaeobotanical results from Northton will then be discussed in detail and the hazelnut results from two other recently excavated Mesolithic sites at Temple Bay and Tràigh na Beirigh, Western Isles will be used together with the results from experimental studies to enhance the interpretation of the material recovered from the site. Finally, the results from Northton will be placed within the wider context of Mesolithic archaeobotany in Scotland.

6.1.2 Archaeobotanical research context

Detailed studies of archaeobotanical remains from Mesolithic sites have rarely been undertaken in Britain (see chapter 2). This is largely a consequence of the assumption that plant resources were not an important component of Mesolithic subsistence strategies and that plant remains are rarely preserved on Mesolithic sites (Hather and Mason 2002:2). This has resulted in a lack of detailed environmental sampling and analysis of Mesolithic plant remains (Mason et al 1994:54), and a consequent reinforcement of pre-existing ideas about the nature of the British Mesolithic economy. At the few sites where detailed sampling strategies have been implemented and techniques suitable for the identification of edible roots and tubers have been used, substantial quantities of plant remains have been found (Hather and Mason 2002:5; Mason et al 2002:195). For instance, the large-scale sampling strategy and the identification methods used at the site of Staosnaig, Colonsay (Mithen 2000; Mithen et al 2001) resulted in the recovery of an estimated 30-40,000 whole hazelnuts and over 400 edible tubers (ibid). The excavation and comprehensive sampling of a Mesolithic site was therefore a major research priority for this study (see chapter 1), in order to explore this poorly-understood element of Mesolithic subsistence in detail.

6.1.3 Archaeobotanical research aims

The overall aims of the excavation at Northton for this study was to undertake large-scale sampling of a Scottish Mesolithic site, to provide a sizeable assemblage of Mesolithic plant macrofossils for analysis. In addition, several specific archaeobotanical research objectives were formulated:

- What types of environments did the plant remains originate from?
- How have taphonomic processes affected the assemblage?
- What evidence is there for the gathering, processing and cooking of wild plants for consumption at Northton?
- Is there any evidence for the seasonality of plant collection in the assemblage?
- How does the assemblage compare to other Scottish Mesolithic assemblages?

6.1.4 Environmental and Mesolithic archaeological background to the Western Isles

6.1.4.1 Location, geology and landscape

The Western Isles (also known as the Outer Hebrides) lie 60 km off the North-West coast of mainland Scotland (Gregory 2006). The archipelago is approximately 200 km long from north to south and is composed of 119 islands, 16 of which are currently permanently inhabited (Ritchie 1991). Harris and Lewis are located in the northern most end of the island chain, and though geographically they form a single island, they have historically been considered separate entities because of the high mountainous region in North Harris that separates the main habitable areas (Armit 1996:4).

The geology of the Western Isles consists almost entirely of metamorphic gneisses (known as Lewisian gneisses), a Precambrian rock complex dating to approximately 2800 Ma ago, as well as igneous rocks that formed c. 2250-1750 Ma ago, mainly in Southern Harris (Fettes et al 1992; Gribble 1991). The only exception is a small zone around Stornoway, Lewis which has younger Permo-Triassic sandstones and conglomerates, and occasional igneous dykes of Permo-Carboniferous and early Tertiary age (ibid).

Harris contains all the major rocks in the Lewisian and igneous complexes, including: gneisses, granite, gneiss veined with granite and pegmatites, meta-igneous rocks and meta-sedimentary rocks (Fettes et al 1992; Gribble 1991; Philips 2006). However, the geology of the area is predominately igneous and this has created a mountainous landscape, with summits reaching 700-800m above sea level (Gregory 2006; Gribble 1991). The topography of South Harris is also characterised by 'cnoc-and-lochan', a landscape type with numerous rocky outcrops and hollows filled with water, bog or peat, which were created by Quaternary glaciation (Goodenough and Merritt 2007; Gribble 1991). The East and West coast of South Harris have contrasting morphologies; with the East coast diving steeply into deep water, and forming rocky bays and promontories, in contrast to the sea bed on the West which is shallow, producing extensive low-lying sandy beaches and small rocky headlands (Fettes et al 1992; Ritchie 1991).

6.1.4.2 Palaeoclimate

Proxy indicators of palaeoclimate indicate that the beginning of the post-glacial period was marked by a rapid increase in temperature and that the Mesolithic climate of Scotland was in general slightly warmer (+ 2°C) than at present (Ballantyne 2004; Whittington and Edwards 2003). However, the available palaeoclimatic evidence is insensitive to short-term climatic shifts and it is probable that there were numerous small fluctuations in the climate during the Mesolithic (Ballantyne 2004). For instance, there is evidence for climatic instability in the 5th millennium cal BC and that there was a cooling event in the 7th millennium cal BC that lasted for approximately one hundred years (ibid). Overall, moisture availability appears to have been very similar to the present day in Scotland, except for wetter periods before c. 9000 uncal BP, at 7300 uncal BP and at 6500-6000 uncal BP in some areas (ibid).

6.1.4.3 Sea-level change

In Scotland, the effects of deglaciation on the coastline varied in different areas according to the distance from the centre of the glacial ice sheet (Ballantyne and Dawson 2003:33). Land closest to the middle of the ice-sheet, where it was thickest, experienced the highest levels of depression, and consequently rose ('glacio-isostatic rebound') more rapidly relative to sea-level rise than land in more peripheral areas (ibid). In the Western Isles, deglaciation largely resulted in submergence, because the Western Isles were located on the margin of the glacial ice sheet (Ballantyne and Dawson 2003:37; Ritchie 1991:12). Consequently, glacio-isostatic rebound was lower and slower than relative sea-level rise and so there has been an overall increase in sea level since the end of the last glacial period (ibid). This sea level rise implies that many coastal Mesolithic sites in the Western Isles may be submerged beneath the sea (Ballantyne 2004:37).

A recent study in South Harris suggests that although sea levels have risen by approximately 1.5-4 m since the beginning of the 8th millennium cal BC, sea levels fluctuated during the Mesolithic in this area (Jordan et al 2010). The first major sea level rise during the Holocene, which may have been caused by the Storegga Slide tsunami, occurred at 6404-6069 cal BC (ibid). After this time sea-levels fell again before continuous sea level rise initiated in the 4th millennium cal BC from c. 2m below present high water mark (ibid).

6.1.4.4 Vegetation history and pedogenesis

Today, the Western Isles is an open, virtually tree-less environment, which is dominated by blanket peat, peaty podzols, gleys, and rankers, which support an extremely restricted plant flora, together with agricultural soils amended by human activity (known as 'inbye') in coastal areas (Birks 1991; Boyd and Boyd 1990; Hudson 1991). Another major aspect of the current coastal landscape of the Western Isles, is 'machair', a fertile calcareous wind-blown shell sand formed of crushed marine molluscs, quartz sand and glacio-fluvial deposits, which supports rich grassland communities (Edwards et al 2005; Gilbertson et al 1999).

However, these features, which characterise the current vegetation and soils of the Western Isles, have largely developed since the 4th millennium cal BC and the Mesolithic environment would have been very different. For instance, many of the amended agricultural soils were essentially created during the Post-Medieval period (Boyd and Boyd 1990) and the OSL dating of carbonate sands suggests that the first major phase of machair development did not occur until the 4th millennium cal BC (Gilbertson et al 1999). However, in some areas, windblown sands began to accumulate as early as the 7th-5th millennium cal BC (Edwards et al 2005; Gilbertson et al 1999; Ritchie 1979), perhaps partially accelerated by the removal of woodlands by human impact, which had previously acted as a natural barrier to inland sand movement (Edwards et al 2005).

Likewise, although the present landscape of the Western Isles is virtually denuded of trees, woodlands would have been present in the Mesolithic. However, the extent to which the Western Isles were wooded in the early-mid Holocene has been an area of contention amongst palynologists. Early palynological investigations produced sequences with low levels of arboreal pollen (Blackburn 1946; Heslop-Harrison and Blackburn 1946;

Ritchie 1966) and as a result vegetation reconstructions depicted the Western Isles as predominantly treeless in the early Holocene, with open scrub woodlands only sparsely scattered and mainly restricted to the East coast of Harris/Lewis (McVean and Ratcliffe 1962). This picture was reinforced by the first well-dated pollen sequence from the Western Isles (Little Loch Roag, Lewis), which contained only low levels of tree/shrub pollen (<30%) throughout the Holocene (Birks and Madsen 1979). In contrast, after identifying and dating sub-peat pine, birch and willow macrofossils from 40 sites in Lewis, Wilkins (1984), proposed that woodlands were significant in the area prior to 4500 uncal BP. Birks (1991) explained the discrepancy between the palynological and macrofossil evidence from these two studies to be a consequence of the different scales of analysis of the two approaches, "Both can indicate small areas of scrub in *local,* sheltered situations and a predominately treeless *regional* vegetation. It is perfectly feasible to have sparse tree populations at densities of 0.25 trees ha^{-1} (= 200 trees or less within 2-5km radius of a pollen site) that are largely undetected pollen analytically."

However, several subsequent studies suggest that the evidence from the peat sequence at Little Loch Roag may not be representative of the wider environment on Lewis or elsewhere on the Western Isles. For instance, pollen profiles from a peat bog at Tob nan Leobag and from a lake at Loch Builaval Beag, Lewis have produced arboreal pollen levels which ranged between 30-80% prior to the 4th millennium cal BC (Bohncke 1988; Fossitt 1996), suggesting that though some more exposed locations and marginal areas of Lewis may have lacked trees, woodlands were present outwith these areas (Bennett et al 1997; Church 2006). It also seems likely that there may have been greater woodland coverage in the Southern isles than on Lewis (Bennett et al 1990a:296; Church 2006), with most sites on South Uist and Barra producing maximum arboreal pollen percentages ≥60% (Bennett et al 1990a; Brayshay and Edwards 1996).

Whilst there are currently no published pollen diagrams from Harris (Bennett et al 1997; Church 2006; Tipping 1994), it is reasonable to expect that the environment would have been similar to Lewis. The analysis of a series of stratified samples for land snails from Northton, Harris, supports this conclusion: with results showing the preponderance of species associated with moist or shady habitats, and low frequencies of open grassland indicator species in the basal machair layers above the Mesolithic land surfaces (Evans 1971). Though some of these species may also be able live in open grassland habitats, the dominance of these generally 'shade-loving species' together with the dearth of snails associated with open environments, indicates that the environment would have been wooded in the Mesolithic (Evans 1979).

Several studies have also indicated that taphonomic factors are probably responsible for the low levels of arboreal pollen in many regional pollen sequences from the Western Isles. For instance, Wilkins (1984) analysed the pollen from a peat sample contemporaneous with one of the early Holocene tree macrofossil sites in his study and found that it produced low levels of arboreal pollen. He proposed that the strong coastal winds which characterise the climate of the Western Isles may have kept the tree pollen air-borne and prevented it from reaching the pollen sampling sites (ibid). Several studies based on modern pollen data support this proposition. For example, the analysis of pollen traps in the vicinity of a modern tree plantation on Barra, Western Isles, has shown that, within an open environment, woodlands are only detectable if the pollen sampling site is within 40m of the woodland (Gearey and Gilbertson 1997). Likewise, Fossitt (1994) has shown that pollen derived from long-distance transport does not mask the local pollen signal in the Western Isles, with 13.8% of pollen inputs in small lakes estimated to originate from out with the islands. Therefore, in contrast to the present day, it is likely that woodlands would have been widespread throughout most of the Western Isles in the Mesolithic, except in exposed locations (Bennett et al 1997; Church 2006).

Similarly, the heather moor and blanket peat that dominates the environment of the Western Isles today, only became a significant aspect of the topography after the Mesolithic. Whilst a complex range of factors, including climate, human disturbance and local site topography and hydrology are involved in initiating peat formation, the key process responsible for the accelerating this process was the removal of the trees (Moore 1993). Since major woodland decline only occurred after the Mesolithic in most areas, partially as a result of anthropogenic impacts, the main period of moorland and blanket peat expansion was not until the Neolithic-Bronze Age at most sites and moorland did not become the dominant feature of the environment until the 1st millennium cal BC (Bennett et al 1990a, 1997; Brayshay and Edwards 1996; Church 2006; Fossitt 1996). However, moorland and blanket peat had already begun to develop naturally during the Mesolithic in most areas as a result of the cool, wet climate and the acidic soils, and in Western Lewis it became dominant soon after c. 7000-6500 cal BC (ibid). This early moorland expansion and peat initiation is also associated with woodland declines, which may have been anthropogenically (e.g. Bohncke 1988:451) or naturally (e.g. Fossitt 1996:190) induced. Thus, areas of heath and moorland would have been present within the Mesolithic environment of the Western Isles, but in most areas it would not have been the predominant landscape feature.

6.1.4.5 Mesolithic environment of the Western Isles

Overall therefore, the Mesolithic environment of the Western Isles was very different from the present day. During most of the Mesolithic, sea level would have been approximately 1.5-4m lower than today and though machair and moorland may have begun to form in some areas, they would not have been a major feature of the topography. Birch-hazel woodlands would have extended across considerable areas of the landscape, but would have been interspersed with grassland, tall-herb, heath and blanket bog communities (Brayshay and Edwards 1996:16; Church 2006:7).

Palynological and wood macrofossil evidence suggests that the woodlands would have been primarily composed of birch and Hazel and that willow, Rowan, Aspen, oak, elm, Alder, Ash and Scots Pine (*Pinus sylvestris* L.) would also have been present in low frequencies (see chapter 3; Bennett et al 1997; Church 2006; Fossitt 1996; Tipping 1994). The density of these woodlands is not known for certain, but the presence of woodland ferns and herbs, such as cow-wheat species and Bracken, and low-medium arboreal pollen percentages at some sites seems to suggest that open woodlands that supported rich understory communities predominated (Bohncke 1988; Brayshay and Edwards 1996:23; Fossitt 1996:187; Tipping 1994).

6.1.4.6 Mesolithic archaeology in the Western Isles

Until recent years, archaeological evidence for Mesolithic human occupation on the Western Isles of Scotland has remained elusive. Though palynologists have argued for Mesolithic human impact on the environment in the region since the 1980s (Bohncke 1988; Edwards 1996a, 2000a, 2004, 2009; Edwards and Sugden 2003), this evidence has remained contentious because of a lack of indisputable palynological indicators of Mesolithic human impact (Tipping 1994, 2004) and the absence of archaeological evidence for human settlement. The discovery of the first Mesolithic archaeological site in the Western Isles in 2001 at Northton, Toe Head peninsula, Harris was therefore of considerable international research significance and represented the most north-westerly Mesolithic site in Europe (Figure 15; Gregory et al 2005; Simpson et al 2006a).

However, rather than indicating a rarity of Mesolithic archaeology in the area, the delay in the discovery of Mesolithic sites in the region is probably a reflection of the difficulty of locating Mesolithic sites under the thick peat and machair deposits that characterise the topography of these islands, together with the destructive effects of relative sea-level rise since the early to mid-Holocene (Edwards 1996a:34; Edwards and

Sugden 2003:11). Indeed, subsequent radiocarbon dating in 2009 of samples taken in 1997 during a coastal erosion survey of Aird Calanais, East Loch Roag, Lewis (NGR: 206 335; Flitcroft and Heald 1997; O'Brien et al 2009), and detailed coastal survey and sampling in 2011 at Tràigh na Beirigh, Cnip, Lewis (NGR: NB 1002 3628; Blake et al 2012a; Church et al 2012b) and at Temple Bay, Toe Head Peninsula, Northton, Harris (Blake et al 2012b; Church et al 2012a) has identified three additional previously unknown Mesolithic sites. It is therefore likely that further Mesolithic sites are preserved beneath the peat and machair.

6.1.5 Archaeological investigations at Northton

6.1.5.1 Site location

The Mesolithic site at Northton is located on the South end of the Toe Head peninsula, South Harris in the Western Isles of Scotland (Figure 15; NGR: NF 975 912). The peninsula projects westwards into the North Atlantic and is separated from the rest of South Harris by an extensive area of machair, dune and beach sands and low-lying salt marsh which surrounds the tidal inlet to the North side of the peninsula (Simpson et al 2006a:12). The site itself is situated on low-lying ground, immediately above the present beach surface, in an area of eroding machair (figures 16 and 17). The machair grasslands above the site slope gently upwards to Ceapabhal, the Western most-summit of Harris.

As will be made apparent in section 6.1.5.3, the Mesolithic layers predate the basal machair at this site. Therefore, on the basis of the available evidence (see sections 6.1.4.3, 6.1.4.4 and 6.1.4.5) it is likely that the Mesolithic site at Northton would have been located within an area of open birch-hazel woodland, close to, but not directly overlooking the beach.

Figure 15: Location of Northton, Harris, Western Isles of Scotland (After Gregory et al 2005).

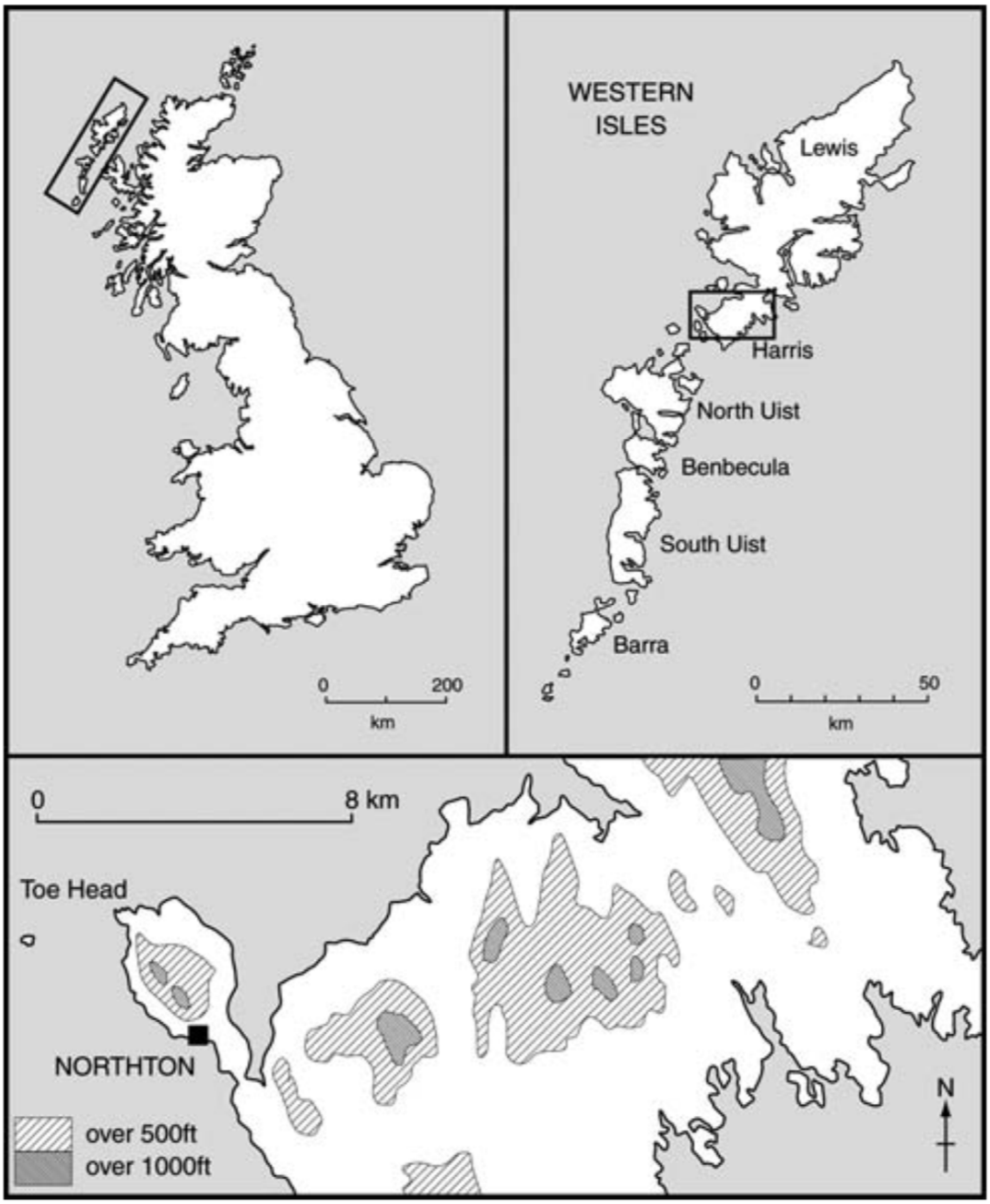


Figure 16: View of the coastline at Northton, Harris showing the location of the Mesolithic excavation conducted in 2010, looking North-West.

Figure 17: North-facing view of Northton trench 1, prior to excavation.

6.1.5.2 Previous excavations at Northton

A major rescue excavation project conducted at Northton in the 1960s, uncovered a series of Neolithic and Beaker midden deposits associated with stone-built structures (Simpson 1976). The basal horizon, which lay directly above the boulder clay, was interpreted as an earlier Neolithic occupation phase due to the presence of a sherd of Neolithic pottery in the deposit. However, during a subsequent survey of the settlement in 2001, two eroding sections containing comparable pre-machair deposits were identified and sampled (Gregory et al 2005; Murphy et al 2001a, b; Simpson et al 2006a). As with the basal deposit recorded in the 1960s, the 2001 pre-machair horizons were initially regarded as Neolithic layers, because of the stratigraphic similarity to the basal deposit identified in the 1960s excavations and the presence of a single barley grain and a possible sheep phalanx in the 2001 samples (ibid).

However, subsequent radiocarbon dating and analysis of charred hazelnut shell from these deposits provided evidence for 2 Mesolithic phases of occupation, with samples producing dates ranging between c. 7060-6650 cal BC for phase 1 and c. 6510-6090 cal BC for phase 2 respectively. Despite the presence of the post-Mesolithic material in the horizons, the remainder of the artefactual and environmental material recovered from the site was consistent with a Mesolithic interpretation. Therefore, the Neolithic material became incorporated within the Mesolithic deposits as a result of post-depositional processes (Simpson et al 2006a:19).

6.1.5.3 Excavations at Northton in 2010-2011

Following the initial small-scale sampling and dating of the Mesolithic horizons at Northton in 2001 (Gregory et al 2005; Simpson et al 2006a), it became clear that the site was being rapidly destroyed by coastal erosion. Coastal erosion is one of the biggest threats to archaeology in Scotland (Ashmore 2003a, b), and is becoming an increasing problem, as sea levels rise and there is an increased frequency of severe storms as a result of global warming. Consequently, a small-scale excavation was undertaken in 2010-2011 to characterise the nature of the deposits and to undertake detailed environmental sampling before the site is further eroded. As one of the most North-Westerly sites in Europe, the analysis of the material from the site provides an important opportunity to study the nature of Mesolithic human-environment interaction at the limits of European hunter-gatherer expansion.

The overall aims of the 2010-11 field seasons at Northton (Bishop et al 2011, 2012) were:

- to establish the nature of the Mesolithic deposits.
- to undertake detailed sampling of the archaeobotanical and zooarchaeological remains from the Mesolithic deposits.
- to assess the spatial extent of the Mesolithic horizons and the anthropogenic activity.
- to assess the state of erosion.

Five stratigraphic phases were identified in the 2010 excavation trench (figure 18). Phase 1 represents the most recent windblown sand layers encountered at the site. During the excavation, it became clear that there was a stratigraphic discontinuity in the sequence and that the later prehistoric and historic layers had been removed by a recent erosion event. This may have occurred during a huge storm in 2006, which, according to members of the local crofting community, resulted in severe erosion of the coast in this area. Consequently, the Phase 1 layers probably consist of re-deposited material from the exposed section above the site (figure 18). Phase 2 is interpreted as a mixed interface horizon. It consists of a series of disturbed, truncated or redeposited windblown sand layers, which contain varying quantities of later intrusive material and prehistoric artefactual material. Phases 3 and 4 contain the only *in situ* early prehistoric layers. Phase 3 (contexts 14, 3 and 9) is the upper prehistoric horizon, and it is thought to equate to contexts 10 and 5 in the 2001 excavations, dated to c.6600-6100 cal BC (table 17; figures 18 and 19). Phase 4 represents the earliest Mesolithic layers on the site. These contexts are equivalent to context 7 in the 2001 excavations, which was radiocarbon dated to c. 7060-6650 cal BC (table 17). Finally, Phase 5 is the natural glacial till.

Figure 18: Northton trench 1 Harris matrix.

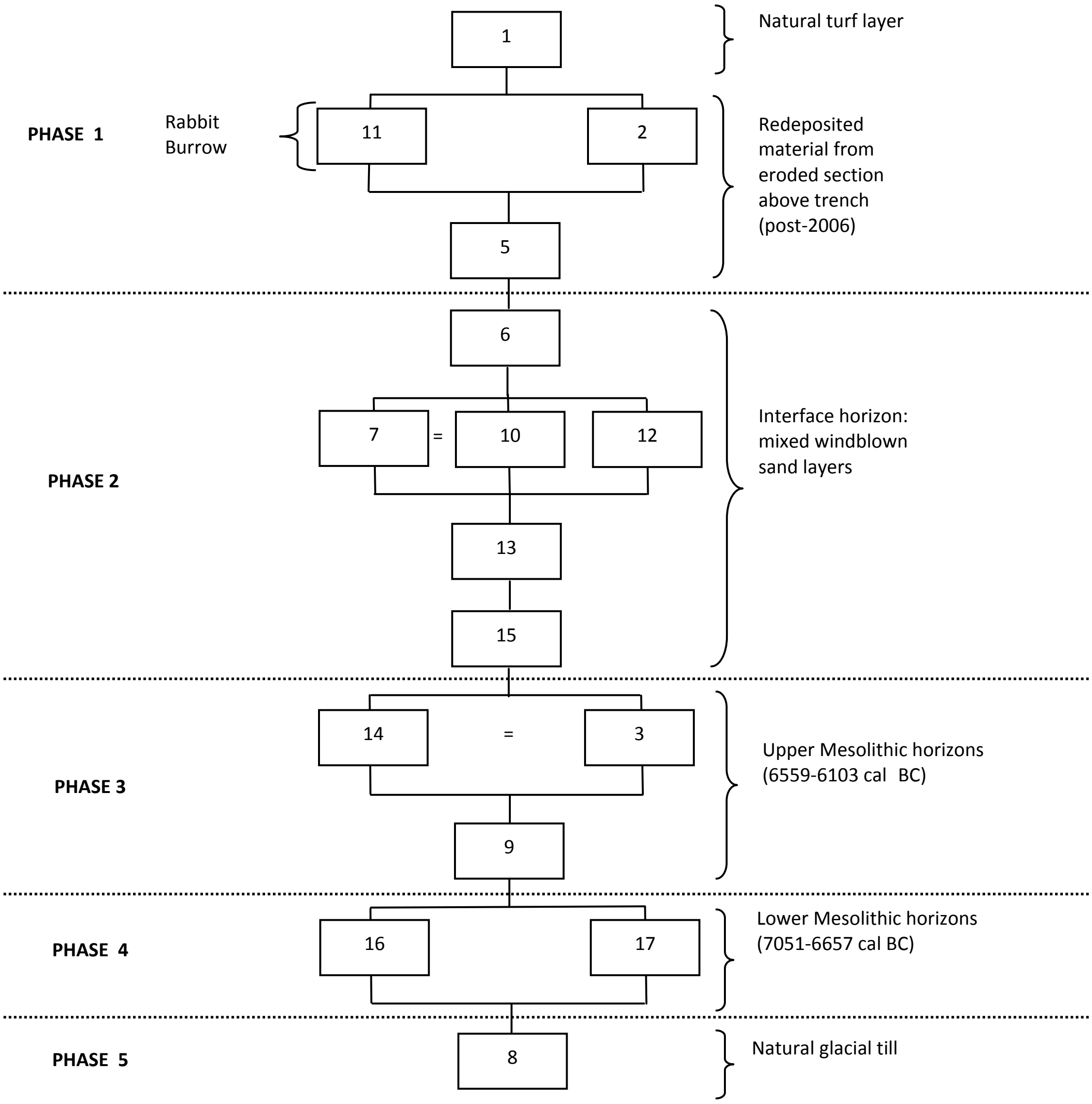


Figure 19: East-facing view of Northton trench 1, context 9, prior to excavation.

After the excavation, four fragments of charred hazelnut shell retrieved from context 14 (equivalent to context 10 in the 2001 excavations) were chosen for radiocarbon dating, with four additional samples of limpet shell selected to establish the marine reservoir effect for this geographical region in the early Holocene (table 17). The new radiocarbon dates from the hazelnut shell from context 14 are contemporary with the dates from context 5 in the 2001 excavations (equivalent to context 9 in the 2010 contexts). However, unfortunately, the resulting marine shell dates from context 14 were significantly younger than the hazelnut shell dates. Visual examination of the stratigraphy of the site showed that there was no gradual transition from the phase 3 old ground surfaces into the phase 2 wind blown sand layers. This suggests that the original *in situ* machair layers have been removed by erosion. Therefore, when the later sand layers deflated onto the stable surface of contexts 14 and 3, eroded material, such as the Neolithic marine shells were redeposited, creating a palimpsest of Mesolithic and Neolithic ecofacts in contexts 14 and 3 (Gilbertson et al 1996:96, 1999:453). In contrast, with the exception of the eroded *possible* sheep phalanx recovered in 2001, context 9 is not known to contain any intrusive material and it appears that contexts 14 and 3 protected context 9 from major deflation and redeposition episodes.

The excavation in 2010 was successful in providing a large sample of environmental and artefactual material from the Mesolithic horizons in order to characterise the nature of the deposits. Excavation and sampling of the site revealed a concentration of Mesolithic lithics, charcoal, carbonised plant macrofossils, fish bones, marine shells and terrestrial animal bones. Since no archaeological features were detected in the excavated area, the site has been interpreted as a series of old ground surfaces that incorporate a scatter of lithic material and a palimpsest of disturbed and bioturbated hearth deposits containing fuel remnants and food waste. On the basis of the absence of podzolisation in the soil micromorphological samples examined from the 2001 excavation, Guttmann (2006) has argued that the post-Mesolithic material in the Mesolithic layers was probably derived from Neolithic or Bronze Age cultivation at the site. However, considering the extent of coastal erosion at the site and the fact that no ard marks were visible within the Mesolithic layers, this material is interpreted here as resulting from erosion and redeposition (cf. Gilbertson et al 1996:96, 1999:453) or bioturbation.

A subsequent field season was conducted in 2011 to establish the spatial extent of the Mesolithic horizons around the headland. Samples were taken at 3m intervals from trench 1 in North-West and North-East transects around the coastal edge (figure 20). The absence of the upper Mesolithic horizon (context 9) in sections over 18 metres to the North-West of trench 1 suggests that the later Mesolithic deposits at this site are spatially restricted to an area approximately 45-50m around the coast. Additional evidence for the large spatial extent of this horizon comes from the borehole survey conducted as part of fieldwork in 2001, which provided evidence that this horizon continued at least 40m into the interior of the headland to the North of trench 1 (figure 21). The lower Mesolithic horizon appears to cover an even greater spatial area (> 40 x 40m). With the exception of section 6, which contained no archaeological deposits, the lower Mesolithic horizon was present in all of the sampling locations on the North-West and North-East transects (sections 1-15), as well as in all of the successful cores in the bore hole survey (cores B, F, H and J). This suggests that these buried early-mid Holocene land surfaces are preserved over a considerable area of the Toe Head peninsula and most probably extend beyond the sampled area. Within this landscape, the artefactual and ecofactual concentrations in and around Northton Trench 1 appears to represent a discrete location of activity.

Table 17: Radiocarbon dates from excavations at Northton in 2001 (Gregory et al 2005) and 2010 (P. Ascough, unpublished data). The radiocarbon dates from the 2010 excavations formed part of an on-going research project, led by Philippa Ascough of SUERC, investigating the variability in the Marine Reservoir Effect across the North Atlantic (cf. Ascough et al 2009). The dates were calibrated using Oxcal 4.1 (Bronk Ramsey 2009) using IntCal 09 (Reimer et al 2009).

Reporting Number	Sample details	Sample material	Age BP	δ13C (‰)	Calibrated Date (95.4% probability)
AA-50332	NT'01 C.5 (=NT'10 C.9)	Hazel nutshell	7525 ± 80	-24.4	6559-6226 cal BC
AA-50333	NT'01 C.5 (=NT'10 C.9)	Hazel nutshell	7395 ± 45	-23.7	6396-6103 cal BC
AA-50334	NT'01 C.5 (=NT'10 C.9)	Hazel nutshell	7420 ± 45	-24.1	6406-6220 cal BC
AA-50335	NT'01 C.7 (=NT'10 C.16/17)	Hazel nutshell	7980 ± 50	-24	7051-6699 cal BC
AA-50336	NT'01 C.7 (=NT'10 C.16/17)	Hazel nutshell	7925 ± 55	-26.3	7033-6657 cal BC
SUERC-33736	NT'10 C.14	Hazel nutshell	7470 ± 30	-23.5	6421-6249 cal BC
SUERC-33737	NT'10 C.14	Hazel nutshell	7440 ± 30	-23.3	6391-6240 cal BC
SUERC-34911	NT'10 C.14	Hazel nutshell	7460 ± 40	-25	6416-6241 cal BC
SUERC-34912	NT'10 C.14	Hazel nutshell	7400 ± 40	-21.9	6395-6117 cal BC
SUERC-34913	NT'10 C.14	Limpet shell	5070 ± 35	1.5	n/a - used to establish Marine Reservoir Effect
SUERC-34914	NT'10 C.14	Limpet shell	5080 ± 35	0.5	n/a - used to establish Marine Reservoir Effect
SUERC-34915	NT'10 C.14	Limpet shell	5105 ± 35	1.4	n/a - used to establish Marine Reservoir Effect
SUERC-34916	NT'10 C.14	Limpet shell	5085 ± 35	1.2	n/a - used to establish Marine Reservoir Effect

Figure 20: Topographic survey of the Northton headland, showing the location of 2010 trench 1, 2011 sections 1-17, the 2001 borehole locations (A-J) and the earthworks identified on the machair surface. The survey was conducted by Claire Nesbit, Durham University.

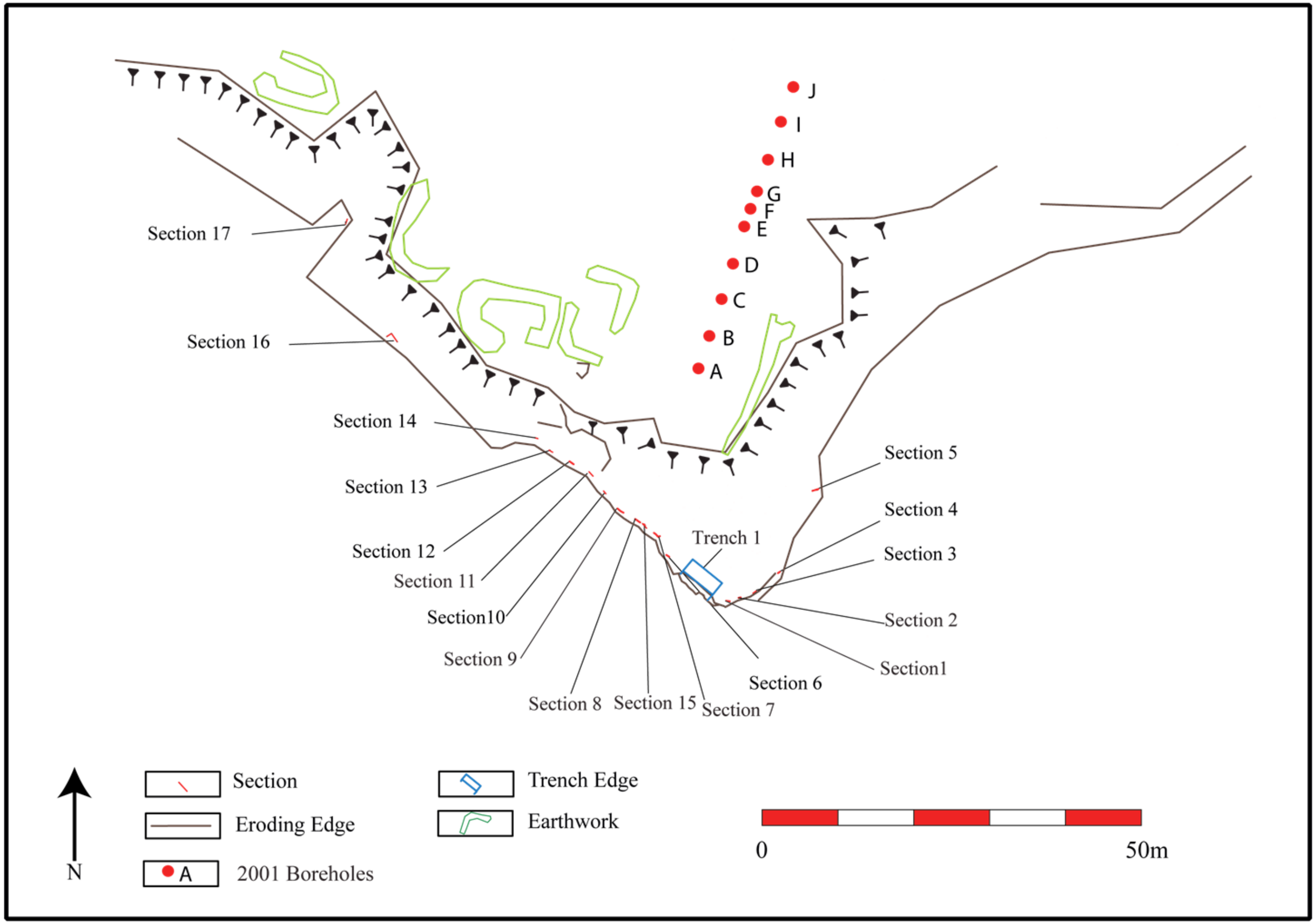
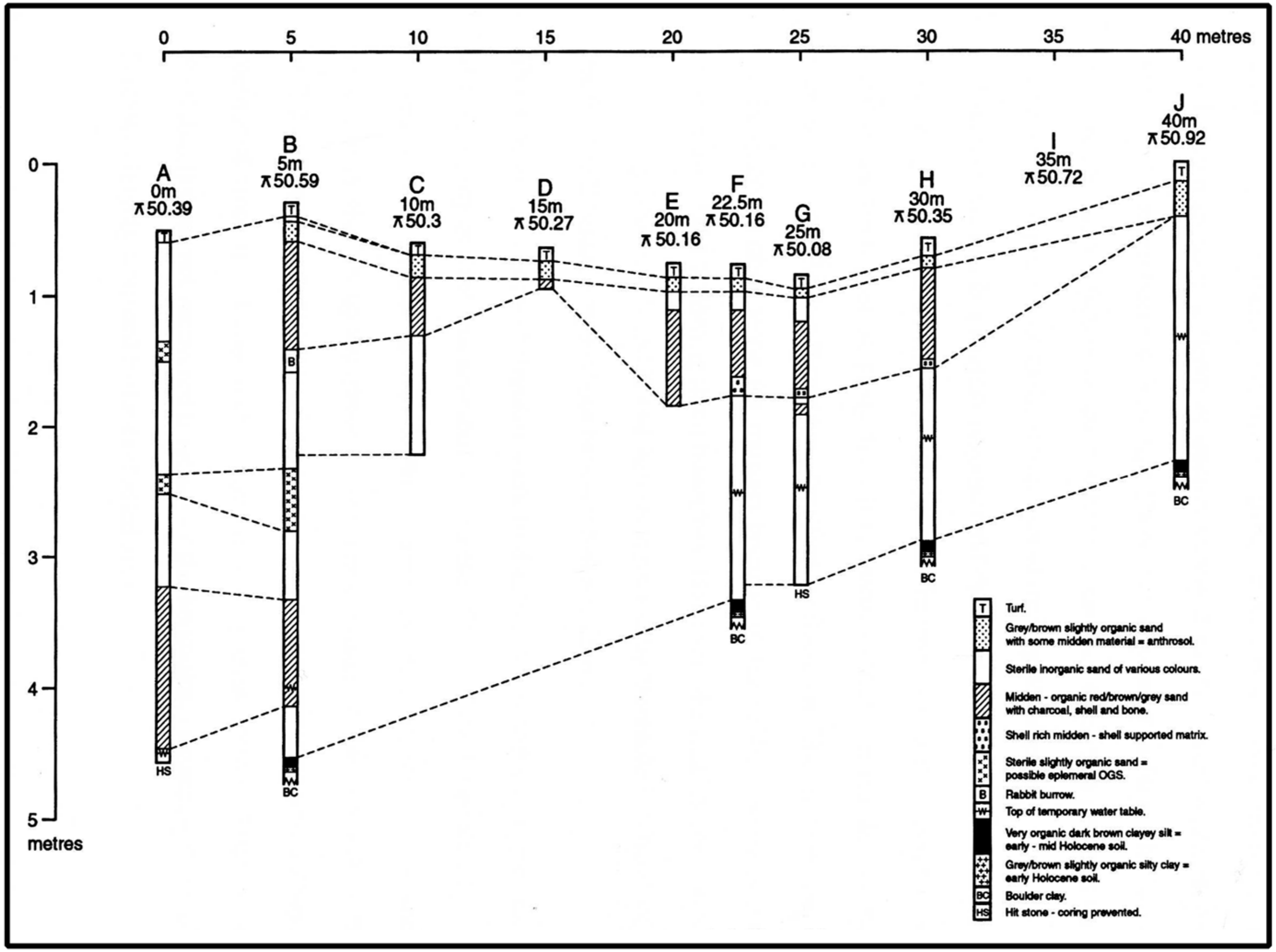


Figure 21: Results of the borehole survey, conducted in 2001 by Mike Church, Durham University (After Murphy et al 2001a).



6.2 Methodology

6.2.1 Field methods

A small trench (2 x 5 m) was laid out along the eroding edge of the exposed Mesolithic horizons, with the long axis of the trench running parallel to the now-eroded 'large section' identified by Simpson et al (2006a) in 2001. Due to time constraints, it was not possible to excavate and sample the entire trench to the glacial till, and though the whole trench was excavated to the surface of the upper Mesolithic horizons, only a 1 x 5m area adjacent to the eroding edge was completely excavated. The excavation was undertaken by hand and all deposits encountered were fully excavated using standard archaeological excavation methods. A single context recording system was used and finds were located in three dimensions relative to the site grid. Plans were drawn at 1:20, sections at 1:10 and digital photographs were taken. Following Ballin (2009:90), unworked, as well as worked quartz was kept for specialist analysis.

A 100% sampling strategy was adopted and so all the excavated archaeological deposits were collected as bulk samples for specialist analysis. The windblown sand layers (phases 1 and 2) were clearly non-anthropogenic and consequently bulk samples were not taken from these horizons (figure 18). This intensive sampling strategy was employed for several reasons. Firstly, since plant remains are typically present in low densities on Mesolithic sites (see chapter 2) and one if the main aims of the excavation was to produce a large sample of archaeobotanical material for analysis, it was considered necessary to process a large volume of soil (cf. Wright 2005:19). Secondly, as mentioned previously, the site is threatened by coastal erosion and as it is the first discovered Mesolithic site in the Western Isles, it was clearly important to take as large a sample as possible before the site is further destroyed.

The soil from the bulk samples was processed using a Siraf-style flotation tank (Kenward et al 1980; Williams 1973), with the residue caught in a 1 mm mesh and the flot in 1.0 mm and 0.3 mm sieves. It has been noted that large-scale flotation methods can fragment fragile root/tuber remains (Hather 2000a:74). However, due to logistical reasons it was not feasible to process all of the samples using small-scale manual methods. Since a large volume of soil was excavated and because of the restricted time available on site, there was not sufficient time to process the samples using manual methods whilst in the field. Equally, it would not have been possible to transport all the samples (c. 890 litres) to Durham from the Western Isles without processing. Consequently, as one of the aims of the excavation was to establish whether edible tubers/roots were present in the Mesolithic horizons, a 10-20l subsample from each of the non-disturbed Mesolithic contexts (contexts 9, 16, 17) was taken for bucket flotation in the laboratory. The flots and residues from the samples processed on site were air-dried before transportation back to the environmental laboratories in the Archaeology Department at Durham University for post-excavation analysis.

6.2.2 Laboratory methods

6.2.2.1 Sample processing and sorting

The time available precluded the identification of all the remains from all of the samples and so the remainder of this chapter will focus exclusively on the plant remains recovered from context 9, the main undisturbed horizon from the Upper Mesolithic site phase, dated to 6559-6103 cal BC. Two samples were taken from this context: sample 21, which was processed using a flotation tank as described above, and sample 31, which was floated in a bucket using the wash-over technique (Kenward et al 1980:9; Pearsall 2000:16), using a 0.3mm sieve for the flot and a 1mm sieve for the residue.

Experiments have shown that plant macrofossil recovery rates from Siraf and the similar ‘SMAP’-style flotation systems can vary considerably, sometimes according to soil clay or moisture content, and though in general usually more than 80% of plant macrofossils are successfully recovered from flots, there are instances where less than 50% of plant macrofossils have been recovered using these methods (Church 2002b:42; Pearsall 2000:95; van der Veen 1983; Wagner 1988:24; Wright 2005). Consequently, in order to ensure high recovery rates of archaeobotanical remains from the samples and to reduce residue sorting time, a secondary reflot of the dried residues was undertaken in the laboratory (van der Veen 1983; Wagner 1988:21) using the wash-over technique (Kenward et al 1980:9; Pearsall 2000:16) with a 1mm sieve. Fragile bone was removed from the residues prior to refloation. Considering that a 1mm sieve was used for the basal mesh in the original flotation system, in samples with poor flotation recovery rates it is probable that charred plant material <1mm will be underrepresented (ibid). However, previous research suggests that little additional information is gained from studying the <1mm fraction (Smith 1999:336) and so this was not considered to be a major problem.

After reflotation, the reflots were air dried and combined with the flots prior to sorting. The flots were then separated into >4mm (4F), 2-4mm (2F), 1-2mm (1F) fractions using geological sieves and sorted using a Leica M80 stereo microscope under x7.5-60 magnification. Time precluded the sorting of the 0.3mm flot, but as previously noted past research suggests that little additional information is gained from sorting this fraction (Smith 1999:336). Table 18 summarises the plant material sorted from each sieve fraction.

Table 18: Material sorted from each sample fraction. C: count; W: weigh; 4F: 4mm flot; 4R: 4mm residue; 2F: 2mm flot; 2R: 2mm residue; 1F: 1mm flot; 1R: 1mm residue; *: subsample examined.

	4F	2F	1F	4R	2R	1R
Charcoal	CW					
Carbonised seeds	C	C	C	C	C	C
Tuber/ root/ parenchyma	C	C	C	C	C	C
Culm node	C	C	C	C	C	C
Culm base	C	C	C	C	C	C
Culm fragment	C	C	C	C	C	C
Buds/catkins	C	C	C	C	C	C
Nutshell	CW	C*W	W*	CW	C*W	W*
Amorphous plant material (burnt peat)	CW			CW		
Other carbonised plant material	C	C	C	C	C	C
Uncarbonised plant remains						

All hazelnut shell was extracted from the 4mm and 2mm flots from both samples, but due to the abundance of very small fragments within the 1mm flots only a subsample of the 1mm flot from sample 21 was sorted for nutshell. A riffle box (van der Veen and Fieller 1982:290) was used to create a reasonable sized sub-sample (12.5%) for sorting in the available time. Using the estimate for the total mass of nutshell in sample 21 divided by the number of litres, an estimate for the mass of nutshell in the 1mm fraction of sample 31 was calculated. Charcoal was only sorted from the >4 mm fraction, as identification is very difficult below this size (Pearsall 2000:130). Uncarbonised plant macrofossils were removed from the samples but not recorded due to the absence of waterlogged conditions at the site.

The residues were sorted by eye to 4mm and the 2mm fraction was sorted under a microscope to ensure the comprehensive recovery of heavy plant macrofossils, such as hazelnut shell. A 6.25% sub-sample of the 1mm residue from sample 21 was created using a riffle box (van der Veen and Fieller 1982:290) and this sub-sample was completely sorted to estimate the quantity of plant macrofossils present in the 1mm fraction (table 19). The 1mm residue of sample 31 was sorted under a microscope and all material, except hazelnut shell was removed. The quantity of nutshell present in the 1mm residue from sample 31 was estimated using the sub-sample from sample 21 using the same method as described above for the 1mm flot. Whilst recovery rates suggest that a greater proportion of nutshell was recovered in the flot for sample 31 than sample 21 (table 20), this difference should not have affected the estimate of the overall quantity of 1mm nutshell calculated for sample 31.

Table 19: Quantification of the plant macrofossils present in the 1mm residue from Northton 2010 using the 6.25% subsample from sample 21. Asterisks indicate figures calculated using the subsample.

Sample number	21	21	21	31
Context number	9	9	9	9
Sample volume (litres)	413	413	413	10
	6.25% subsample	100% sample estimate	id/ litre	100% sample estimate
1R hazelnut shell (mass in grams)	6.21	**99.28***	0.24	**2.4***
Seed/tuber epidermis (plus small part of interior) (1R)	1	**16***	n/a	n/a
Indeterminate culm node (1R)	1	**16***	n/a	n/a
Indeterminate culm base (1R)	1	**16***	n/a	n/a
indeterminate culm fragment (1R)	24	**384***	n/a	n/a
Indet glassy/vesicular tuber/root (1R)	2	**32***	n/a	n/a

All plant macrofossil identifications were made using botanical literature (Anderburg 1994; Beijerinck 1947; Berggren 1969, 1981; Cappers et al 2006; Hather 1993, 2000a; Long 1929) and modern reference material from the Department of Archaeology, University of Durham. Nomenclature follows Stace (1997), and ecological information was taken from Stace (1997), Clapham et al (1987) and Pankhurst and Mullin (1991). Ethnobotanical information was obtained from the sources in appendix 1. Both whole and fragmented seeds and tubers were counted, but they were quantified separately. Hazelnut shell was recorded using the detailed methodologies outlined in appendix 2.

During sample sorting, fragments of charred parenchyma were separated into different types of fragment, according to the different categories of plant storage parenchyma present (Hather 2000a) and these general fragment categories were checked by Dr Jon Hather, formerly of University College London. As will be made apparent in the discussion of the results below, it was possible to identify many of the parenchyma fragments by gross morphology and further identification under higher magnification was not necessary. However, some of the fragments would require an SEM for full identification. Considering the wide scope of this PhD research, the lack of practical expertise of the author in parenchyma identification and the time available, the identification of this material was considered to be outwith the immediate confines of this research project. Consequently, material that could not be identified by gross morphology, but was considered suitable for further identification under SEM was separated, ready for future specialist analysis, but was not identified at this stage. Likewise, charcoal was sorted from the flots, but not identified as part of this research, because it was not considered that the identification of the charcoal fragments to species would add significantly to the identifications made in the 2001 excavations (Cressey 2006). Moreover, an initial evaluation of the material suggested that the preservation was insufficient to allow detailed analysis of pith-bark ring counts necessary for identifying woodland management strategies (see chapter 1).

6.2.2.2 Hazelnut shell recording from Temple Bay and Tràigh na Beirigh

This section outlines the detailed methodologies used to quantify the hazelnut shell from the Mesolithic sites at Temple Bay and Tràigh na Beirigh, Western Isles, excavated by archaeologists from Durham University in 2011 (Blake et al 2012a, b; Church et al 2012a, b). The overall aim of the analysis of the nutshell from Temple Bay and Tràigh na Beirigh was to quantify and record the preservation in detail, to provide a comparison with the nutshell results from Northton. The hazelnut shell quantification from these sites was conducted by MSc students (Jamie Joyce and Nikki Chiampa) in the Department of Archaeology, Durham University in 2012 under the supervision of the author and Dr Mike Church. Background information about these sites is given in chapter 2, table 2.

During the small-scale excavations conducted at these sites in 2011 a 100% sampling strategy was adopted and so all the excavated archaeological deposits were collected as bulk samples for specialist analysis. Samples from both sites were floated in the laboratory at the Department of Archaeology, University of Durham in a bucket using the wash-over technique (Kenward et al 1980:9; Pearsall 2000:16), using a 0.3mm sieve for the flot and a

1mm sieve for the residue. After drying, the residues were refloated using the same technique, to ensure the comprehensive recovery of nutshell and to reduce residue sorting time. The hazelnut shell was sorted by eye from the 4mm residues and the 2mm residues were sorted under a Leica M80 stereo microscope at x7.5-60 magnification. Both the 4mm and 2mm flots and residues from Temple Bay were sorted for hazelnut shell, but due to time restrictions, only the 4mm fraction from the Tràigh na Beirigh samples was sorted for hazelnut shell. All sorted fragments from both sites were recorded using the preservation and quantification criteria as described in appendix 2. However, though the number of bases/apexes were only counted for the >4mm fragments in the assemblages from Northton and Tràigh na Beirigh, due to the small number of fragments in the Temple Bay assemblage, it was possible to count the total number of nutshell fragments with bases and apexes >2mm. This enabled the accuracy of only counting the >4mm bases/apexes to be assessed, through a comparison with the results from the other sites. Additionally, a small-scale hazelnut preservation experiment was undertaken to understand the taphonomy of the nutshell from the three sites: the methodologies used are described in detail in appendix 3.

6.3 Results

6.3.1 Flot and residue recovery rates

Calculation of flot and reflot recovery rates has shown that at least 98% of the carbonised seeds in the samples were successfully recovered using both manual bucket flotation and using the Siraf-style flotation tank (table 20). The recovery of hazelnut shell was more variable, with only 66% of nutshell >2mm recovered using the flotation tank compared to 80% of nutshell >2mm recovered using manual bucket flotation. Rather than indicating that the system was inadequate for recovering carbonised plant macrofossils, the low percentage of nutshell recovered using the flotation tank is probably a reflection of the fact that nutshell is much denser than other plant macrofossils and often doesn't float (Monk and Pals 1985:79).

Table 20: Recovery efficiency of flotation methods.

Sample	Context	Sample volume (litres)	Soil description	Soil wetness prior to processing	Flotation method	Flot + reflot recovery (% of >2mm nutshell)	Flot + reflot recovery (% of seeds)
21	9	413	Black organic sandy clayey silt	damp-wet	Siraf-style flotation tank	66.33	97.96
31	9	10	Black organic sandy clayey silt	damp-wet	Manual/wash-over bucket flotation	80.41	100

6.3.2 Hazelnuts

6.3.2.1 Quantification

Considering the depositional and post-depositional factors involved in the preservation of nutshell in archaeobotanical assemblages (see chapter 2), it could be argued that providing a detailed method of hazelnut shell quantification to estimate the number of whole nuts is a pointless exercise. Yet, due to the extreme fragmentation of nutshell in many assemblages, it can often be difficult to assess whether very large or very small quantities of nuts are represented. Converting the amount of nutshell to a number of nuts can therefore provide a useful figure for characterising an assemblage. For instance, it is important to know whether the amount of nutshell recovered is likely to represent the mass gathering and processing of nuts on site or the casual charring of a handful of nuts during the consumption of a tasty snack! In practice, medium-low levels of nut exploitation are probably impossible to differentiate, but it should in theory be possible to identify when large-scale nut processing and consumption have taken place.

The overall results of the hazelnut shell quantification in the Northton assemblage are shown in table 21 and the detailed results of the nutshell quantification for Northton, Temple Bay and Tràigh na Beirigh are discussed in appendix 2. A summary of the results is presented here. Using the methods described in appendix 2, it has been estimated that the Northton assemblage contained approximately 570-85 nuts, whereas the examined samples from Temple Bay and Tràigh na Beirigh probably contained less than 25 whole nuts. It should be noted that the large difference in the number of nuts represented between these sites might be purely a consequence of the vastly different sample volumes processed. This is supported by the fact that very similar nut densities (mass per litre) were produced for the three sites (appendix 2).

Table 21: Non-parenchymous plant macrofossil results from Northton 2010. F: fragment; 4F: 4mm flot; 4R: 4mm residue; 2F: 2mm flot; 2R: 2mm residue; 1F: 1mm flot; 1R: 1mm residue. Bold text and asterisks indicate figures that incorporate totals calculated using a subsample.

Sample number			21	31
Context number			9	9
Sample volume (litres)			413	10
Nuts				
Corylus avellana L.	Hazel	4F/4R nutshell (no. of fragments)	264F	12F
Corylus avellana L.	Hazel	4F/4R nutshell (mass in grams)	10.182	0.238
Corylus avellana L.	Hazel	2F/2R nutshell (no. of fragments)	**8484F***	293F
Corylus avellana L.	Hazel	2F/2R nutshell (mass in grams)	65.549	2.044
Corylus avellana L.	Hazel	1F/1R nutshell (mass in grams)	**160.144***	**3.87***
Corylus avellana L.	Hazel	4F/4R/2F/2R/1F/1R nutshell (mass in grams)	**235.875***	**6.15***
cf. *Corylus avellana* L.	Hazel?	kernel?	4F	
Seeds				
Bromus sp.	brome	caryopsis	3	
Carex sp. (trigonous)	trigonous sedge	nut	6	
Fabaceae	pea family	seed	5+12F	
Galium aparine L.	Cleavers	nutlet	3+7F	
Rumex sp.	dock	achene	2	
Stellaria neglecta Weihe	Greater Chickweed	seed	1	1
Stellaria cf. *neglecta* Weihe	Greater Chickweed?	seed	1	
Stellaria sp.	stitchwort	seed	2	
cf. *Stellaria* sp.	stitchwort?	seed	14 +1F	
Vicia/Lathyrus sp.	vetch/tare	seed	10+1F	
cf. *Vicia/Lathyrus* sp.	vetch/tare?	seed	1	
indeterminate	indeterminate	seed / fruit	2	
indeterminate	indeterminate	seed / fruit?	95	7
indeterminate	indeterminate	seed/tuber epidermis (plus small part of interior)	**192F***	19F
Chaff				
cf. Poaceae	grass?	culm node (2F/2R)	44	1
cf. Poaceae	grass?	culm node (1F/1R)	**113***	
cf. Poaceae	grass?	culm base (2F/2R)	16	
cf. Poaceae	grass?	culm base (1F/1R)	**84***	1
cf. Poaceae	grass?	culm (1F/2F/1R/2R)	**905F***	12F
Other plant macrofossils				
indeterminate	indeterminate	buds (2F)	2	
indeterminate	indeterminate	buds/catkins (1F)	3	
indeterminate	indeterminate	fruiting capsule	1	
indeterminate	indeterminate	amorphous plant material (4R)	1F	
Cenococcum sp.	fungal sclerotia	fungal sclerotia	2	

6.3.2.2 Preservation and fragmentation

The hazelnut shell assemblage from Northton contained a mix of poorly-preserved and fairly well-preserved fragments, with 53% of the hazelnut fragments in sample 21 falling within the worst two classes of preservation (P3 and P4) and 47% of the fragments being classed as fairly well preserved (P2) (figure 22a, b). Though there appeared to be little difference between the preservation of hazelnut shell in the flots and residues, the 4mm fractions were slightly better preserved than the 2mm fractions (figure 22a). In contrast, the assemblages from Temple Bay and Tràigh na Beirigh were more poorly preserved with at least 95% of fragments from both sites classed as poorly preserved or barely identifiable (P3 and P4) (figure 22b).

The nutshell from all three sites was highly fragmented and no complete or half shells were recovered from any of these sites. Overall, less than 15% of the nutshell fragments derived from the 4mm sieve fractions and over 92% of fragments examined from all three sites represented <12.5% of a whole nutshell (figures 23 and 24). It should be noted that the percentages in figure 23 were calculated using the number of fragments >2mm in each size category and so the >12.5% fraction would have been even smaller if the 1mm fraction had been included. The highly fragmented nature of the nutshell from Northton is further highlighted by the fact that there was a very high proportion (68%) of fragments in the 1mm fraction (figure 24a). Moreover, consideration of the number and mass of fragments per litre, shows that though context 9 at Northton contained more than double the number of fragments per litre than Temple Bay, the total mass of fragments per litre was very similar (appendix 2). This suggests that the Northton assemblage was more fragmented than the Temple Bay assemblage. There is no significant difference in the fragmentation of nutshell between samples 21 and 31.

Consideration of the mean percentage of worn edges per fragment at Northton shows that a fairly high proportion of this fragmentation was caused during excavation and sample processing (figure 25). Though most fragments have edges that are predominantly worn, in comparison to Temple Bay and Tràigh na Beirigh, there is a much higher level of modern nutshell fragmentation. However, of the examined fragments, there appears to be little difference in the level of modern fragmentation between the 4mm and 2mm flots and residues from sample 21.

Thus, overall, the assemblage from Northton appears to contain the highly fragmented remains of approximately 570-585 hazelnuts, which were poor to fairly well-preserved. By contrast, the samples from Temple Bay and Tràigh na Beirigh contained the remains of less than 25 poorly-preserved and highly fragmented hazelnuts.

Figure 22: Hazelnut shell preservation in Mesolithic assemblages from the Western Isles of Scotland compared to modern experimental data: (a) Preservation of hazelnut shell in residue and flot fractions of sample 21, context 9 from the Northton 2010 excavation. 4F: 4mm flot, 4R: 4mm residue, 2F: 2mm flot, 2R: 2mm residue, (b) comparison of hazelnut shell preservation between Northton 2010 (sample 21), Temple Bay 2011 (samples 2,3,5,7,8), Tràigh na Beirigh 2011 old ground surfaces (samplse 13,15) and Tràigh na Beirigh 2011 shell midden (samples 6,8,11,12), Western Isles, (c) Results of trial hazelnut preservation experiments, showing the difference in preservation between hazelnuts charred in open hearths and roasting pits (see appendix 3 for a description of the methodologies used).

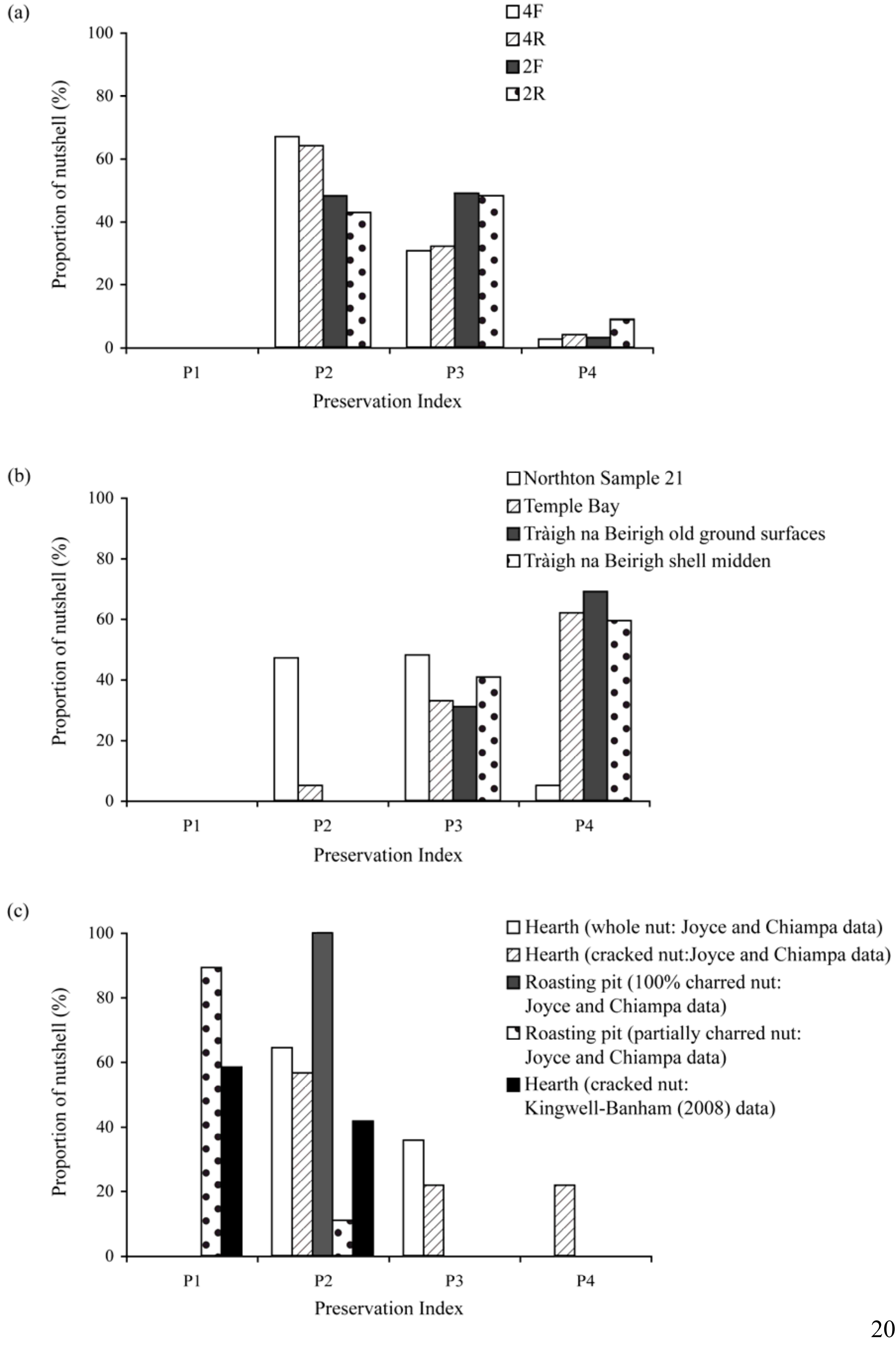


Figure 23: Hazelnut shell fragment sizes in Mesolithic assemblages from the Western Isles of Scotland compared to modern experimental data: (a) comparison of hazelnut shell fragment sizes between sample 21, context 9 (processed with a flotation tank) and sample 31, context 9 (processed in a bucket), (b) comparison of hazelnut shell fragment sizes between Northton 2010 (samples 21 and 31), Temple Bay 2011 (samples 2,3,5,7,8), Tràigh na Beirigh 2011 old ground surfaces (samples 13,15) and Tràigh na Beirigh 2011 shell midden (samples 6,8,11,12), Western Isles, (c) results of a trial hazelnut fragmentation experiment, showing the difference in hazel nutshell fragment size between hazelnuts charred on a hearth and in a roasting pit (see appendix 3 for a description of the methodologies used).

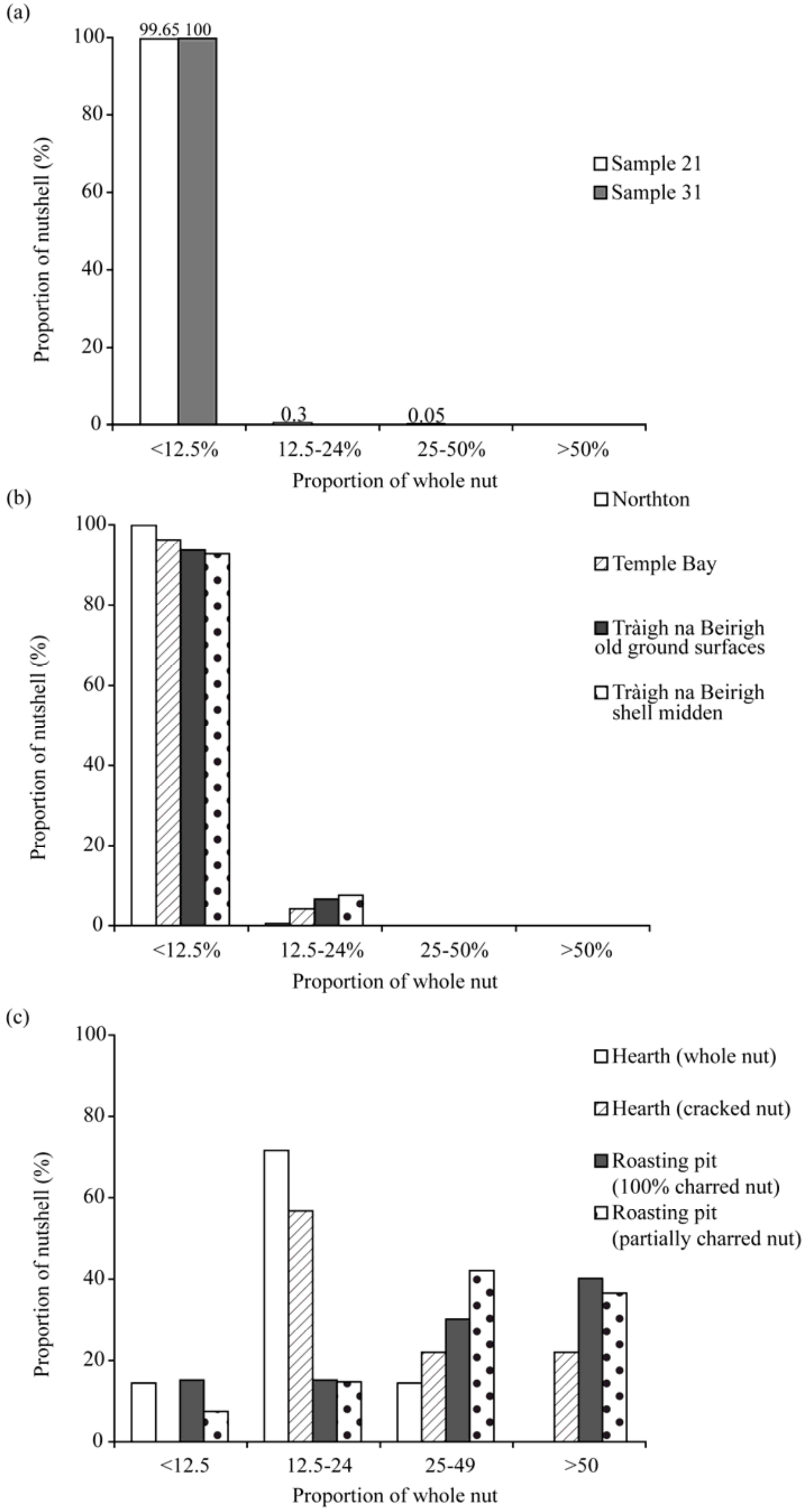


Figure 24: Proportion of hazelnut shell in different sample sieve fractions in Mesolithic assemblages from the Western Isles and Inner Hebrides compared to modern experimental data: (a) proportion of hazelnut shell in different sample sieve fractions of Northton 2010 sample 21, context 9, calculated using the total mass of fragments, (b) comparison of the proportion of hazelnut shell fragments in different sample sieve fractions of Northton 2010 sample 21, context 9 (processed with a flotation tank), Northton 2010 sample 31, context 9 (processed in a bucket) and Temple Bay 2011 (samples 2,3,5,7,8), calculated using the total number of fragments >2mm, (c) comparison of the proportion of hazelnut shell in Northton 2010 (samples 21 and 31), Temple Bay 2011 (samples 2,3,5,7,8), Western Isles, Staosnaig F24 (context 17), Inner Hebrides, and modern experimental data from Carruthers (2000), calculated using the total mass of fragments >2mm.

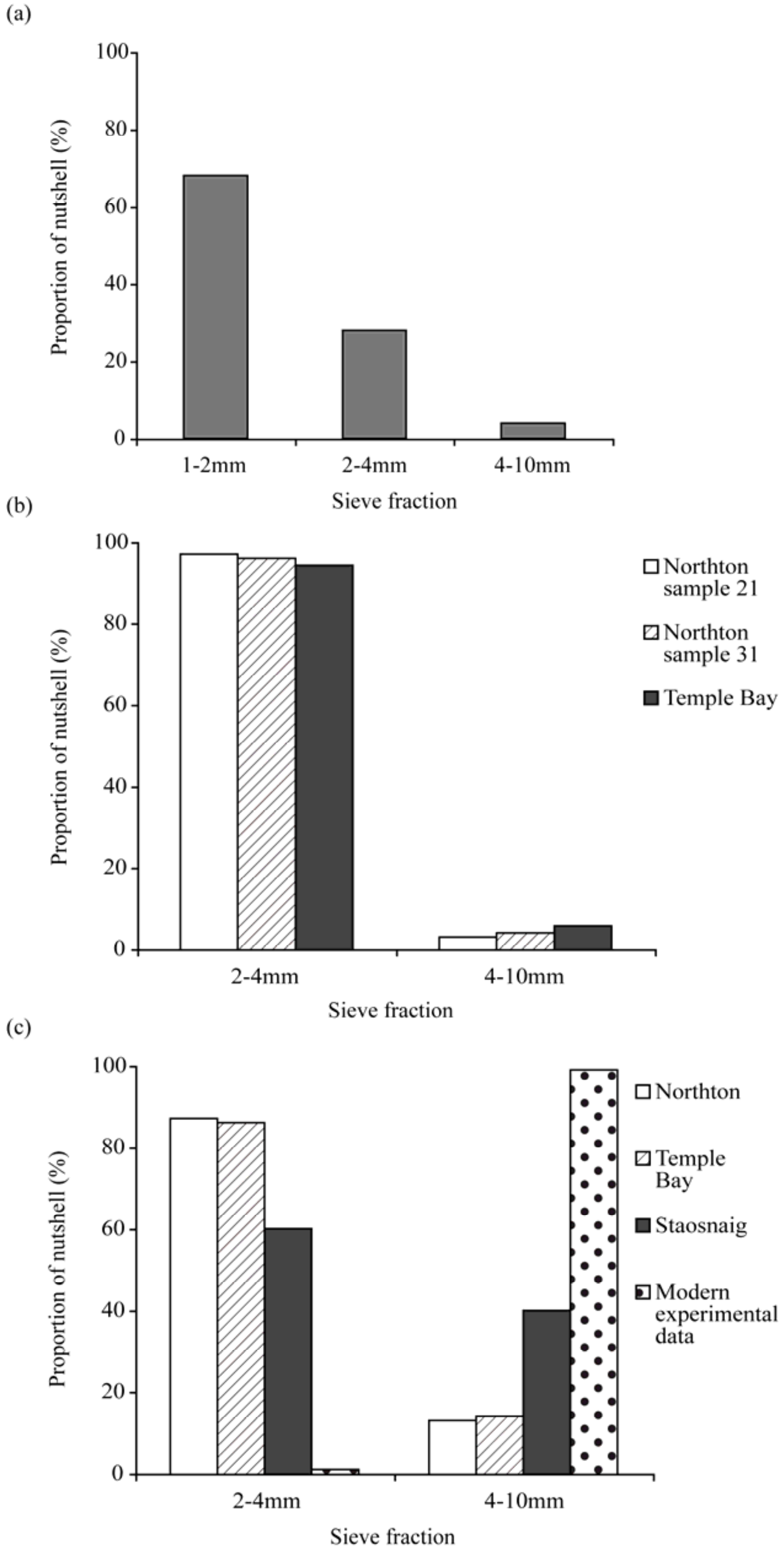
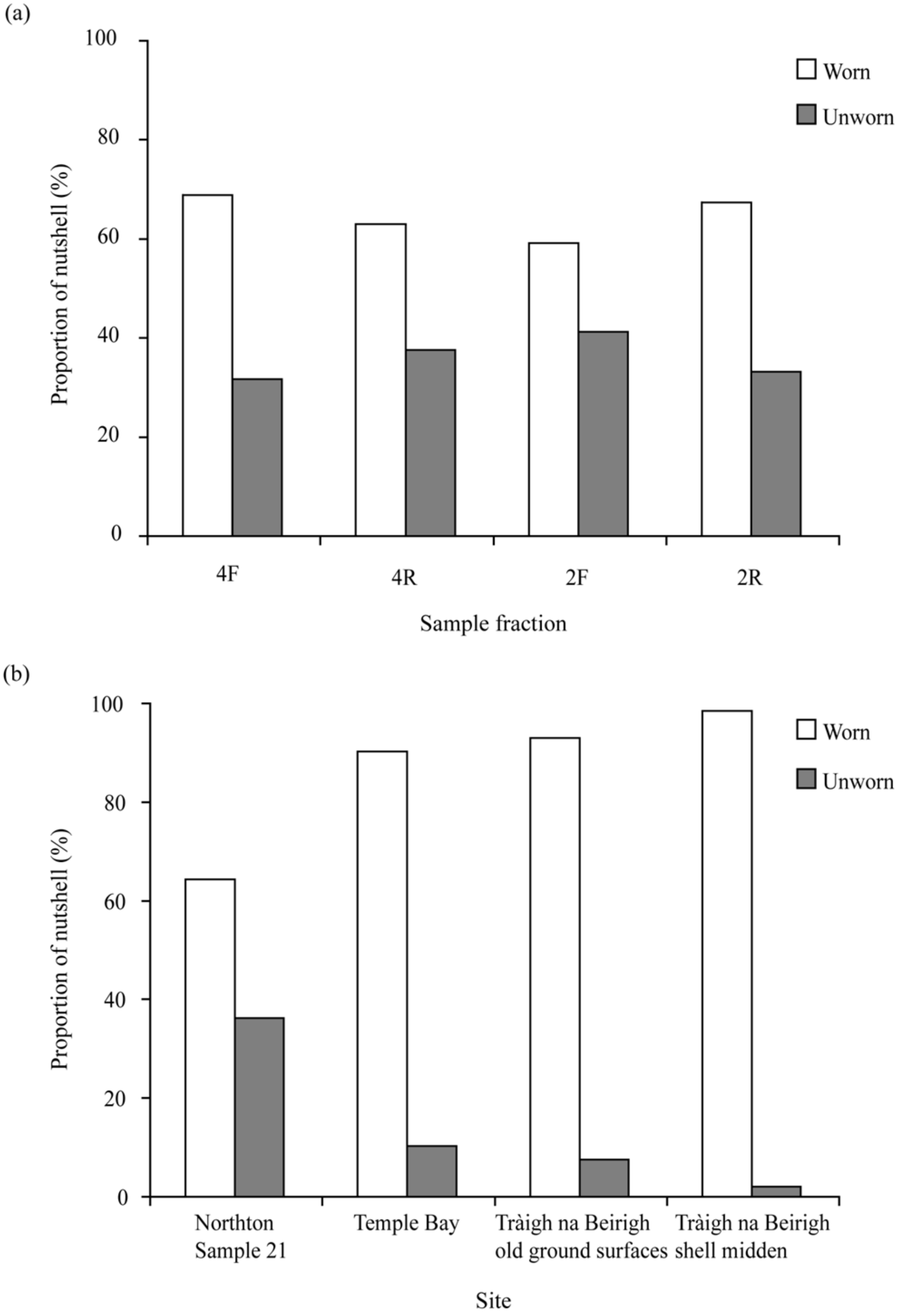


Figure 25: Level of modern hazelnut shell breakage in Mesolithic assemblages from the Western Isles of Scotland: (a) level of modern hazelnut shell breakage in residue and flot fractions of sample 21, context 9 from the Northton 2010 excavation. 4F: 4mm flot, 4R: 4mm residue, 2F: 2mm flot, 2R: 2mm residue. (b) comparison of the level of modern hazelnut shell breakage between Northton 2010 (sample 21), Temple Bay 2011 (samples 2,3,5,7,8), Tràigh na Beirigh 2011 old ground surfaces (samples 13,15) and Tràigh na Beirigh 2011 shell midden (samples 6,8,11,12), Western Isles.



6.3.3 Seeds

Despite the large volume of samples processed, only a small number of seeds were recovered from the Northton samples (table 21). However, the assemblage contained a notable concentration of seeds from the fabaceae family and in particular, vetch/tare seeds. Seeds from the stitchwort family (*Stellaria* sp.) were also fairly frequent, but the extremely poor level of preservation of these seeds prevented the identification of most of these seeds to species level. Having said this, considering that one of these seeds was positively identified as Greater Chickweed (*Stellaria neglecta* Weihe) and another as a possible Greater Chickweed (*Stellaria* cf. *neglecta* Weihe) seed, it is possible that many of the Stitchwort family seeds were also from this species. Fragments and whole nutlets of Cleavers were also well represented in the assemblage, but all other species were extremely sparse and comprised only occasional identifications of: brome (*Bromus* sp.), sedge and dock.

A sizable concentration of poorly preserved seed/tuber epidermal fragments and possible seeds were also present in the assemblage. Due to the highly fragmented nature and poor preservation of the epidermal fragments, it was not possible to be certain whether the fragments were originally derived from seeds or tubers. Similarly, the size and shape of the possible seeds was suggestive of indeterminate carbonised seeds, but the extremely poor preservation of this material, in particular the absence of surface features, meant that it was not possible to rule out the possibility that these were carbonised wood sap remains.

6.3.4 Other non-parenchymatous plant macrofossils

Culm nodes, culm bases and culm fragments were particularly prevalent in the samples and these most probably derive from plants of the grass family. Other plant components were extremely scarce and consisted of several indeterminate buds/catkins, a fruiting capsule and a single fragment of amorphous plant material, which may be a remnant of burnt turf.

6.3.5 Parenchymatous plant remains

The parenchymatous plant macrofossil results are shown in table 22.

Table 22: Parenchymatous plant macrofossil results from Northton 2010. F: fragment; 4F: 4mm flot; 4R: 4mm residue; 2F: 2mm flot; 2R: 2mm residue; 1F: 1mm flot; 1R: 1mm residue. Asterisks and bold text indicate figures calculated using a subsample.

Sample number			21	31
Context number			9	9
Sample volume (litres)			413	10
Tubers/roots/rhizomes				
Ranunculus ficaria L.	Lesser Celandine	root tuber/bulbil (2F/2R)	49	1
Ranunculus ficaria L.	Lesser Celandine	root tuber/bulbil (2F/2R)	21F	1F
cf. *Ranunculus ficaria* L.	Lesser Celandine?	root tuber/bulbil (2F/2R)	5	
cf. *Ranunculus ficaria* L.	Lesser Celandine?	root tuber/bulbil (2F/2R)	33F	
Ranunculus ficaria L.	Lesser Celandine	root tuber/bulbil (1F/1R)	53	4
Ranunculus ficaria L.	Lesser Celandine	root tuber/bulbil (1F/1R)	25F	
cf. *Ranunculus ficaria* L.	Lesser Celandine?	root tuber/bulbil (1F/1R)	130F	3F
cf. *Lathyrus linifolius* (Reichard) Bässler	Bitter-vetch?	root tuber (4F)		1
cf. *Lathyrus linifolius* (Reichard) Bässler	Bitter-vetch?	root tuber (2F)		2+1F
indeterminate	indeterminate	cf. secondary root/tuber (4F/4R)	3F	
indeterminate	indeterminate	cf. monocotyledon root (4F/4R)	3F	
indeterminate	indeterminate	cf. 2F/2R parenchyma fragments (possibly further identifiable under SEM)	50F	4F
indeterminate	indeterminate	glassy/vesicular parenchyma fragments (2F/2R)	29F	3F
indeterminate	indeterminate	cf. secondary root/tuber (2F/2R)	2F	
indeterminate	indeterminate	cf. monocotyledon root (2F/2R)	4F	
indeterminate	indeterminate	cf. 1F parenchyma fragments (possibly further identifiable under SEM)	179F	3F
indeterminate	indeterminate	glassy/vesicular parenchyma fragments (1F/1R)	**156F***	2F
indeterminate	indeterminate	cf. 1F parenchyma fragments (small, poorly preserved, irregular fragment, too small for further identification)	61F	
indeterminate	indeterminate	cf. secondary root/tuber (1F)	5F	1F
indeterminate	indeterminate	cf. monocotyledon root (1F)	1F	
indeterminate	indeterminate	cf. monocotyledon rhizome/stolon (1F)	1	
indeterminate	indeterminate	2F/1F cf. parenchyma epidermis fragment (& small amount of interior)	27F	1F

6.3.5.1 Lesser Celandine tubers/bulbils

Whole Lesser Celandine root tubers/bulbils and fragments dominated the parenchyma assemblage. The whole root tubers/bulbils were identified using low-powered microscopy only, on the basis of their characteristic ‘club’-like shape and/or cell structure and arrangement, which was visible on the transverse section or surface of fragments in areas where the epidermis was absent (Hather 1993:22-23; Mason and Hather 2000:417). A quantity of small internal fragments of parenchyma showing the characteristic polygonal cell structure and arrangement of cells, were also identified as possible Lesser Celandine fragments.

Hather (2000a:14-15) suggests that it may be possible to distinguish Lesser Celandine root tubers from bulbils on the basis that the bulbils are usually smaller (<5mm) and more pointed at one end than the root tubers, which are usually >5mm in size. However, the examination of modern reference material collected from Durham University woodlands suggests that there is little morphological distinction between these two plant components. Although it is acknowledged that root tubers are on average larger than the bulbils, there is an overlap in the size range and the smaller root tubers are indistinguishable from bulbils. Having said this, it is rare for bulbils to be larger than 5mm in length and so the presence of larger remains probably indicates the presence of root tubers. Although there were several Lesser Celandine remains present in the assemblage which were > 5mm in length the majority of the complete remains were <5mm long. Therefore, it seems likely that root tubers did form part of the assemblage, but it is not possible to rule out the possibility that many of the remains were bulbils rather than root tubers. Consequently, it is not possible to be certain which subspecies - ssp. *bulbilifer* Lambinon or ssp. *ficaria* - is represented (Stace 1997).

The assemblage contained a mix of well-preserved and poorly preserved whole/near complete root tubers/bulbils and fragments. Since many of the whole/near complete root tubers/bulbils had exposed transverse sections, it was possible to consider the state of the material prior to charring. Although the epidermis was often exposed to some extent and small glassy areas were present on the surface of many of the whole/near complete tubers/bulbils and many of them had small areas missing, most had well-preserved internal tissues with the complete cross-section preserved. In only a small number of pieces had the stele been pushed against the epidermis to reveal a hollow interior or had the cross-section become glassy or vesicular (Hather 1993:22-23). Likewise, most of the fragments were physically broken, but had well preserved interiors and although many of the small internal fragments had sections that were glassy/vesicular, this state was usually restricted to a small area and was never across the whole fragment. This suggests that the majority of the root tubers/bulbils were dry prior to charring (ibid) and that much of the fragmentation occurred after charring as a result of post-depositional processes.

6.3.5.2 Possible Bitter-vetch root tubers

Three whole and one half root tuber of possible Bitter-vetch were also present in sample 31 (table 22). These root tubers were identified by gross morphology only using a low-powered stereo microscope and so these identifications require confirmation with an SEM. All of the fragments had multiple approximately circular detachment scars on the sides and bases, indicative of the detachment of a fibrous root system and a protruding detachment 'stalk' towards the top of the tubers. The roughly spherical morphology of the remains strongly resembled modern reference material and although the root tubers were small (c. 3-7mm long), they were within the size range of the modern reference material examined. One of the whole root tubers had burst open on one side to reveal a hollow interior, suggesting that it had been charred in a fresh state (Hather 1993:52). Although the surface of the other two whole root tubers was dull and the interior was not exposed, the tissue inside several of the detachment scars was visible and this had become fused against the outer edge of the scar, leaving a cavity. The parenchymatous interior of the half tuber was vesicular and poorly preserved. Overall, it seems likely that these root tubers were not dry at the time of charring.

6.3.5.3 Secondary root fragments

Several fragments of possible secondary root were identified by the presence of rhexigenous formed radial cavities surrounded by glassy tissue (Hather 2000a:65). Although examination under an SEM may confirm that these fragments are derived from secondary roots, further taxonomic identification of this material is probably not possible, even with an SEM because the diagnostic characteristics will have been lost during charring (ibid:62). However, the presence of this material is important for understanding the taphonomy of the assemblage, since these radially orientated cavities only form when secondary roots are charred in a fresh state (ibid; Hather 1993:4).

6.3.5.4 Monocotyledon root/rhizome/stolon fragments

Several of the fragments examined were classed as possible monocotyledon root fragments on the basis of their cylindrical shape and pointed ends, which may indicate the presence of central steles containing vascular bundles (Hather 2000a:62) and the absence of radial cavities in the tissue, suggesting the roots had not undergone secondary thickening. In addition, a single complete monocotyledon rhizome/stolon was identified by the presence of an attachment scar on the side of the fragment. Since none of these fragments were glassy or vesicular, they may be further identifiable under SEM.

6.3.5.5 Hazelnut cotyledon

Several possible hazelnut cotyledon fragments were separated from the other parenchymatous tissues under low powered microscopy on the basis of their external morphology. These identifications are tentative and require confirmation under SEM (Mason and Hather 2000:417).

6.3.5.6 Other parenchymatous tissues

Numerous glassy/vesicular/vitreous parenchyma fragments were also present within the samples. Most of these fragments are probably too poorly preserved for further taxonomic identification, but as noted by Mason and Hather (2000:425), it is possible that other features may become apparent under SEM. The remainder of the parenchymatous tissue fragments in the assemblage could not be classified using light microscopy, and were simply counted as indeterminate fragments. Some of these fragments may be further identifiable under an SEM, but much of this material is too small and poorly preserved to allow further identification.

6.4 Discussion

6.4.1 Environmental origin of the plant remains

The taxa present in the samples grow in a range of environments, which would have been locally prevalent in Harris in the Mesolithic period (see sections 6.1.4.4 and 6.1.4.5). Several of the main identified species are indicative of wood and scrub environments: Hazel, Lesser Celandine, vetch/tare family and Bitter-vetch (Clapham et al 1987; Stace 1997). Both Lesser Celandine and vetch/tare family plants are also common in grassy areas and some *Vicia*/*Lathyrus* species are sometimes found on sand dunes, shingle, cliffs and heathland (ibid). Similarly, the *Cenococcum* sp. fungal sclerotia, commonly forms mycorrhiza with many trees, though it is also found in the upper soil in a range of soil types, including relatively dry raised bogs (Trappe 1964; van Geel 1978:102).

Brome and dock are particularly suggestive of grassland environments and both are also common in waste places/rough ground (Clapham et al 1987; Stace 1997). Additionally, dock is also found growing on heaths, open places in woods and on damp ground and some brome species also grow on dunes and shingle banks (ibid). Cleavers is a common weed in waste places and open ground, but is also often found growing in maritime shingle, bushes and scrub (ibid).

In contrast, sedge species and Greater Chickweed are both indicative of wet and damp places (ibid). Greater Chickweed is often found growing in wood-margins or by streams and sedge species usually grow in damp grassy places, fens, bogs, marshes, moorland and beside rivers/lochs (ibid).

In summary, all of the species present in the samples could have derived from open woodlands/scrub, woodland openings and grassy habitats, which would have been present within the immediate vicinity of the site. Several species are also indicators of rough ground, which may have been created by the human activities on site.

6.4.2 Taphonomy

In part, the abundance of the hazelnut shell in the samples relative to the other types of remains is probably a consequence of its good preservation in domestic hearths relative to other types of plant remains and the fact that it represents a waste product of consumption (see chapters 2 and 5 for further discussion). The over representation of the nutshell is highlighted by the presence of only 4 possible fragments of hazelnut kernel, despite the recovery of the nutshell from approximately 570-585 whole hazelnuts. Experiments have shown that charred hazelnuts are oily and crush easily to powder, suggesting that they would rarely survive archaeologically (Carruthers 2000:411; Score and Mithen 2000:512). Likewise, small seeds and moisture-rich tubers would normally be burnt to ash when exposed to fire and, as the product of consumption, they would only be charred occasionally during processing or cooking accidents (see chapter 2). Therefore the depositional taphonomy and differential preservation of each species has had a significant effect on the species representation.

A number of important site formation and post-depositional processes have also affected the nature of the assemblage. Firstly, the recovered material may represent a palimpsest of discrete occupation events, which may have spanned multiple seasons, years, decades or even centuries. Although three close radiocarbon dates have been produced for this horizon, there is little further evidence that the site represents a closely defined occupation period because the artefacts and ecofacts were scattered within the horizon and no negative features were present. Having said this, there is a narrow range of abundant species present within the samples (hazelnut shell, Lesser Celandine root tubers/bulbils, indeterminate parenchyma remains and culm material), which seems to suggest that even if the site was inhabited multiple times, the same types of activities were occurring during different periods of occupation.

Secondly, the absence of evidence for an *in situ* hearth in the trench appears to suggest that the plant macrofossils are derived from a secondary context, away from the primary location of charring. It is important to recognise that the excavation trench itself may not be in the central area of the Mesolithic occupation(s). As discussed in section 6.1.5.3, the upper Mesolithic horizons extend approximately 45-50m around the coast, but it is currently not known how far the archaeological material is spread within these old ground surfaces. Certainly, the Mesolithic archaeology did appear to extend outwith the immediate confines of the 1 x 5m trench into the 2 x 5m area that was originally opened for excavation (see section 6.2.1). However, as discussed in the introduction, it is likely that the horizon has been disturbed by bioturbation to some extent and so it is possible that post-depositional processes have destroyed the primary charring location(s). It is also likely that, in common with many other European Mesolithic sites, no formal cut or structured hearths were used (Sergant et al 2006). It may therefore be reasonable to suppose that the archaeobotanical material was charred within or in close proximity to the excavated area.

Thirdly, the excavation and sample processing procedure has also caused some fragmentation of the archaeobotanical remains. Though there was no significant difference in the level of fragmentation of hazelnut shell between the sample processed using the flotation tank and the sample processed using the wash-over technique, a large number of fragments examined had modern breakages (figure 25). It also seems likely that the flotation tank has fragmented the fragile tuber remains to some extent, because only the bucket flotation sample produced whole possible Bitter-vetch root tubers. This supports the idea that it is important to take additional samples for processing using manual techniques to recover more complete root and tuber remains (Hather 2000a).

6.4.3 Mesolithic plant exploitation

There are a number of different mechanisms that could have resulted in the carbonisation and deposition of the plant remains on site. Firstly, most of the species recovered in the samples could have been deliberately gathered for food and charred accidentally during cooking or drying for storage. For instance, several different species of brome have been processed for food by modern hunter-gatherers in North America (Ebeling 1986:197; Moerman 1998:129) and it was used historically in central Europe in times of famine (Stoličná 2000:197). This includes the native UK species, Soft-Brome (*Bromus hordeaceus* L.), which was parched, pounded and mixed with water to make porridge by the Karok peoples of North America (Moerman 1998:129). Likewise, hazelnuts and most *Lathyrus/Vicia* species seeds are also edible and have been eaten historically in Britain, mainland Europe and North America (see chapter 2 for detailed discussion). Cleavers shoots, leaves and stems can also be eaten and the nutlets can be roasted and made into a hot drink (Burrows 2005:137; Evelyn 1699:16; Grieve 1992:206-7; Hedrick 1919:285; Irving 2009:52; Mabey 2001:179; Mears and Hillman 2007:292; Phillips 1983:21; Pierpoint Johnson 1862). There is also considerable ethnographic and historic evidence for the consumption of the roots, seeds, stems and leaves of many dock and sedge species (Fenton 2000; Kuhnlein and Turner 1991; Lightfoot 1777; Mears and Hillman 2007; Moerman 1998; Tardío et al 2006).

Both of the identified root tuber species, possible Bitter-vetch and Lesser Celandine are also edible (see also chapter 2; Darwin 1996; Grigson 1975; Irving 2009; Mabey 2001; Mears and Hillman 2007; Pierpoint Johnson 1862). The fact that most of the Lesser Celandine root tubers/bulbils were well-preserved, supports the idea that they were collected for food, by suggesting that the material had already been deliberately dried or was in the process of being dried or cooked, at the time of charring (see chapter 2; Hather 1993, 2000a). The presence of possible root tubers of Bitter-vetch and the vetch/tare seeds in the samples may suggest that whole Bitter-vetch plants were harvested for both seeds and tubers. The status of the indeterminate parenchyma remains is uncertain, but secondary root tubers are rich in carbohydrates and most are edible (Mason and Hather 2000:424). Moreover, the mix of different types of parenchyma fragments in the samples points against the accidental charring of *in situ* roots/tubers growing beneath hearths.

Having said this, some of the Lesser Celandine root tubers/bulbils, the possible Bitter-vetch root tubers and many of the indeterminate parenchyma fragments were vesicular or had internal cavities suggesting that they were charred in a fresh state (Hather 1993, 2000a). Whilst the possibility of deliberate collection cannot be ruled out, the poor preservation of these fragments is also consistent with the accidental charring of roots and tubers growing on site. Likewise, many of the seeds in the assemblage could have been deposited by natural processes. For instance, Greater Chickweed is an unlikely foodstuff. Although it was not listed as poisonous in any of the books consulted, none of the references mentioned that any part of this plant was edible (see appendix 1). Many of the other seeds, in particular dock, Cleavers and brome are also indicators of waste/rough ground (Clapham et al 1987; Stace 1997), which could have been created by human activities on the site itself. Consequently they may have been deposited on site by the wind, animals or accidentally transported attached to human hair or clothing (Dark 2004:2; Minnis 1981:145; Pearsall 2000:502; Sievers and Wadley 2008:2911). This is the most likely origin of the sticky Cleavers nutlets, because the plant is usually harvested prior to nutlet formation, before the stems become stringy and bitter (Burrows 2005:50; Irving 2009:52). The infrequency of the brome, sedge and dock seeds within the samples also supports a non-anthropogenic origin for these remains.

6.4.4 Season of gathering/deposition

Although they can be collected all year round, roots and tubers are best gathered after flowering, when the most energy is stored in the roots (Cameron 1977:56; Hardy 2007:6; Mears and Hillman 2007:106-7). Bitter-vetch flowers from April-July (Clapham et al 1987:192) and therefore would have been best gathered from August onwards. The leaves of the Lesser Celandine form in mid-January and flowering occurs in March-April, after which the above-ground parts of the plant die back (Clapham et al 1987:50; Grieve 1992:180). The bulbils of the subspecies *bulbilifer* are only present during spring after flowering (Clapham et al 1987:50; Stace 1997:92; Taylor and Markham 1978:1012). Without a definite identification to sub-species, the Lesser Celandine collection period cannot be closely defined. Though the bulbils could only have been collected in May-June, the root tubers are most likely to have been collected from May-December when they are biggest. However, Irving (2009:73) notes that the tubers of Lesser Celandine, "are best when the whole plant has withered, shortly after flowering. Before this stage they are very tough; no amount of cooking would soften them." This may suggest that the Lesser Celandine root tubers/bulbils were collected in the summer.

In contrast, hazelnuts can only be gathered in September/October (Burrows 2005:23; Hill 1941:41; Mabey 2001:122) and most of the seeds of vetch/tare, Cleavers, brome, sedge and dock are available during the summer, with some species also available in the autumn (Irving 2009; Mears and Hillman 2007). Therefore, the available evidence suggests that the plant remains were gathered or accidentally accumulated on site during the summer and autumn, though the collection of the edible tubers at other times of the year cannot be discounted. Interestingly, the fish bone data from context 9 supports a summer-autumn occupation for this horizon (Blake 2011). Having said this, the seasonality of deposition of the plant remains cannot be established with any certainty, because all of the edible seeds, roots and hazelnuts could have been dried for storage and deposited at any time of the year (see chapter 2; Dark 2004). Moreover, as most flowering plants do not produce seeds or nuts over the winter, it is not possible to rule out winter occupation (ibid:42). Also, since the site may represent a palimpsest of activity from multiple visits, it may have been occupied in different seasons in different years.

6.4.5 Mesolithic plant processing and cooking: roots/tubers and seeds

The abundance of grass culm fragments, nodes and bases within the samples is particularly important for understanding the processes which resulted in the carbonisation of the archaeobotanical remains. It is possible that this material represents the waste product of the processing of the brome caryopses for consumption, with the presence of the culm bases suggesting that the Poaceae culms had been harvested by uprooting the entire plant (Hillman 1981b:149). However, it is unusual for such a large quantity of culm fragments to be preserved during grain processing, as this fragile and highly flammable material is usually quickly destroyed once in contact with fire. This suggests that the culm material was preserved at a low temperature in reducing conditions or not in direct contact with the fire (cf. Boardman and Jones 1990).

A possible process which could explain the abundance of the culm material and the poorly preserved root/tuber remains and the presence of the amorphous plant material, fungal sclerotia and the sedge nut is the burning of turf or peat: all of this material could have been present within the peat or turf during harvesting (Church et al 2007b; Dickson 1998) and the amorphous plant material may represent a piece of charred peat/turf. The fact that many of the parenchyma remains were charred in a fresh state supports this interpretation. The burning of peat and turf as a fuel was a common practice in the North Atlantic islands from the Neolithic onwards, especially in areas depleted of woodlands (Church et al 2005, 2007b; Dickson 1998; Dockrill et al 2007:15; Hunter et al 2007:22-23; Mills et al 2004; Peters et al 2004; Simpson et al 2003, 2006b). However, as mentioned in the introduction, it is probable that open birch-hazel woodlands would have dominated the environment in the Mesolithic and it is unlikely that wood would have been in short supply. The abundance of charcoal within the sorted samples supports this idea;

approximately 1236 fragments were recovered from context 9. Thus, if turf or peat was burnt on the hearths at Northton, then it was probably used for a specific activity rather than as a main fuel source.

One possibility is that turf or peat may have been burnt during the cooking of the other environmental material recovered from the site, such as the Lesser Celandine root tubers/bulbils or the fish. Ethnographic literature describes the steaming/roasting of edible roots over heated rocks in pits sealed with layers of vegetation and earth (Mears 1992:136; Mithen 2000:433; Pokotylo and Froese 1983:130-131; Turner and Kuhnlein 1982:424-6; Wandsnider 1997) and meat and fish may be smoked under wooden racks covered with vegetation (Mears 1992:127). The frequent presence of fire-cracked rocks (Bishop et al 2011) and burnt fish bones (Blake 2011) within context 9 supports the idea that steaming/roasting was taking place. Although no mention of turf or peat has been found in the references examined, it is potentially possible that turf or peat was used to seal a steaming pit or cover a smoking shelter. Alternatively, the well-preserved culm material may have been derived from the use of grass within a steaming pit or on a smoking shelter. Though the brome caryopses may have been deliberately gathered for food, they could also have been accidentally charred during the use of whole grass plants for these processes. Since neither smoking nor pit roasting/steaming would require the grass or turves to be in direct contact with fire, such processes could explain the abundance and good preservation of the culm material within the samples.

In fact, a cooking or drying accident seems the most likely reason for the abundance of Lesser Celandine root tubers/bulbils in the samples and their mixed preservation. The mixed state of preservation of this material can be explained by the differential rates of water loss for different root tubers/bulbils during roasting/steaming or drying, according to the closeness of the material to the fire (Mithen 2000:438). As Turner and Kuhnlein (1982:426) note,

> "The cooking techniques, especially the pit-cooking, required a great deal of skill and expertise. From the authors' own experience, the type of soil, the number of rocks used, the amount of water added, and the placement of the food in the pit are all crucial in determining whether the cooking will be successful. Too many rocks and too little water can result in a burned or over-cooked product, whereas too few rocks and too much water will not cook the food adequately. Due to the variability in pit size, these factors could not have been standardized; experience would have been the main criterion for successful pit-cooking."

Interestingly, roots can also be roasted over fire heated stones covered with vegetation on the soil surface without the use of a pit (ibid) and so it is not necessary to find a pit to argue that this practice was taking place. Another possibility is that the Lesser Celandine root tubers/bulbils were naturally present within turf burnt during the cooking of other foodstuffs.

6.4.6 Mesolithic plant processing and cooking: hazelnuts

Comparison of the preservation of the Mesolithic hazelnut shell to the results of experimental studies is important for understanding the original charring conditions. Experiments suggest that hazelnut shell charred in oxidising conditions above 400°C deteriorates very rapidly and that most fragments are converted to ash after 1 hour (figures 44 and 45; Carruthers 2000; Kingwell-Banham 2008). The production of well-preserved fragments seems to be restricted to low temperatures (<300°C) or short time periods at higher temperatures (<45 minutes) in oxidising conditions (figures 44 and 45; Kingwell-Banham 2008). Though hazelnut shell charred in experimental open hearths has produced mixed results (poor-excellent preservation), nutshell charred in experimental roasting pits tends to produce consistently well-preserved fragments (figure 22c). These results reflect the fact that plant macrofossils charred in a reducing atmosphere are generally better preserved (Boardman and Jones 1990:8). Reducing conditions are created in the roasting pit by the separation of the nuts from the fire by a layer of sand (see section 2.4.1), and are sometimes created in a hearth if the nutshell falls within the ashes of the fire.

Considering that much of the nutshell from Northton was fairly well preserved, it seems likely that at least some of the shell was charred in reducing conditions rather than directly on an open fire. This could conceivably have happened during pit roasting, cooking using hot ashes, or if the nuts were left too long to dry beside an open hearth. The fairly large quantity of nutshell (representing c. 570-585 whole nuts) recovered from the deposit is consistent with the idea that large-scale hazelnut processing was taking place at the site, especially considering that only about 20–25% of nuts become charred during pit roasting (Score and Mithen 2000:512). However, because of the scattered nature of the deposit, the quantity of nutshell recovered could just as easily represent small-scale but repeated exploitation of hazelnuts during multiple site visits. The mixed preservation of the assemblage supports this interpretation. The nutshell could have been disposed of directly on domestic hearths after small-scale consumption, with the better-preserved fragments representing those that were protected in the ashes of the fire. Even if large-scale hazelnut processing was not taking place at Northton, the quantity of nutshell recovered suggests that hazelnuts were a staple foodstuff, which was consumed regularly throughout the occupation of the site.

In contrast, considering the poor preservation of the nutshell from Temple Bay and Tràigh na Beirigh, it is very unlikely that any of the nutshell from these sites was preserved during roasting or drying. It is possible that post-depositional processes have eroded the nutshell to some extent, but as much of the older Northton assemblage is much better preserved, the preservation of the nutshell appears to be affected more by the original charring conditions. The recovery of only a small quantity of poorly preserved nutshell from Temple Bay and Tràigh na Beirigh suggests that large-scale hazelnut processing was not taking place and that hazel nutshell was only occasionally deposited on domestic hearths. Alternatively, the small mass of nutshell recovered at these sites may be purely a function of the smaller sample volume processed, as the nut mass density per litre was very similar for all three sites (table 48).

Analysis of the fragmentation of the hazelnut shell charred in different experimental conditions may also be useful for understanding the depositional taphonomy. Although Score and Mithen (2000) have shown that hazelnuts charred in roasting pits are very brittle and becomes highly fragmented, experiments conducted by Joyce and Chiampa (figure 23c; appendix 3) suggest that nutshell charred in open hearths tends to break into even smaller fragments. This is supported by Carruther's (2000) experiment, which showed that nuts broken and then charred in reducing conditions at a low temperature (figure 24c) produces large fragments. Thus, on the basis of the experiments that have so far been conducted, it seems that when hazelnuts are charred in a reducing environment, such as in a roasting pit, larger fragments are produced than when nutshell is disposed of directly onto a fire. However, because post-depositional processes can cause further disintegration of the nutshell (Carruthers 2000:410), fragment size probably only provides an indication of the original charring process when large fragments are recovered. Consequently, considering the extreme fragmentation of the hazelnut shell from Northton, Temple Bay and Tràigh na Beirigh (figure 24), little can be discerned about the original charring conditions from the fragmentation data, except that post-depositional processes appear to have significantly affected the fragmentation of these assemblages.

6.4.7 Northton within the wider context of Mesolithic Scotland

The range of species recovered from Northton is closely comparable to the results from Staosnaig, Colonsay, one of the only other Scottish Mesolithic sites where large-scale sampling has been undertaken (chapter 2). The assemblages from both sites were dominated by hazelnut shell and Lesser Celandine root tubers/bulbils, together with a range of different unidentified parenchyma fragments and occasional carbonised hazelnut cotyledons and seeds. Intriguingly, almost exactly the same range of edible seeds was present in the samples from both sites: Cleavers, dock, sedge and vetch/tare. Though these seeds were only present in low frequencies at both sites, this lends some support for the deliberate collection of these species (Carruthers 2000:413). Several additional mainly non-edible species were also present at Staosnaig in very low frequencies. The only notable absence from the Northton assemblage was Crab Apple seed and fruit remains, which were recovered in some quantity at Staosnaig (see chapter 2).

The estimated total number of nuts recovered from Northton context 9 (c. 570-85 nuts) was considerably lower than the number recovered from Staosnaig (30-40,000 nuts), but closely comparable to the number recovered from East Barns, East Lothian (c. >560 nuts) (see chapter 2). Although all the other Scottish Mesolithic assemblages with quantified nutshell appear to have a much smaller quantity of nuts, this may be a consequence of the low volume of soil processed at most sites (chapter 2). A greater proportion of the Staosnaig assemblage was composed of large (>4mm) fragments than at Northton, which lends some support for the idea that hazelnut roasting was taking place at Staosnaig, but probably not at Northton (figure 24c). Alternatively, this may suggest that post-depositional process caused greater nutshell fragmentation at Northton than at Staosnaig.

6.5 Conclusions

The large-scale sampling methods employed at Northton produced a sizable assemblage of Mesolithic archaeobotanical remains for analysis. The horizon may represent a palimpsest of activity, but the uniformity of the assemblage suggests that if multiple occupations are represented, then similar modes of exploitation, processing and deposition were occurring during each occupation. The dispersed nature of the archaeobotanical material in the deposit and the evidence for bioturbation suggests that the remains have probably been moved from the primary charring location, but this may have been within an open, non-structured hearth within the trench area.

The assemblage was dominated by woodland and grassland species, in particular hazelnuts and Lesser Celandine root tubers/bulbils, which would have been abundant around the site. With the exception of the Greater Chickweed seeds, all of the recovered remains with taxonomic identifications have edible components and may have been deliberately collected for consumption. However, it is possible that some of the seeds were deposited by natural processes and many of the poorly preserved root/tuber remains may have been charred *in situ* beneath hearths. Taken at face value, the seasonality of the plants suggests that they must have been gathered in the summer or autumn. However, the plant remains do not provide diagnostic information about the seasonality of deposition on site because all of the edible seeds, roots and nuts could have been dried and stored, and because the site may represent a palimpsest of activity.

The abundance of well-preserved culm material within the samples may suggest that turf/peat or grassy vegetation was being used as part of a specific cooking or food preservation process, such as roasting/steaming over fire-cracked rocks, which charred the culms in reducing conditions or without direct contact with fire. The abundance of fire-cracked rocks and the mixed preservation of the Lesser Celandine root tubers/bulbils may suggest that the root tubers/bulbils were accidentally charred during roasting/steaming over hot rocks and grassy vegetation.

The analysis of hazelnut shell frequency and preservation at Northton is consistent with the large-scale processing of hazelnuts by drying or roasting. However, considering the moderate frequency and preservation of the hazelnut shell in the samples and the post-depositional taphonomy of the site, it is also possible that the hazelnuts were routinely consumed on a small-scale.

Chapter 7. Case study 2: plant exploitation in Neolithic Orkney

7.1 Introduction

7.1.1 Chapter outline

This chapter will consider the nature of Neolithic plant exploitation in Orkney, using new archaeobotanical evidence from an early Neolithic settlement site at the Braes of Ha'Breck, Wyre, Orkney, together with the existing archaeobotanical dataset from the region. The first section will explain the archaeobotanical research rationale and the main research aims for this chapter. In the following sections, the nature of the Neolithic environment and archaeology in Orkney will then be described and the excavation sequence at the Braes of Ha'Breck will be outlined, in order to contextualise the archaeobotanical results from the site. The on-site sampling and sub-sampling strategies employed at the Braes of Ha'Breck will then be discussed in detail to justify the analysis of the chosen samples. After a description of the analyses undertaken on the dataset, the overall results from the site will be summarised and used to address the key research questions outlined at the beginning of the chapter. Finally, the overall scale and nature of arable cultivation in the region will then be assessed using the results from the site, in conjunction with the wider archaeobotanical and archaeological evidence for agricultural practices in Neolithic Orkney.

7.1.2 Archaeobotanical research rationale

As discussed in chapters 1 and 5, well-preserved domestic structures containing substantial Neolithic cereal assemblages are rare in mainland Britain and consequently the importance of arable cultivation in the Neolithic has been a matter of considerable contention. The Orkney Islands provide an excellent area in which to consider the inter-relationship between Neolithic people and plants in more detail. In contrast to mainland Scotland, Orkney contains multiple well-preserved permanent Neolithic stone-built settlements, many of which have been comprehensively sampled for archaeobotanical remains, enabling extensive inter-site comparison. Also, since Orkney lies at the most north-westerly extent of Neolithic European agricultural expansion, incoming agricultural systems would have been highly developed. Thus, the Orkney Islands provide an excellent opportunity in which to study the plant economy of settled Neolithic farming communities in detail, at the end-point of the chronological and geographical trajectory of Neolithic agricultural development.

7.1.3 Archaeobotanical research aims

The overall aim of this chapter is to understand the scale and nature of arable cultivation and wild plant exploitation in Neolithic Orkney, using a new and extensive archaeobotanical assemblage from the Braes of Ha'Breck as a detailed case study. Several archaeobotanical research questions were developed to explore this issue:

- What types of environments did the wild plants at the Braes of Ha'breck originate from?
- How have taphonomic factors affected the Braes of Ha'breck assemblage?
- How important were domestic plants at the Braes of Ha'breck?
- What was the relative importance of wheat, oat and barley at the Braes of Ha'breck?
- What does the composition of the Braes of Ha'breck assemblage reveal about cultivation methods, crop processing and harvesting methods?
- What evidence is there for the gathering, processing and cooking of wild plants at Braes of Ha'breck?
- How does the Braes of Ha'breck assemblage compare to other Neolithic assemblages in Orkney?
- What other evidence is there for the nature of cereal cultivation in Neolithic Orkney?

7.1.4 Environmental background to Neolithic Orkney

7.1.4.1 Location, landscape and geology

Orkney is a group of about 90 islands, located approximately 10km from the North-East coast of Scotland (Mykura 1976:1). The archipelago is approximately 80 km long from north to south and 47 km wide from east to west (ibid). The islands in this group range in size from small skerries and islets to substantial islands and 14 are currently inhabited (ibid).

Orkney is primarily composed of sedimentary rocks and subordinate volcanic rocks of Devonian age (c. 410-360 million years ago), principally Middle Old Red Sandstone of which Stromness and Rousay flagstones and Eday Beds (flagstones, sandstones, marls) are the major constituents (McKirdy 2010; Mykura 1975, 1976:8-9). Two older rock complexes are present: a Precambrian basement complex of granite-gneiss in a small area around Yesnaby and Stromness, Mainland and the island of Graemsay; and outcrops of Lower Devonian sedimentary rocks at Warebeth and Yesnaby, Mainland (ibid). Younger rocks are only present in Western Hoy, where sedimentary rocks of Upper Old Red Sandstone are dominant (ibid).

This geological structure has created a generally low-lying topography, which has been smoothed by the glacial ice sheets (Mykura 1975:1, 1976:3). The flooding of this low-lying landscape by rising sea levels has created wide, open, rocky, and sometimes sandy bays (Mather et al 1975:10-1; McKirdy 2010:30). Exceptions to this are the high, steep sided hills (up to 477m high) on Hoy created by more resistant sandstones, and the low hills between 170-275m high in West Mainland, Rousay and Westray, which sometimes form terraces of alternating hard and soft flagstones (ibid). High coastal cliffs are only present in areas of high land where the sandstones or flagstones had high resistance, such as Hoy and West Mainland (Mather et al 1975).

7.1.4.2 Current climate and implications for arable agriculture

The present climate of Orkney is characterised by high winds, a mild climate and a small variation in annual temperature (Davidson 1979:7). These features are predominantly caused by Orkney's maritime location and position in relation to the North Atlantic Drift, which results in lower summer and higher winter temperatures compared to other regions at the same latitude (ibid). For example, the mean monthly temperature in Kirkwall is 3.7°C in January and 12.7°C in August (Berry 2000:10). Birse (1971) classes lowland areas of Orkney as 'very exposed' and the high hills on Hoy, West Mainland and Rousay as 'extremely exposed.' Medium-high winds are frequent throughout the year, and calm conditions are rare (Berry 2000:11-12; Davidson 1979:10). Annual rainfall is moderately high (c. 890-1020mm), and although precipitation is highest in autumn and winter, the number of days with rain varies little throughout the year (ibid).

There are several serious consequences of these climatic conditions for arable cultivation. Firstly, though the growing season is prolonged, the mild climate sometimes causes 'false springs', which results in an exhaustion of cereal root reserves and ultimately slow spring growth (Davidson 1979:10). Secondly, the exposed nature of the landscape, the frequent windy conditions and salt spray can result in physical damage to crops (ibid). Finally, high rainfall and humidity in August-September causes difficulties for ripening and drying crops and frequent cloud and fog causes problems for cereal ripening (ibid). Having said this, in comparison to the Western Isles and Shetland, a much greater area of agricultural land was used for arable cultivation in the mid-late 20th century (Coppock 1976:51-2) and even several centuries before the 19th century agricultural improvements, cereals were exported to Shetland, Norway and mainland Scotland (Fenton 1978:333). This suggests that though there is considerable risk of crop failure in Orkney, the climatic conditions are much more favourable for cereal cultivation than elsewhere in the Northern and Western Isles.

7.1.4.3 Palaeoclimate and implications for arable agriculture

Proxy palaeoclimatic evidence indicates that mean annual temperatures have changed relatively little between the late Mesolithic period and the present day in North-West Europe (Davis et al 2003; Whittington and Edwards 2003). However, these general long-term trends mask seasonal and short-medium scale climate changes. Current data suggests that in Northern mid-latitude regions, Holocene temperatures peaked at about 4000 cal BC, when summer temperatures may have been as much as 1.5-2°C higher than present (Davis et al 2003). Subsequently, after this initial increase in temperature, there has been an overall decline in summer temperatures, but a slight relative increase in winter temperatures during the mid-late Holocene (Davis et al 2003; Wanner et al 2008:1811). Recent research also indicates that there have been frequent medium to short-term climatic shifts during the Holocene (Grudd et al 2002; Mayewski et al 2004; Wanner et al 2008; Whittington and Edwards 2003). For instance, current data from terrestrial proxy palaeoclimatic indicators suggests that precipitation was lower during most of the earlier Neolithic in Scotland (c. 4100-3100 cal BC) than the later Neolithic (c. 3100-2400 cal BC) (Anderson 1998; Bonsall et al 2002; Tipping and Tisdall 2004:76; Whittington and Edwards 2003:21).

Similarly, ice-rafted detritus records from sediment cores (Bond et al 2001) provide evidence for a major period of cooling of the North Atlantic Ocean at c.4300-3600 cal BC (Tipping and Tisdall 2004:72), which coincides with glacier expansion and tree line retreat in North-West Europe (Davis et al 2003:1710). This may have resulted in increased storminess, with higher wind strength and wave size (Tipping and Tisdall 2004:73). Though Tipping and Tidsall (2004) suggest that this cooling event ended around c. 3600 cal BC, using multiple lines of evidence, Mayewski et al (2004) propose that this cool phase extended until c. 3000 cal BC. However, there are difficulties in correlating proxy climatic indicators which respond to climatic change at contrasting rates and are measured on different chronological scales (Tipping and Tisdall 2004:74) and it should also be noted that in a recent paper, Wanner et al (2008) reject Mayewski et al's (2004) climate change model. Moreover, during this cool phase temperatures did not drop below early Holocene values, which were comparable to modern levels (Davis et al 2003:1710).

Considering all of this data together, it seems likely that the early Neolithic of Orkney (c.3600/3500-3000 cal BC) was a relatively dry period (until c. 3100 cal BC) and that though winter temperatures may have been slightly cooler (-0.5-1°C), summer temperatures would have been similar to or marginally warmer (+1-2°C) than at present. Consequently, overall conditions would have been slightly more favourable for Neolithic farming than today (see section 7.1.4.2). The lower rainfall and slightly warmer summer temperatures would have reduced cereal ripening and drying problems for Neolithic farmers and the higher vegetation cover (see section 7.1.4.2) would have helped to protect crops against high winds and salt spray. However, since the climate was similar or warmer than at present, it is possible that 'false springs' and root exhaustion may also have been a problem in the Neolithic.

7.1.4.4 Sea-level change

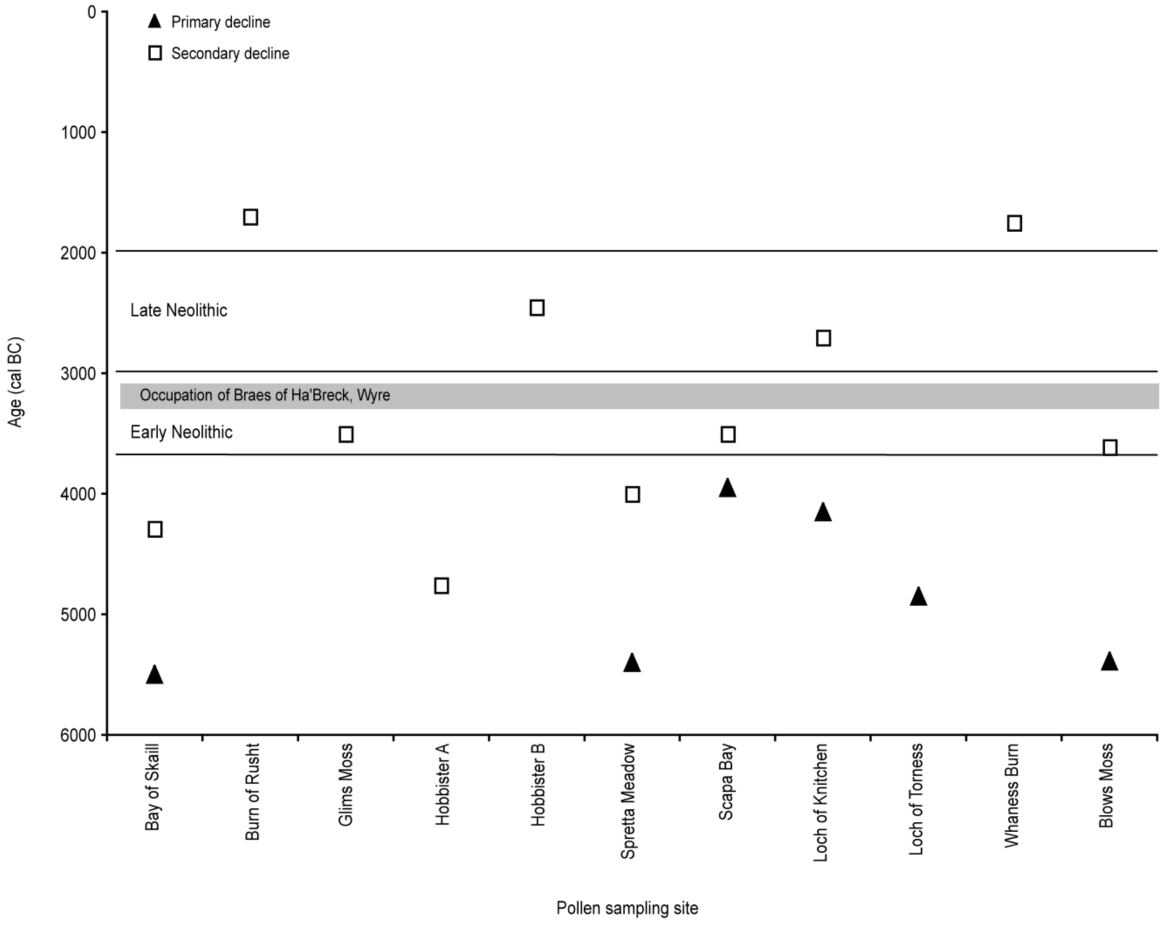
As in the Western Isles, deglaciation largely resulted in submergence, because the Orkney Islands were located on the margin of the glacial ice sheet (Ballantyne and Dawson 2003:37). Consequently, glacio-isostatic rebound was slower than relative sea-level rise and so there has been an overall increase in sea level since the end of the last glacial period (ibid). This increase in relative sea level has caused substantial changes in the size and number of islands in Orkney during the early-mid Holocene. The exact timing and nature of these changes is not certain, but recent research suggests that at the beginning of the Mesolithic, sea levels may have been as much as 10m lower than present and that Orkney may have been a single landmass at this time (Bates et al 2013; Dawson and Wickham-Jones 2007). Current data also indicates that the sea level rise was variable throughout the Holocene in Orkney and that relative sea levels only reached present levels at the end of the Neolithic period (c. 4000 uncal BP; Bates et al 2013). The precise relative sea level during the Neolithic in Orkney is poorly understood, but current evidence suggests that it may have been as much as 1.5-2m lower than present (Bates et al 2013 figure 2).

7.1.4.5 Vegetation history

Orkney has traditionally been portrayed as an essentially treeless environment during the Holocene. It has often been assumed that only birch-Hazel scrub woodlands developed at the end of the post-glacial period and that this scrub was rapidly cleared within a few hundred years after the start of the Neolithic period (Davidson and Jones 1990; Tipping 1994). However, recent research suggests that there are significant problems with the traditional dating and interpretation of palynological reconstructions from Orkney. Farrell et al (2013) point out that most palynological reconstructions of woodland decline on Orkney, are either undated (e.g. Moar 1969), based on radiocarbon dates affected by the 'hard water effect' (Keatinge and Dickson 1979), or are based on age models from cores with hiatuses in their sequences (Bunting 1994). Recent investigations by Farrell et al (2013) show that woodland decline was not simultaneous across the whole of Orkney, but occurred at different times in different areas during the early prehistoric period (figure 26). Whilst major declines occurred in the Mesolithic at several sites, in other areas some woodland survived until the Bronze Age (ibid). Consequently, though woodland extent was already in decline and had disappeared before the Neolithic in some places, areas of woodland remained (ibid).

Recent studies have also shown that in the early post-glacial period, dense-canopied woodlands, rather than scrub developed in less exposed areas, and that woodlands contained a more diverse range of species than has been previously recognised (Bennett et al 1997; Bunting 1994; de la Vega-Leinert et al 2007; Donaldson 1986; Farrell 2009; Farrell et al 2013). This is supported by the fact that even today, woodlands containing full-size trees can grow on Orkney in sheltered locations protected from grazing (figure 27). Woodland extent is difficult to estimate in relatively open environments (Bunting 2002; Farrell et al 2013:7; Gearey and Gilbertson 1997), but current evidence suggests that substantial woodland stands existed in many places in the Neolithic (Farrell et al 2013). These woodlands would have been primarily composed of birch and Hazel, but willow, oak, Alder, pine, and Rose family species would also have been present (Bennett et al 1997; Bunting 1994; de la Vega-Leinert et al 2007; Farrell 2009; Farrell et al 2013).

Figure 26: Radiocarbon dated primary and secondary woodland decline at various pollen sites across Orkney (adapted from Farrell et al 2013). Farrell et al (2013) define open landscapes (with occasional woodland stands) as having 0-20% arboreal pollen and wooded landscapes (with some open areas) as having more than 50% arboreal pollen. They define primary woodland declines as those with pollen percentages which were originally >50%, with a decrease of >20% (except for Loch of Knitchen and Loch of Torness, which never had extensive woodland and the declines were considered as primary) and secondary woodland declines as pollen percentages which were originally ≤50%, with a decrease of 20% or less. Bay of Skaill, Burnt of Rusht, Glims Moss, Hobbister A & B, Spretta Meadow and Scapa Bay are located on Mainland, Orkney. Loch of Torness and Whaness Burn are located on Hoy, Blows Moss is on South Ronaldsay and Loch of Knitchen is on Rousay (Farrell et al 2013).



In many areas, open, herbaceous grassland vegetation would have dominated the Neolithic landscape, but as well as woodlands, heathland and fen communities would also have been present in some areas (Bunting 1994, 1996; Farrell 2009; Keatinge and Dickson 1979). At several sites, the presence of Ribwort Plantain and Common Sorrel (*Rumex acetosa* L.) pollen in Neolithic levels suggests that pasture developed in areas where woodlands had declined (table 23; Farrell 2009). However, it should be noted that these species also occur in arable land, so the presence of these species is not a clear-cut indicator of pasture (Behre 1981; see section 7.4.2.1 and table 40). Cereal pollen has also been identified in Neolithic levels at a number of sites across Orkney (table 23), showing that arable land was also present within the environment. The spatial extent of arable land is difficult to establish using pollen evidence because cereal pollen is only produced in very low quantities and does not travel far beyond the point of production (Behre 1981:227-8; Caseldine and Whittington 1975-6:38-9; Lowe and Walker 1997:169; Tipping 1994:19). Consequently pollen sampling sites must be located in close proximity to arable fields to detect cereal cultivation and the absence of cereal pollen cannot be taken as evidence for an absence of arable cultivation in an area (Behre 1981:228). This problem is exacerbated in relatively open environments, such as Orkney, where regional pollen rain may dominate pollen assemblages from small lakes (Fossitt 1994). It is also important to note that there are 2 sites (Loch of Knitchen and Bay of Skaill) where cereal pollen has been identified which may date prior to the earliest evidence for archaeobotanical cereal grains in Orkney (c. 3600 cal BC) (e.g. Bunting 1996; de la Vega-Leinert et al 2000) and given that there are there are problems in distinguishing cereal pollen from wild grass pollen, particularly in coastal areas where coastal grasses produce large pollen grains (Behre 2007; Edwards 1998:73; Hirons and Edwards 1984:76; Tipping 1994:19) this evidence must be treated with caution.

Figure 27: Photo of modern natural woodland at Berriedale, Hoy, Orkney, showing that full-sized trees rather than scrub can grow even today in sheltered areas protected from sheep grazing. This is one of the only natural woodlands remaining on Orkney.

Table 23: Pollen sites with indicators of arable cultivation in dated (radiocarbon or tephrochronology) Neolithic phases.

Site	Neolithic Ribwort Plantain pollen?	Neolithic cereal pollen?	Reference
Blows Moss	yes	yes	Farrell 2009
Hobbister	yes	yes	Farrell 2009
Loch of Skaill	yes	no	Keatinge and Dickson 1979
Bay of Skaill	yes	yes	de la Vega Leinert et al 2000
Loch of Knitchen	yes	yes	Bunting 1996
Glims Moss	yes	no	Keatinge and Dickson 1979
Maeshowe	yes	yes	Davidson et al 1976
Quoyloo Meadow	yes	yes	Bunting 1994
Scapa Bay	yes	no	de la Vega Leinert et al 2007
Stones of Stenness	yes	yes	Caseldine and Whittington 1975-6

7.1.5 Archaeological background to Neolithic Orkney

Orkney contains some of the best-preserved Neolithic archaeological settlements, monuments and ceremonial sites in Europe, and indeed the world. Within a land area of just 970 sq km there are more than 70 Neolithic chambered cairns, at least 14 known settlements and several henges, stone circles and standing stones (table 24; Davidson and Henshall 1989; Ritchie 1990b), providing an outstanding inter-connected record of Neolithic society, economy and religious life (Wickham-Jones 2006:19). The importance of the area has been internationally recognised through the designation of five of the key Neolithic sites on Mainland Orkney with UNESCO World Heritage status (ibid:6).

7.1.5.1 The earliest Neolithic occupation of Orkney

Prior to 2007, with the exception of occasional mainly unstratified surface finds of Mesolithic-style lithics (Saville 2000:24; Wickham-Jones 2006; Wickham-Jones and Firth 2000), there was an absence of archaeological evidence for settlement on Orkney before c. 3600 cal BC (Ashmore 2000; Card 2005a:47). However in the last 5 years, new radiocarbon dates have extended this chronology. Firstly, radiocarbon dated hazelnut shell recovered from two new sites has provided evidence for Mesolithic settlement in the 8th-7th millennium cal BC on Orkney (see chapter 2, table 2). Secondly, at one of these sites (Links House), fragments of willow charcoal dated to 3975-3800 cal BC were recovered from a pit containing no artefacts or other ecofacts (Alldritt 2011; Lee and Woodward

2009b). The much later dates produced from this pit compared to the rest of the site suggest that this is an isolated feature, unassociated with the earlier activity on site (D. Lee pers. comm.). It is also possible that the charcoal may be intrusive into the pit, though this is less likely considering that 3 pieces of charcoal were dated and there was no indication of disturbance to the feature (D. Lee pers. comm.).

Similarly, radiocarbon dates from willow charcoal recovered from layers sealed beneath a Bronze Age mound at Varme Dale, Gorn, Orkney produced dates of 3770-3630 cal BC (Downes 2003, Forthcoming). This charcoal was associated with an unusual cereal assemblage for this date and location. Though the assemblage was dominated by naked barley (*Hordeum* sp. naked), significant concentrations of Einkorn Wheat (*Triticum monococcum* L.) and wheat grains were also present, together with three Flax seeds, a possible Rye grain and a possible oat grain (Downes Forthcoming). Considering the context of discovery and the fact that none of the cereal grains have been directly radiocarbon dated, it is not possible to be certain if this cereal assemblage is contemporary with the dated charcoal. However, once directly dated, this cereal assemblage may extend the Neolithic Orcadian chronology back to c. 3800 cal BC.

Consequently, although there is now secure evidence for the Mesolithic occupation of Orkney in the 8th-7th millennium cal BC, there is currently no certain evidence for domestic animal and plant remains or artefacts and structures conventionally considered to be of 'Neolithic' character prior to c. 3600 cal BC. Therefore, whilst these new dates provide evidence that Orkney was occupied before 3600 cal BC, they do not yet contradict the conventional chronology, which implies that the 'Neolithic' on Orkney began some 200-400 years later than in mainland Scotland.

Whether or not this reflects a real delay in the adoption of Neolithic practices or a chance absence of earlier Neolithic features on sites excavated by archaeologists is uncertain. However, several factors suggest that this delay is illusionary. Firstly, timber-built Neolithic structures have only been recognised in Orkney within the last decade, for instance at the Braes of Ha'Breck, Wyre (Thomas 2008a) and at Wideford, Mainland (Richards 2007). This suggests that there may be a problem of identifying earlier, perhaps less substantial timber structures in an environment where stone-built structures are archaeologically more visible and conform to prior archaeological expectations of Orcadian Neolithic settlement patterns (Carey 2012:56; cf. Downes and Richards 2000; Wickham-Jones 2004a:56, 2006:26). Secondly, the earlier phases of several Neolithic stone-built settlements, such as Knap of Howar (Ritchie 1983:44) were built on top of earlier midden deposits, suggesting that earlier settlements must have existed beneath the later structures (Ritchie 1983:46; Wickham-Jones 2011:22). Finally, considering changes in relative sea level since the early-mid Holocene, it is also possible that many early Neolithic coastal sites have been submerged by rising sea levels (Bates et al 2013; Ritchie 1990a:39).

7.1.5.2 Orcadian Neolithic cultural associations and chronology

Traditionally, the Orcadian Neolithic was categorised into two main 'cultures' on the basis of differing ceramic and architectural styles (Childe 1946:25; Piggott 1954). The first cultural group was considered to have used Unstan Ware pottery and built chambered cairns and the second culture was thought to have constructed the settlements of Skara Brae and Rinyo and produced Grooved Ware ("Rinyo-Clacton") pottery (ibid). Additionally, Childe (1952:137) suggested that Maes Howe type tombs were part of the Grooved Ware cultural tradition. Piggott (1954:234) also drew a distinction between Maes Howe type cairns and stalled cairns, but viewed them as forming part of a single megalithic culture which utilised Unstan Ware. Unstan Ware pottery is typified by carinated round-bottomed, shallow bowls, with collars often decorated with incised or stab-and-drag lines arranged in triangles, and uncarinated, plain round-bottom bowls (Davidson and Henshall 1989:65-77). Conversely, Grooved Ware pottery is a flat-bottomed bucket-shaped, uncarinated form, extensively decorated with applied and incised geometric patterns (Fraser 1983:161). Whereas in stalled or 'Orkney-Cromarty' cairns, the chambers are subdivided into a series of compartments by upright slabs which project from the drystone walls (Davidson and Henshall 1989:19), Maes Howe cairns are characterised by central high roofed chambers with internal doorways which lead to a series of side cells (ibid:37).

Subsequently, on the basis of radiocarbon dates, Renfrew (1979:206-8) suggested that these typological categories can be interpreted chronologically. He characterised Unstan Ware pottery, Orkney-Cromarty tombs and settlements such as Knap of Howar as belonging to the early Neolithic, and suggested that the later Neolithic was typified by Grooved Ware, Maeshowe type tombs and settlements such as Skara Brae (ibid). Recent research using well-dated sequences of pottery has confirmed this general classification scheme (Hunter 2000; Hunter and MacSween 1991) and the current accepted chronology dates the earlier Neolithic to c. 3600/3500–3000 cal BC and the later Neolithic to c. 3000–2000 cal BC (Ashmore 2000; Card 2005a:47). However, despite the general chronological separation of the two architectural and ceramic types, there is an overlap in the radiocarbon dates produced from Unstan ware and Grooved Ware settlements and tombs (Card

2005a:47; Davidson and Henshall 1989:86; Jones 2000a:128; Renfrew 1979:209). There is also considerable variation within the 2 broad categories of tomb styles and many tombs incorporate elements of both forms of architecture (Ashmore 2000:306; Card 2005a:47).

Consequently this evidence has been open to interpretation in a number of different ways. For instance, Renfrew (1979:208-212) interpreted this evidence in an evolutionary framework from simple to complex, with Grooved Ware pottery, settlements and tombs gradually developing from Unstan Ware forms. In contrast, even into the 1980s, many still perceived the two forms of pottery/tombs as contrasting styles used by different cultural groups (Davidson and Henshall 1989:64). More recently it has been suggested that culture acts subconsciously on human behaviour, and that the variation within each of these categories probably reflects changing practices and subconscious modes of expression throughout the Neolithic (Jones and Richards 2000).

7.1.5.3 Settlement

In contrast to mainland Scotland, several exceptionally well-preserved stone and timber-built Neolithic settlements have been found in Orkney (table 24). In general, the layout and spatial arrangement in early and late Neolithic houses tends to echo the overall forms of the main monument styles associated with these periods (Richards 1992:66-7; 1993:163-7; Ritchie 1990a:50). For instance, whereas early Neolithic houses and tombs are usually subdivided into separate areas by upright orthostatic slabs, late Neolithic houses and tombs lack stalled compartments and instead have a main central room/chamber that leads to side cells (ibid).

The two best-preserved early and late Orcadian Neolithic sites are the Knap of Howar, Papa Westray (Ritchie 1983) and Skara Brae, Mainland (Childe 1931; Clarke 1976b), which have traditionally been seen as ‘type sites’ for each of their respective periods. House walling survives to over 1.5 metre high and internal stone-built features and external midden deposits are preserved at both sites (ibid). Whereas at Knap of Howar, two long rectangular stone-built structures were conjoined by an internal passage-way (Ritchie 1983), at Skara Brae the final phase of construction included at least six short rectangular houses, which were linked by a passage-way which ran through the centre of the settlement (Childe 1931). Consequently, based mainly on the evidence from these two sites, it has traditionally been believed that there was a simple linear development in settlement pattern from single isolated farmsteads to larger nucleated villages (Clarke and Sharples 1990:56; Ritchie 1983:58).

However, new excavations have revealed that the picture is considerably more complex, with multi-dwelling sites also forming an aspect of earlier Neolithic settlement patterns, for instance at Stonehall, Mainland and the Braes of Ha'Breck, Wyre (see section 7.1.6.2; Richards 1999; Richards et al 2000, 2001). Also, though recent excavations have confirmed the general division between earlier (e.g. Braes of Ha'Breck and Stonehall: ibid) and later Neolithic house forms (e.g. Barnhouse: Richards 2005), it has become clear that not all Neolithic houses conform to these idealised types. For instance, the houses in the earliest phases at Pool were small, sub-circular cellular structures defined by single faced walls (Hunter et al 2007) and at Wideford, Mainland (Richards 2007) and the Braes of Ha'Breck (see section 7.1.6.2) the earliest houses were constructed of wood rather than stone. The form of these wooden structures differed considerably, with 2 or 3 circular and 1 possible rectangular structure present at Wideford (Richards 2007) and 2 rectangular structures present at the Braes of Ha'Breck (see section 7.1.6.2). There is also variation in the size and shape of contemporary houses within particular settlements. For example, at Barnhouse, one of the houses (house 2) was considerably larger than the other contemporary structures on site, suggesting that it may have been used for ceremonial rather than domestic purposes (Richards 2005). Detailed analysis of the houses at Skara Brae also suggests that there was more variability between the structures than is apparent from their overall form (Richards 1991:41). This emphasises the fact that there was more diversity in settlement form and layout than has been previously recognised.

Table 24: Neolithic settlements on Orkney. OEN: Orkney early Neolithic; OLN: Orkney late Neolithic; *: possible settlement.

Site	Location	Period	References
Bay of Stove	Sanday (NGR: HY 6121 3531)	OLN	Bond et al 1995; Morrison 1995
Barnhouse	Mainland (NGR: HY 307 127)	OLN	Richards 2005
Braes of Ha'breck	Wyre (NGR: HY 4375 2592)	OEN	Thomas 2007a, 2008a, 2009, 2010, 2011, Thomas and Lee 2012
Crossiecrown	Mainland (NGR: HY 423 137)	OLN	Downes and Richards 2000; Richards et al 2000, 2001
Deepdale *	Mainland (NGR: HY 2670 1234)	OEN?	Carey 2012; Richards 2005:14-6
Garson *	Mainland (NGR: HY 268 092)	N?	Lynn and Bell 1985, 1986, 1988
Green	Eday (NGR: HY 56971 28987)	OEN	Miles 2009, 2010, 2011
Knap of Howar	Papa Westray (NGR: HY 483 518)	OEN	Ritchie 1983
Knowes of Trotty	Harray, Mainland (NGR: HY 342 174)	OEN	Card and Downes 2002; Card et al 2006, 2007c
Links of Noltland	Westray (NGR: HY 428 493)	OLN	Clarke and Sharples 1990; Moore and Wilson 2011
Pool	Sanday (NGR: HY 619 37)	OEN/ OLN	Hunter et al 2007
Rinyo	Rousay (NGR: HY 4398 3224)	OLN	Childe and Grant 1938-9, 1946-7
Skara Brae	Mainland (NGR: HY 231 188)	OLN	Childe 1931; Clarke 1976b
Stonehall	Mainland (NGR: HY 366 126)	OEN/ OLN	Downes and Richards 2000; Richards et al 2000, 2001
The Howe	Mainland (NGR: HY 276 109)	OEN	Ballin Smith 1994; Davidson and Henshall 1989:90
Tofts Ness	Sanday (NGR: HY 757 464)	OLN	Dockrill et al 2007
Wideford	Mainland (NGR: HY 405 127)	OEN	Richards 2007
Maeshowe *	Mainland (NGR: HY 3182 1277)	OEN	Richards 1996:195

7.1.5.4 Faunal evidence

The 2 main faunal species recovered from Neolithic settlements in Orkney are sheep/goat (*Ovis* sp.) and cattle (*Bos* sp.) (table 25). Domestic pig (*Sus* sp.) remains are also present on most Neolithic domestic sites on Orkney, but they only form a minor component of all assemblages. In several assemblages, such as Knap of Howar, Skara Brae and Links of Noltland, a high proportion of young cattle remains are present, which may indicate that cattle were predominantly used for dairying (Fraser 2011:45; Noddle 1983:99). Alternatively, Watson (1931:201) has suggested that inadequate winter fodder supplies were available, though if this was the case, the milk could still have been utilised. In contrast, cattle tooth eruption and wear evidence from Tofts Ness suggests that the herd was mainly kept for meat and skins (Nicholson and Davies 2007:177). Similarly, Bond (2007c:224) proposes that a non-intensive cattle husbandry system operated at Pool, with some adults milked while the calves were still suckling and with the calves kept until the autumn when they were killed for meat. Noddle (1983:99) proposes that a large number of the adult cattle bones from Knap of Howar were used for bone working and that this may have skewed the relative proportions of young and old cattle bones in the assemblage. She also suggests that the young cattle may have been killed off so that the skins could be used for clothing (ibid). The use of cattle for both meat and milk in Neolithic Orkney is supported by the presence of probable cattle milk and meat lipids in organic residues in Neolithic pottery from Barnhouse, though meat/milk cannot be absolutely distinguished using this method (Jones et al 2005).

In contrast, the age data from Knap of Howar, Links of Noltland and Toft Ness suggests that sheep/goat were predominately kept for meat (Fraser 2011; Nicholson and Davies 2007:178; Noddle 1983:98). It is unlikely that sheep were kept for wool because early forms do not produce much wool (Noddle 1983:99) and this wool is self-shedding (Nicholson and Davies 2007:178). The absence of the tools required for weaving in artefactual assemblages supports this conclusion (Clarke and Sharples 1990:75).

A range of wild species, were also utilised in Neolithic Orkney: predominantly red deer (*Cervus elaphus*), fish and birds, though seal (Pinniped), otter (*Lutra lutra*), whale/dolphin/porpoise (Cetacean), shark (Selachimorpha) and marine molluscs have also been recovered from several sites, but usually in low quantities. A wide variety of birds were exploited at some sites, with 40 species identified at the Knap of Howar and 15 species identified at Tofts Ness. Most of the bird remains were sea birds, such as Greak Auk (*Alca impennis*), Guillemot (*Uria aalge*), Gull (*Larus* sp.) and Gannett (*Sula bassana*). At Tofts Ness, Skara Brae and Knap of Howar, there is evidence for both onshore and offshore fishing and it is possible that Common Limpets (*Patella vulgata* L.), the most abundant marine mollusc recovered from these sites, were collected for use as bait rather than for direct consumption (Clarke 1976b:22; Clarke and Sharples 1990:77; Nicholson 2007a:214; Ritchie 1983:56). Overall, the Neolithic inhabitants of Orkney exploited a diverse range of wild and domestic species, with domestic cattle and sheep/goat the most important animal resources utilised.

Table 25: Faunal remains from Neolithic settlements on Orkney. P: present; D: dominant species; OEN: Orkney early Neolithic; OLN: Orkney late Neolithic; * Unpublished data, preliminary analysis only.

Site	Area	Period	Cattle	Sheep/ Goat	Pig	Dog	Wild cat	Red Deer/ Roe Deer	Whale/ Dolphin/ Porpoise (Cetacean)	Shark	Seal	Otter	Bird	Fish	Marine Mollusc	Reference
Barnhouse	Mainland	OLN	P	P	P										P	King 2005
Braes of Ha'Breck	Wyre	OEN	P	P				P						P		Antonia Thomas pers. comm.*
Crossiecrown	Mainland	OLN	P	P				P								Richards Jones pers. comm.*
Knap of Howar	Papa Westray	OEN	D	D	P	P		P	P		P	P	P	P	P	Bramwell 1983; Evans and Vaughan 1983; Noddle 1983; Wheeler 1983;
Links of Noltland	Westray	OLN	D	D	P	P		P	P	P		P	P	P	P	Crowston 2011; Fraser 2011
Pool	Sanday	OEN	D	D	P			P	P				P	P		Bond 2007c; Serjeantson 2007b; Nicholson 2007c
Pool	Sanday	OLN	D	D	P			P	P					P		Bond 2007c; Serjeantson 2007b; Nicholson 2007c
Rinyo	Rousay	OLN	P	P				P								Childe and Grant 1938-9, 1946-7
Skara Brae	Mainland	OLN	D	D	P	P	P	P	P				P	P	P	Clarke 1976b; Clarke and Sharples 1990; Jones 1998; McCormick and Buckland 2003; Watson 1931
Stonehall	Mainland	OEN	P	P												Richards Jones pers. comm. *
Stonehall	Mainland	OLN	P	P	P								P			Richards Jones pers. comm. *
The Howe	Mainland	OEN/ OLN?	P	P	P			P								Smith et al 1994
Tofts Ness	Sanday	OLN	D	D	P	P		P	P		P	P	P	P	P	Nicholson 2007a, 2007b; Nicholson and Davies 2007; Serjeantson 2007a

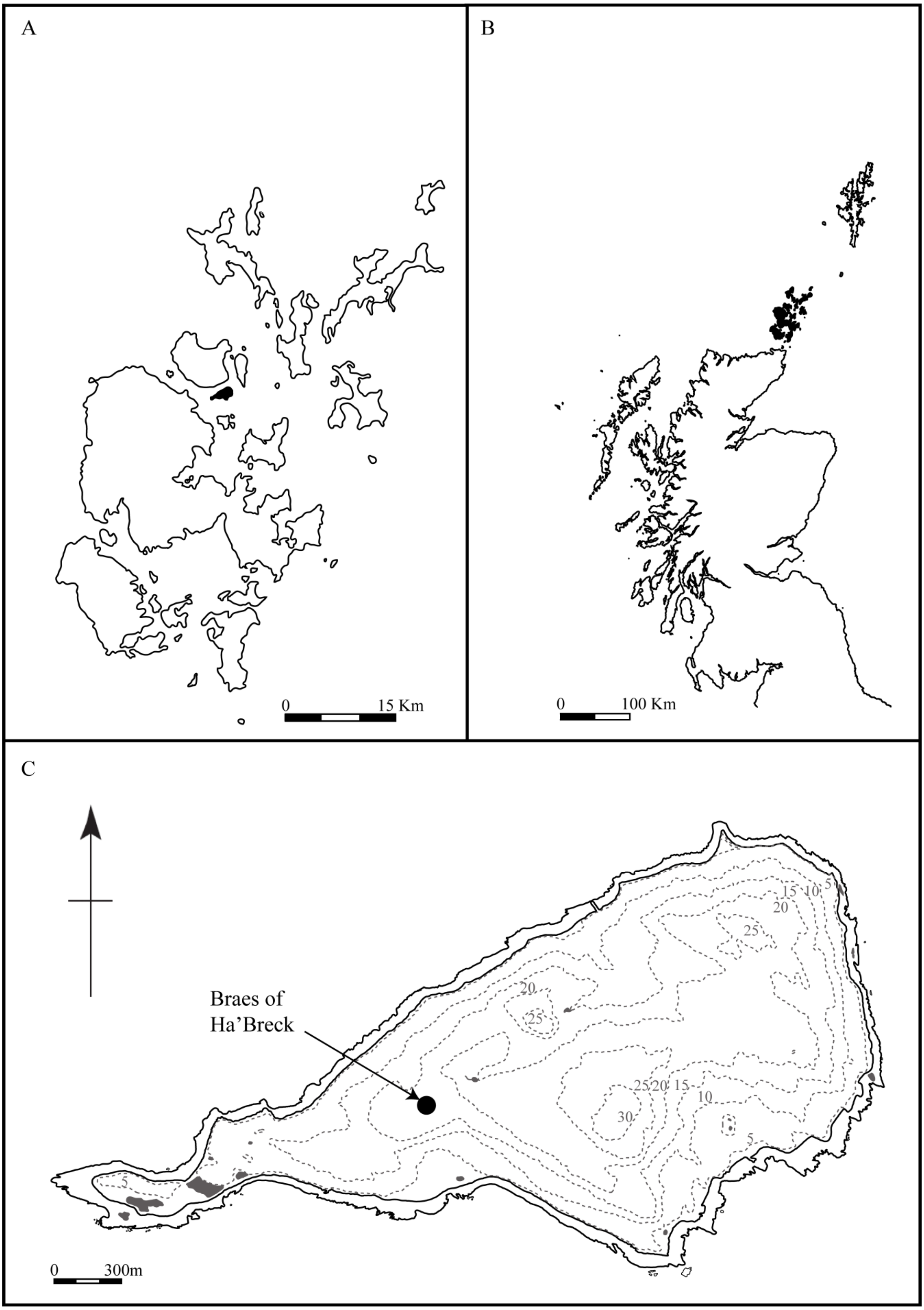
7.1.6 Archaeological investigations at the Braes of Ha'Breck

7.1.6.1 Site location and context

The Neolithic site at the Braes of Ha'Breck, is located on the West side of Wyre (NGR: HY 4375 2592), Orkney, one of the smallest (c. 1.5 x 2.5 km) inhabited islands in Scotland, which is situated approximately 3.2 km from Mainland Orkney, 0.8 km from Rousay and 1.6 km from Egilsay (figure 28). The site is positioned on an area of gently sloping ground in a recently ploughed field, and is approximately 15m above sea level (Thomas and Lee 2007). Birse (1971) classes the island of Wyre as 'exposed' and therefore it is slightly less exposed than most low-lying areas of Orkney, which are classed as 'very exposed'.

There are no other known sites of Neolithic date on the island (Thomas and Lee 2007), but the nearby island of Rousay contains one of the densest concentrations of early Neolithic chambered tombs in Britain (Davidson and Henshall 1989). Within an area of approximately 50 square km^2 there are 15 Orkney-Cromarty chambered cairns, many of which are of a rare or unusual character (ibid). For instance, Taversoe Tuick is one of only two two-storied tombs in Orkney and the longest chambered tombs in Orkney, such as Midhowe, are all found on the South-side of Rousay, opposite Wyre (ibid). There are no certain earlier Neolithic settlements on Rousay, but round-based pottery was recovered from the earliest phases of the late Neolithic settlement at Rinyo, in the North-East side of the island, which may suggest that the earliest phases date to the early Neolithic (Richards 1999). Considering that relative sea levels have risen by approximately 1.5-2m since the early Neolithic, Rousay may have been more easily accessible from Wyre during the Neolithic.

Figure 28: Location of the Braes of Ha'Breck, Wyre, Orkney. A: Orkney, with Wyre highlighted; B: Scotland, with Orkney highlighted; C: Wyre, showing the location of the site at the Braes of Ha'Breck.



7.1.6.2 Archaeological investigations at the Braes of Ha'Breck 2006-2011

The archaeological site at the Braes of Ha'Breck was first identified in 2006 during a walkover survey of the island of Wyre (Thomas 2006; Thomas and Lee 2007). During this survey, course masonry, stone tools and prehistoric pottery were visible on the surface of a recently ploughed field, with particular concentrations associated with areas of darker plough soil (ibid). Subsequent fieldwalking resulted in the recovery of over 700 artefacts, predominantly of early prehistoric date (ibid). These included characteristic Neolithic artefacts, such as stone axes, macehead fragments and Neolithic pottery (ibid). A gradiometry survey of the artefact-rich area of the field revealed a number of positive anomalies, some of which were associated with negative responses suggestive of the presence of stone structures (ibid).

From 2007-2011 a series of trenches were excavated to characterise the nature, date, significance and spatial extent of this archaeology and to assess the effects of the recent ploughing on the underlying archaeology (Thomas 2007a, 2008a, 2009, 2010, 2011; Thomas and Lee 2007, 2012). The excavations uncovered a substantial early Neolithic settlement, which extends over several 100m^2 and has produced one of the largest artefactual assemblages from an early Neolithic domestic site in Orkney (Thomas 2008a). Radiocarbon dates from the early and late phases of the site were virtually identical, and suggested that the settlement was occupied between 3369-2923 cal BC, during the earliest known period of the Neolithic on Orkney (table 26). As one of the few earlier Neolithic settlement sites on Orkney, the post-excavation analysis of the recovered material will add significantly to knowledge about the nature of early Neolithic settlement in the region.

In two of the trenches (A and C), a series of stone and timber built structures were uncovered, together with an external working floor and midden areas (figure 29). These structures were associated with hundreds of fragments of early Neolithic pottery, worked flint and lithic debitage, and coarse stone tools, including a total of 15 polished stone axes (Thomas 2007a, 2008a, 2009, 2010, 2011). A number of agricultural artefacts were also recovered, including a quern stone fragment and two quern rubbers (A. Thomas pers. comm.; Thomas and Lee 2012). Several stone ard points, similar to ard points recovered elsewhere in the Northern Isles (Clarke 2006), were recovered from the topsoil and a single ard point was also recovered from house 5 (A. Thomas pers. comm.). Trenches B and D contained a rammed stone floor incorporating pottery, worked and unworked lithics and burnt stones (Thomas 2010). In trench E, a large rock-cut feature was uncovered (Thomas 2011). This feature has been interpreted as a small-scale domestic stone quarry, perhaps used as a source of building stone, which was later infilled with rubble, artefacts and domestic midden material (Thomas 2011; Thomas and Lee 2012).

Table 26: Radiocarbon dates from the Braes of Ha'Breck, Wyre, Orkney (Antonia Thomas unpublished data), calibrated using IntCal09 (Reimer et al 2009) within OxCal v4.1.7 (Bronk Ramsey 2009).

Reporting number	Trench	Sample	Context	Area	Phase	Sample material	Age BP	δ13C (‰)	Calibrated date (95.4% probability)
SUERC-34503	A	249	676	House 4	Early	Hawthorn fruit stone	4530 ± 30	-24.5	3361-3103 cal BC
SUERC-34504	A	112	197	House 3	Late	Barley grain	4470 ± 30	-22.3	3339-3026 cal BC
SUERC-34505	A	98	139	External midden	Late	Hazel nutshell	4510 ± 30	-28.4	3352-3099 cal BC
SUERC-35990	C	128	528	House 1?	Early?	Barley grain	4425 ± 30	-25	3323-2923 cal BC
SUERC-34506	C	88	436	House 2	Late	Barley grain	4550 ± 30	-22.7	3369-3104 cal BC
SUERC-37959	E	362	2019	Quarry	Lower quarry fill	Birch roundwood	4690 ± 35	-24.8	3629-3369 cal BC
SUERC-37960	E	339	2014	Quarry	Upper quarry fill	Hulled barley grain	3780 ± 35	-22	2336-2046 cal BC

Two main stratigraphic phases were identified in trench C: an earlier predominantly post-built structure and a later mainly stone-built structure (figures 29 and 30). Both structures were approximately rectangular in outline and contained internal features, such as hearths, pits and orthostatic wall divisions (Thomas 2009). Stone and timber elements formed part of both constructions (Thomas and Lee 2012). For instance, both of the structures had stone lined hearths and the stone phase incorporated internal postholes, which probably supported a timber-framed roof (A. Thomas pers. comm.; Farrell et al 2013:8). It is thought that the earlier structure was disassembled, before the later stone structure was built on the same alignment (Thomas 2009). A narrow ditch with an external bank of redeposited natural cut through several of the house 1 postholes and delimited the probable outer edge of house 2 (ibid). However, since all of the features were considerably plough-truncated and there was heavy iron panning across the trench, little of the stone remained *in situ* from the stone-built phase, and many of the features cannot be clearly assigned to either phase of construction (A. Thomas pers. comm.; Thomas 2008a; Thomas and Lee 2007:26-27).

Trench A contained 3 main structures: an earlier timber-built structure (house 4) and two later stone-built structures (houses 3 and 5; figures 29, 31 and 32). House 4 was a sub-rectangular structure composed of about 14 postholes and linear cuts, which are thought to be beam-slots (Thomas 2010). A scoop hearth was present in the northern end of the structure and a line of postholes in the centre of the building may represent the remains of wooden internal divisions, similar to the stone-built orthostatic divisions in the stone-built structures (ibid). To the East of house 4 was a compact surface which contained burnt and unburnt stone and stone tools, interpreted as an external working area (Thomas 2011). Several factors suggest that house 4 may have been occupied for a relatively short period of time: there is limited evidence for the reuse or reworking of postholes; the artefactual assemblage was recovered directly from the glacial till; there was an absence of occupation deposits and only a shallow hearth fill (Farrell et al 2013:8; Thomas and Lee 2012:18). Indeed, it has been suggested that the earliest use of house 3 may have been contemporary with the use of this structure (Farrell et al 2013:8) and that it may have been built as a temporary habitation structure whilst house 3 was being constructed (Thomas and Lee 2012:18). This is supported by the fact that the external paving around house 3 partially respected the outer edge of house 4 (Thomas 2009).

Though trench A was still plough-truncated to some extent (Thomas and Lee 2007:14), the stone-built structures were better preserved than in trench C, with at least 2-3 courses of stone walling surviving in some places (Thomas 2010). Both stone-built structures were approximately rectangular with rounded internal corners and had stone-lined drains (Thomas 2010, 2011). House 3 was divided into 2 main areas by internal stone-built orthostatic divisions and contained hearths and other internal features, including postholes and pits (ibid). In the external area to the East of house 3, was a paved area, composed of slabs up to 1.5m long, which lead to the entrance of the structure (Thomas 2008a). The second stone-built structure in trench A, house 5, is also divided into two internal areas by stone orthostatic divisions, but unlike house 3, the Southern area was considerably smaller than the Northern room (Thomas 2011). A large stone-lined hearth was present in the Northern area of house 5 (ibid).

Figure 29: Schematic site plan of the structures at the Braes of Ha'Breck, Wyre (Farrell et al 2013).

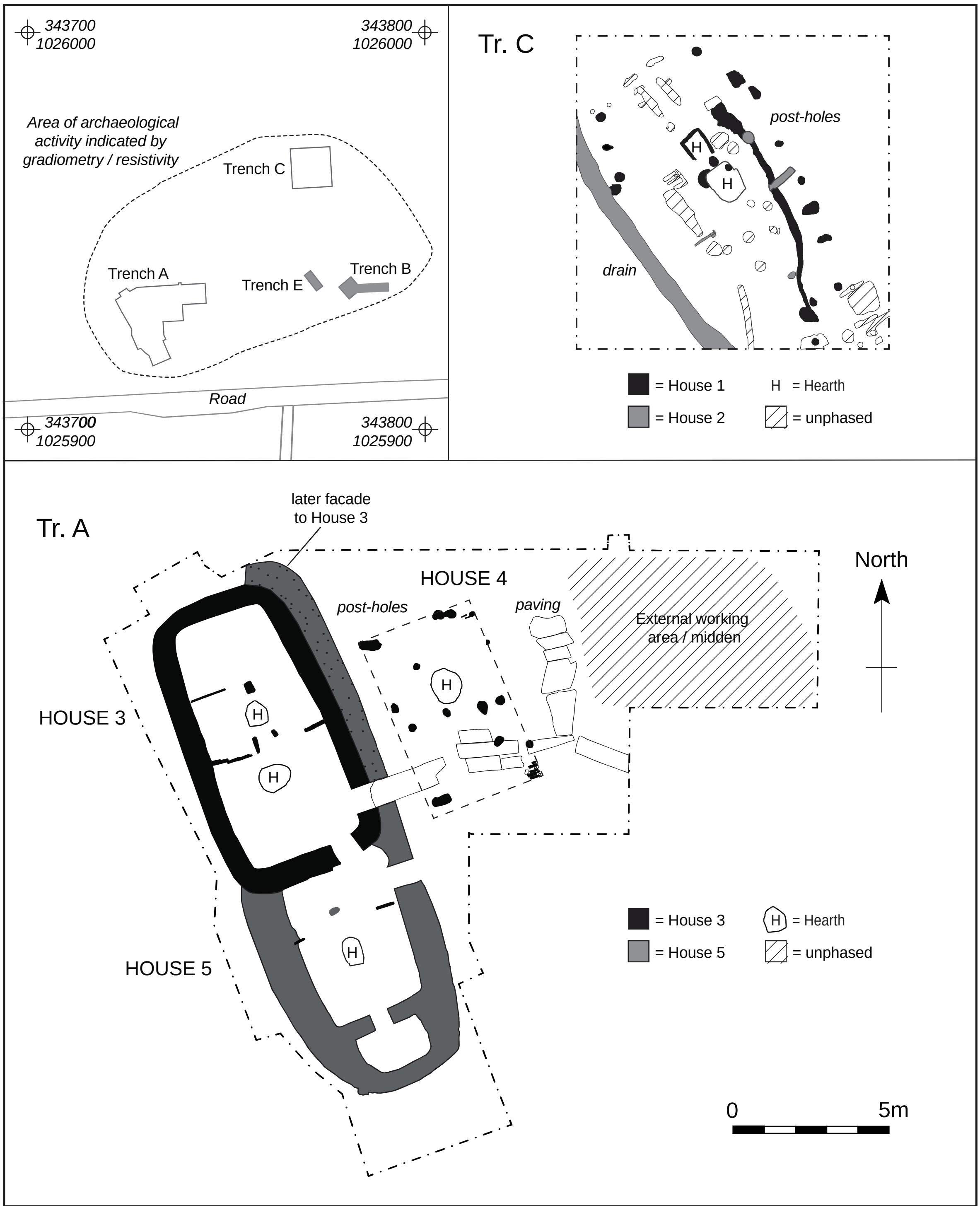


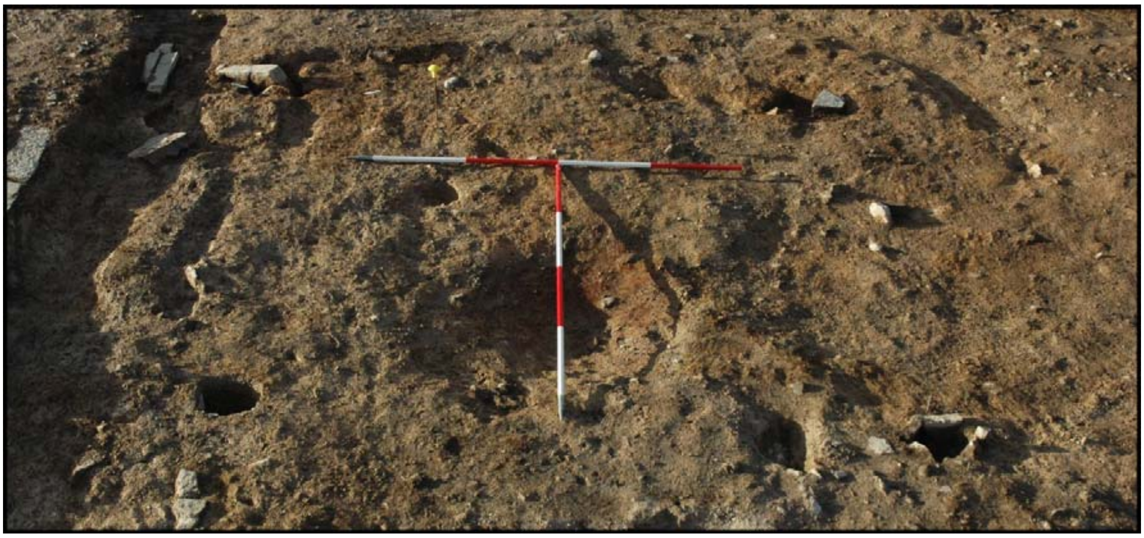
Figure 30: Braes of Ha'Breck, Wyre, Orkney, trench C (photos: A. Thomas). (a) North-west looking view of structures 1 and 2, after excavation, showing the outline of the negative features. (b) Detail of one of the hearths in houses 1 and 2 during excavation, showing the earlier and later hearths: the upper hearth is from house 2, looking South-East.

(a)

(b)

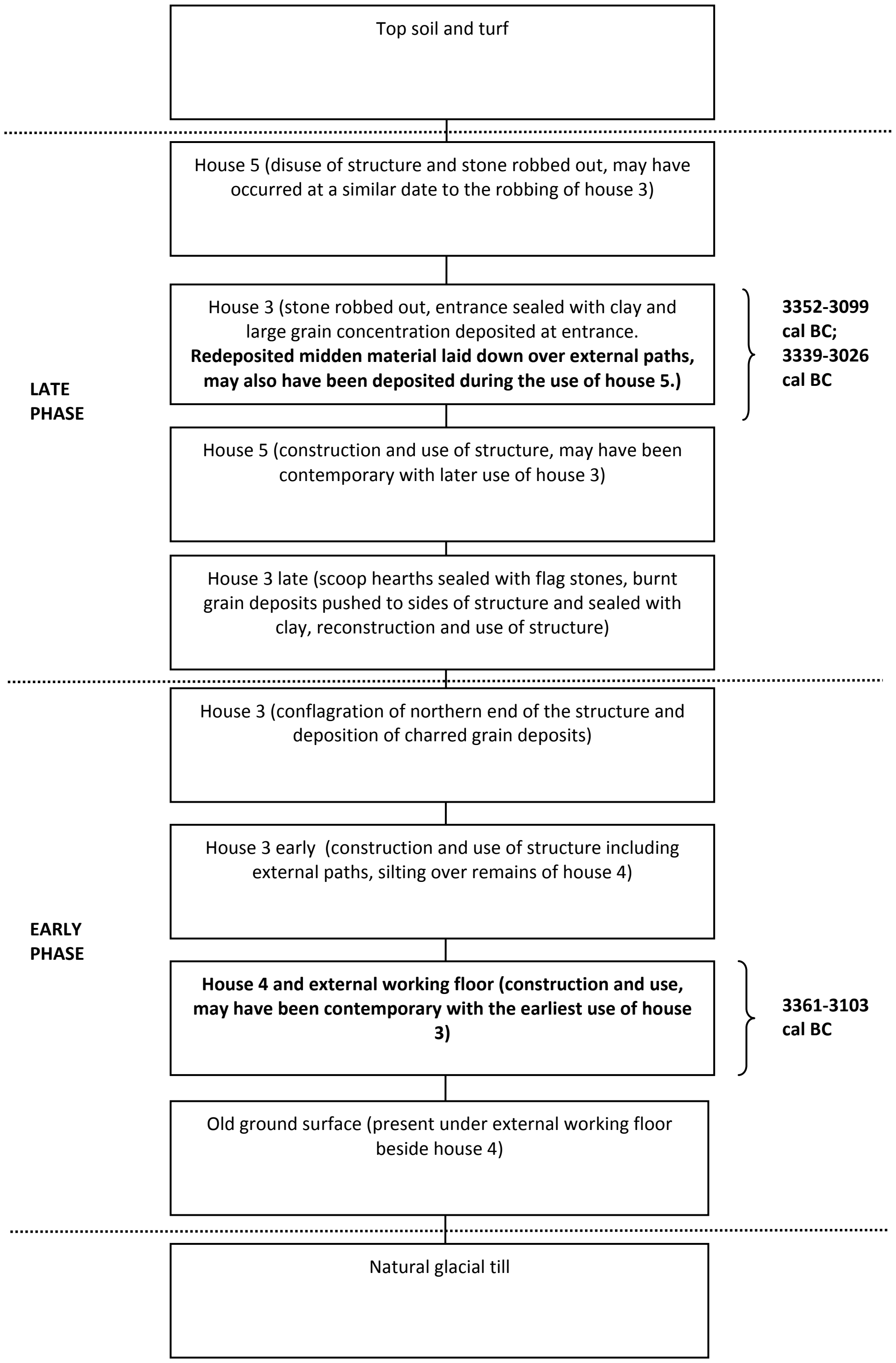
Figure 31: Braes of Ha'Breck, Wyre, Orkney, trench A (photos: A. Thomas). (a) North looking view of the North end of house 4. The scoop hearth is the visible in the centre of the photo. (b) North-East looking view of house 3 after excavation. The division between the Northern and Southern rooms in the structure is visible towards the top of the photo.

(a)



(b)

Figure 32: Outline of the approximate phasing of the structures in Trench A. Highlighted text indicates phases with samples analysed as part of this thesis. The post-excavation analysis of the material from the site is currently at a preliminary stage, and so the site phasing should be regarded as a general guide rather than a final statement of results from the site (A. Thomas pers. comm.).



The use of House 3 can be divided into several phases (figure 32). During the initial use of the building, a series of scoop hearths, pits, and gullies were cut into the glacial till inside the structure (Thomas 2011). Over-lying the basal negative features was a thick dense layer of carbonised grain, which covered most of the northern end of the structure (ibid). The scale and density of this deposit was apparent on excavation, with hundreds of thousands of charred cereal grains visible to the naked eye (figure 33). It is probable that this grain-rich deposit was charred *in situ* within the structure because the underlying natural was heat reddened, suggesting that there had been a significant conflagration (Thomas 2011). The southern end of the structure does not appear to have been burnt and no charred grain deposits were recovered (ibid). Considering the scale and density of the grain-rich deposit, the most likely interpretation of this phase is that the northern room was used for storing grain, and that a grain store was destroyed by a catastrophic fire (Thomas and Lee 2012:15). The relative thickness of the grain deposits across the floor suggests that, after this fire, most of the grain was pushed against the side walls, before the scoop hearth was sealed with a large flagstone slab, a quern rubber and a polished stone axe was deposited and the grain-rich deposit was sealed with a thick layer of mixed clay (Thomas 2011). Subsequently, the building was reconstructed and a series of further *in situ* floor deposits built up within the structure (ibid). The fact that one of the post-holes, thought to have held timber roof-supports, was reconstructed 4-5 times suggests that the structure may have been in use for a considerable period (Farrell et al 2013:8).

After the use of house 3, some of the building stone was robbed out, the entrance was sealed with clay and a small grain-rich deposit and the paved area was covered with layers of midden material (Thomas 2011). The midden material contained occasional charcoal flecks, burnt and unburnt stones, flint and a significant concentration of pottery (Thomas and Lee 2007:18). There are several reasons that suggest that this midden may have been redeposited (A. Thomas pers. comm.). Firstly, no specific deposition episodes were identified and the midden deposits were fairly homogeneous. Secondly, the midden layers were stratigraphically close to the deposits sealing the house 3 entrance. It is therefore probable that this midden material was created elsewhere on site during the use of house 3 and redeposited over the paved area during the end of the use of the structure. However, it is also possible that this midden material was deposited *in situ* during the use of house 5. Though house 5 is stratigraphically later than house 3, an internal entrance links the two structures and they may have been used contemporaneously for at least part of the occupation of house 3 (Thomas 2011). This is supported by the fact that a stone-lined drain which surrounds the Eastern side of house 3 was recut and an additional external wall was constructed around house 3 when house 5 was in use (ibid).

Figure 33: Braes of Ha'Breck, Wyre, Orkney, trench A, early phase of house 3 (photos: A. Thomas). (a) South looking view of the North end of house 3, showing the carbonised grain layers, which may be the remains of a burnt grain store. (b) Detail of the carbonised grain in the structure. The deposit appeared to be almost completely composed of carbonised grain and little soil was present.

(a)

(b)

7.2 Methodology

7.2.1 Aims of data analysis

Due to the close correspondence of the radiocarbon dates obtained from each of the site phases, the overall aim of the sampling strategy was to obtain a representative sample to calculate the following for the site as a whole, and where appropriate, for individual contexts (see section 7.2.4.1):

a) mean grain density (per litre of sediment)
b) the proportion of wild and domestic species
c) the proportion of barley, wheat and oat grains
d) the proportion of each cereal species
e) the proportion of grain, chaff and weed seeds
f) the proportion of straight to twisted naked barley grains

A full list of each plant taxa and component included in each of the general categories is listed in table 27.

Table 27: Plant species and components in each category.

Latin name	Common name	Plant part	Wild/ domestic group	Cereal group (genus)	Cereal group (species)	Arable group	Annual/ perennial weed seed group	Woodland/ non-woodland weed seed group
Cerealia indet.	Indeterminate cereal	Grain	Domestic	Not included	Cereal indet.	Grain	n/a	n/a
cf. *Avena* sp.	Oat?	Grain	Domestic	Oat	Oat	Grain	n/a	n/a
Hordeum sp.	Barley	Grain	Domestic	Barley	Barley	Grain	n/a	n/a
Hordeum hulled asymmetric	Twisted hulled barley	Grain	Domestic	Barley	Hulled barley	Grain	n/a	n/a
Hordeum hulled symmetric	Straight hulled barley	Grain	Domestic	Barley	Hulled barley	Grain	n/a	n/a
Hordeum cf. hulled asymmetric	Twisted hulled barley?	Grain	Domestic	Barley	Hulled barley	Grain	n/a	n/a
Hordeum cf. hulled symmetric	Straight hulled barley?	Grain	Domestic	Barley	Hulled barley	Grain	n/a	n/a
Hordeum hulled	Hulled barley	Grain	Domestic	Barley	Hulled barley	Grain	n/a	n/a
Hordeum cf. hulled	Hulled barley?	Grain	Domestic	Barley	Hulled barley	Grain	n/a	n/a
Hordeum naked	Naked barley	Grain	Domestic	Barley	Naked barley	Grain	n/a	n/a
Hordeum naked asymmetric	Twisted naked barley	Grain	Domestic	Barley	Naked barley	Grain	n/a	n/a
Hordeum naked symmetric	Straight naked barley	Grain	Domestic	Barley	Naked barley	Grain	n/a	n/a
Hordeum cf. naked	Naked barley?	Grain	Domestic	Barley	Naked barley	Grain	n/a	n/a
Triticum sp.	Wheat	Grain	Domestic	Wheat	Wheat	Grain	n/a	n/a
cf. *Triticum* sp.	wheat?	Grain	Domestic	Wheat	Wheat	Grain	n/a	n/a
Triticum dicoccum Schübl.	Emmer Wheat	Grain	Domestic	Wheat	Emmer Wheat	Grain	n/a	n/a
Corylus avellana L.	Hazelnut	Nutshell, whole nuts	Wild	n/a	n/a	n/a	n/a	n/a
Empetrum nigrum L.	Crowberry	Seeds	Wild	n/a	n/a	n/a	n/a	n/a
cf. *Empetrum nigrum* L.	Crowberry seed?	Seeds	Wild	n/a	n/a	n/a	n/a	n/a
Crataegus monogyna Jacq.	Hawthorn	Fruit stone fragment	Wild	n/a	n/a	n/a	n/a	n/a
Hordeum vulgare L. emend. Lam.	6-row barley	Rachis internode	n/a	n/a	n/a	Chaff	n/a	n/a

Latin name	Common name	Plant Part	Wild/ domestic group	Cereal group (genus)	Cereal group (species)	Arable group	Annual/ perennial weed seed group	Woodland/ non-woodland weed seed group
Hordeum sp.	Barley	Rachis internode	n/a	n/a	n/a	Chaff	n/a	n/a
Cereal indeterminate	Cereal	Rachis internode	n/a	n/a	n/a	Chaff	n/a	n/a
Cereal indeterminate	Cereal	Culm node (>2mm)	n/a	n/a	n/a	Chaff	n/a	n/a
Cereal indeterminate	Cereal	Culm base (>2mm)	n/a	n/a	n/a	Chaff	n/a	n/a
Indeterminate	Indeterminate	Culm fragment	n/a	n/a	n/a	n/a	n/a	n/a
Indeterminate	Indeterminate	Culm node (<2mm)	n/a	n/a	n/a	n/a	n/a	n/a
Indeterminate	Indeterminate	Culm base (<2mm)	n/a	n/a	n/a	n/a	n/a	n/a
Brassica sp.	Cabbages	seed	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa
Brassicaceae	Cabbage family	seed	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Carex sp. (trigonous)	Trigonous sedge seed	nut	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa dominant
cf. *Carex* sp. (trigonous)	Trigonous sedge seed?	nut	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa dominant
Carex sp. (biconvex)	Biconvex sedge seed	nut	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa dominant
cf. *Carex* sp. (biconvex)	Biconvex sedge seed?	nut	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa dominant
Chenopodium sp.	Goosefoots	seed	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa
cf. Chenopodiaceae	Goosefoot family?	seed	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa
Fabaceae	Pea family	seed	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Galium aparine L.	Cleavers	nutlet	n/a	n/a	n/a	Weed seeds	Annual	non-woodland taxa
Montia fontana L.	Blinks	seed	n/a	n/a	n/a	Weed seeds	Annual-perennial	non-woodland taxa
Montia fontana L. ssp. *fontana*	Blinks	seed	n/a	n/a	n/a	Weed seeds	Annual-perennial	non-woodland taxa

Latin name	Common name	Plant Part	Wild/ domestic group	Cereal group (genus)	Cereal group (species)	Arable assemblage group	Annual/ perennial weed seed group	Woodland/ non-woodland weed seed group
Montia cf. *fontana* L.	Blinks?	seed	n/a	n/a	n/a	Weed seeds	Annual-perennial	non-woodland taxa
Plantago lanceolata L.	Ribwort Plantain	seed	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Poaceae (small)	Grass family	caryopsis	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Poaceae (large)	Grass family	caryopsis	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Polygonaceae	Knotweed family	achene	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Polygonum aviculare L.	Knotgrass	achene	n/a	n/a	n/a	Weed seeds	Annual	non-woodland taxa
Ranunculus sp.	Buttercup	achene	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Ranunculus cf. *bulbosus* L.	Bulbous Buttercup	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
cf. *Rosa* sp.	Rose?	achene	n/a	n/a	n/a	n/a	n/a	n/a
Rumex sp.	Dock	achene	n/a	n/a	n/a	Weed seeds	n/a	non-woodland taxa dominant
Rumex crispus L.	Curled Dock	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex cf. *crispus* L.	Curled Dock?	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex crispus L./*obtusifolius* L.	Curled Dock/Broad-leaved Dock	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex cf. *crispus* L./*obtusifolius* L.	Curled Dock/Broad-leaved Dock?	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex acetosella L.	Sheep's Sorrel	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex cf. *acetosella* L.	Sheep's Sorrel?	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex cf. *acetosa* L.	Common Sorrel?	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa

Latin name	Common name	Plant Part	Wild/ domestic group	Cereal group (genus)	Cereal group (species)	Arable assemblage group	Annual/ perennial weed seed group	Woodland/ non-woodland weed seed group
Rumex obtusifolius L.	Broad-leaved Dock	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Rumex cf. *obtusifolius* L.	Broad-leaved Dock?	achene	n/a	n/a	n/a	Weed seeds	Perennial	non-woodland taxa
Sinapis arvensis L.	Charlock	seed	n/a	n/a	n/a	Weed seeds	Annual	non-woodland taxa
Sinapis arvensis L.	Charlock	fruit	n/a	n/a	n/a	n/a	n/a	n/a
cf. *Sinapis arvensis* L.	Charlock?	seed	n/a	n/a	n/a	Weed seeds	Annual	non-woodland taxa
Spergula arvensis L.	Corn Spurrey	seed	n/a	n/a	n/a	Weed seeds	Annual	non-woodland taxa
Indeterminate	Seeds	seed / fruit	n/a	n/a	n/a	Weed seeds	n/a	n/a
Indeterminate	Seeds/Grain	seed/ fruit/ caryopsis	n/a	n/a	n/a	n/a	n/a	n/a

7.2.2 Sampling

7.2.2.1 On-site sampling and sample processing

On site, a total sampling strategy (Jones 1991b:57; van der Veen 1984:193) was adopted and so where possible 2 bulk soil sample tubs (c. 15-25 litres) were taken from all secure archaeological contexts, except deposits clearly affected by modern contamination or bioturbation. Smaller bulk soil samples (<15l) were taken from smaller features and contexts as appropriate. The soil from the bulk samples was processed using a Siraf-style flotation tank (Kenward et al 1980; Williams 1973), with the residue caught in a 1 mm mesh and the flot in 1.0 mm and 0.3 mm sieves. The flots and residues from the bulk samples were air-dried before transportation back to the environmental laboratories in the Archaeology Department at Durham University for post-excavation analysis.

7.2.2.2 Bulk sample sub-sampling

Due to the large number of contexts on the site and the time constraints of this PhD research, it was not possible to analyse 100% of the bulk samples from the site and so it was necessary to randomly sub-sample the bulk samples chosen for analysis at this stage.

The following discussion of the bulk sample sub-sampling methodology will use the terms and definitions summarised in table 28. For this thesis, a decision was made to concentrate exclusively on the two trenches containing the domestic structures (A and C) excavated during the 2007-2009 seasons. Unfortunately, the bulk samples from the probable charred grain store in house 3 could not be included, as this deposit was only uncovered in the final season of excavation, after the final identifications had been completed for this thesis.

Table 28: Sampling definitions used in this chapter (adapted from Lee 2012).

Term	Definition
Bulk sample	An individual soil sample from an archaeological site. Commonly “bulk sample” is abbreviated simply to “sample” in archaeological jargon, but this abbreviation will not be used in the discussion of the sampling methodology because of the confusion that this creates with the statistical definition of a “sample”.
Sample element	The individual units of which the sample is composed. In this research, a sample element is a spatial unit of soil from an individual context from the site.
Sample	A group of sample elements (= contexts) from an archaeological site.
Sample size	The total number of sample elements (= contexts) in the sample.
Sampling fraction	The proportion of the population sampled.
Targeted population	All the plant remains discarded on the site.
Sampled population	All the plant remains preserved on the site.
Retrieved population	All the plant remains recovered during the excavation and sampling of the site.
Subsampled population/ Sub-sample	A random subset of the retrieved population: all the plant remains analysed in the laboratory or a subset of the plant remains in an individual sample.
Simple random sampling	A random set of sample elements is selected from the population; each sample element has an equal chance of selection and cannot be represented more than once in the sample.
Stratified sampling	The population is divided into meaningful strata e.g. site phases and a simple random sample is taken from each strata.
Cluster sampling	The population is composed of sampling units (in archaeology often spatial units of soil) which contain the group of sampling elements of interest e.g. contexts containing grain. A random sample of sampling units is taken, but the sampling elements are not directly sampled.

In the 1980-90s, two main approaches were proposed for the random sampling of archaeological sites for archaeobotanical analysis:

1) specifying an arbitrary sampling fraction of contexts to be analysed, e.g. 10% (van der Veen 1984);
2) calculating the number of cereals/seeds required for calculating proportions to a desired level of confidence and accuracy using statistical sample size formulae for simple random sampling (van der Veen 1985; van der Veen and Fieller 1982).

However, there are several problems with these methods. Firstly, it is not the sampling fraction (table 28), but the sample size, that has the greatest effect on the precision of the results (Orton 2000:22). There is no 'magic sampling fraction', which can be applied to all sites to provide an adequate sample size (ibid). The appropriate sample size varies between different sites depending on the expected proportion of the targeted species or the variance of the mean between different sample elements in the population, and on the required accuracy and confidence levels required from the result (Agresti and Finlay 2009:126).

Secondly, though van der Veen and Fieller's (1982) formulae are suitable for calculating adequate sub-sample sizes for floated bulk samples in the laboratory, they cannot, as van der Veen (1985) suggests, be applied to calculate the required sample size for different site phases or a site as whole. Since it is the soil that is directly sampled, rather than the archaeobotanical remains, bulk soil samples are technically cluster samples rather than simple random samples (see table 28; Banning 2000:80-81; Lee 2012:653). The archaeobotanical remains from a random selection of features is not the same as a random sample of archaeobotanical material from the site. This is because the remains within an individual context are likely to be correlated or patterned according to the nature of that deposit and it is unlikely that the archaeobotanical material will be evenly distributed throughout the contexts on site (ibid). This is known as 'spatial autocorrelation' (ibid). Therefore, the formulae for simple random sampling are inappropriate for the calculation of sample sizes based on the numbers of archaeobotanical remains recovered.

Consequently, there are two possible options available for the calculation of adequate sample sizes for on-site archaeobotanical sampling. The first approach is to use the formulae for cluster sampling (table 28), with the archaeobotanical remains treated as parameters of the clusters (contexts) (Banning 2000:81). The second method is to treat the individual contexts as the sampling elements (table 28) by converting frequencies of archaeobotanical material to densities (e.g. grain per litre) (Banning 2000:82; Lee 2012).

This removes the problem of spatial autocorrelation, because each context is only included once in the calculation of means or proportions and contexts containing unusually high frequencies of particular remains are not overrepresented in the results. Therefore, if densities of archaeobotanical material are used, the formulae for simple random sampling can be applied to the dataset.

In this research, the second option was favoured and so densities were used rather than absolute numbers in all calculations (ibid). However, since the site could be sub-divided into several different phases, it was decided to employ a stratified sampling procedure (table 28). This method ensures that each phase of the excavation was appropriately represented in the sample and reduces the sample size required to calculate the means and proportions for the site as a whole by increasing the precision of the estimates (Cochran 1977:90; Drennan 1996:241).

Prior to subsample selection, the site contexts were divided into the categories of Trench A early (House 4 and eastern working area), Trench A late (Deposits post-dating Houses 3 and 4), Trench C early (House 1), Trench C late (House 2) and Trench C unphased, according to the preliminary site phases provided by the excavation director (A. Thomas pers. comm.). It must be emphasised that the early and late phases in the two trenches should not be regarded as contemporary. Unphased contexts (with the exception of those used in the preliminary sample: see below) were not included in the sampling population. Each context was also assigned to a generic context type and disturbed and heavily plough truncated contexts, wall fills and natural soils were excluded from the sampling population (table 29).

Two methods were used to calculate the minimum sample size required to calculate the means and proportions outlined in section 7.2.1. Firstly, the data from previous archaeobotanical analyses from Orcadian Neolithic sites gathered as part of the review in chapter 5 were examined to get an impression of the likely variance of the mean grain per litre and the main proportions in the Braes of Ha'Breck assemblage (tables 42 and 43). The proportions for the other sites were calculated using absolute frequencies rather than densities because the sample volume was only available for a minority of the sites. The sites were therefore cluster samples and so it is probable that the means and proportions will be slightly biased if there is considerable variability between samples (Banning 2000:81). Nevertheless, they provide a useful guide as to the approximate expected means and proportions at the Braes of Ha'Breck.

Secondly, a preliminary sample of contexts was analysed from the site (Barnett 1991:33; Lee 2012). For the preliminary sample, all the contexts from the 2007 season of the excavation were analysed, since all of these samples had all been floated prior to the beginning of this research and were available for analysis. Since the phasing information was not available at this stage, three samples that were subsequently classed as unphased were analysed as part of this preliminary sample. The preliminary samples included in each site phase and a summary of the results is shown in table 30. The means and proportions were calculated using the methods described in section 7.2.4.

Table 29: Definition of the generic context types included in this research.

Context type	Description	Abbreviation	Analyse?
Negative feature fill	Fill of linear features, pits, postholes, stakeholes, orthostat cuts.	NFF	Yes
Hearth, ash-rich or charcoal-rich deposit	Deposit found within an *in situ* hearth or an ash-rich or charcoal-rich deposit.	HD	Yes
Midden	Deposit rich in domestic material, that is either contemporary with the main structural features of the site phase or is redeposited.	M	Yes
General occupation level	Generic deposit that appears during excavation to be contemporary with main structural features of the site phase.	GOL	Yes
Natural, topsoil, subsoil	Natural soil, subsoil, topsoil or post-deposition soil formation	n/a	No: not contemporary with Neolithic phases.
Heavily plough truncated deposits	Heavily plough truncated deposits	n/a	No: disturbed and mixed deposits.
Wall fill	Mixed material infilling stone walls	n/a	No: mixed material of uncertain origin and phase.

Table 30: The summary of the results from the preliminary sample. The raw results are presented in appendix 4.

Year	2007	2007	2007	2007	2007
Trench	A	A	C	C	C
Trench phase	House 4 and eastern working area	Deposits post-dating Houses 3 & 4	House 1	House 2	Unphased
N	26	24	31	25	48
Preliminary sample size	10	5	3	6	3
Barley (%)	100.00	93.38	97.33	99.40	100.00
Wheat (%)	0.00	0.00	2.67	0.60	0.00
Oat (%)	0.00	6.62	0.00	0.00	0.00
Domestic (%)	73.55	89.99	98.80	99.94	100.00
Wild (%)	26.45	10.01	1.20	0.06	0.00
Grain (%)	35.55	27.85	97.63	99.08	98.71
Chaff (%)	5.33	0.00	0.00	0.00	0.00
Weeds (%)	59.12	72.15	2.37	0.92	1.29
Mean grain density/litre	0.15	0.15	5.50	15.05	17.86
Variance of mean grain density	0.02	0.03	7.63	740.75	401.87

The use of a preliminary sample was considered to be the most reliable method of estimating the likely variance of the mean grain per litre between different samples, since this can vary considerably between different sites and because the volume of soil was unavailable for many of the sites in the review. Therefore, the variances calculated for each site phase of the preliminary sample were used in the sample size formulae for means. None of the individual domestic species or barley proportions from the preliminary sample or from the other Orcadian sites was less than 74% (0.74) (tables 30 and 43). However, the proportion of grain, seeds and chaff was extremely variable between different samples and sites, and the proportion of grain or seeds approached 50-60% in some cases (tables 30 and 43). Consequently, the most conservative estimate (0.5) was used as the proportion in the sample size formulae (Drennan 1996:143). A 95% confidence level was set for all analyses and a 0.1 (10%) margin of error was considered appropriate for this study.

To calculate the appropriate sample size for analysis, the formulae for the presumed optimum allocation were used to ensure that the variably of the different strata were taken into consideration and to reduce sampling errors (Orton 2000:30). The formulae used to calculate the sample size for presumed optimum allocation for proportions was (Cochran 1963:109):

$$n_0 = \frac{(\sum W_h \sqrt{p_h q_h})^2}{V},$$

$$n = \frac{n_0}{1 + \frac{1}{NV}\sum W_h p_h q_h}.$$

The formula used for calculating the presumed optimum allocation for means was (Cochran 1977:105):

$$n = \frac{(\sum W_h s_h)^2}{V + \frac{1}{N}\sum W_h s_h^2}.$$

For both equations, the required variance, V was calculated using the formula: $V = (d/t)^2$ (Cochran 1977:105). Once the overall sample size was calculated, the required number of samples in each strata was calculated using the formulae for optimum allocation. The formula used for calculating the presumed optimum allocation for means was (Cochran 1977:98):

$$n_h = n\frac{W_h S_h}{\sum W_h S_h},$$

where S_h was estimated using the sample standard deviation, s_h (Thompson 1992:107) and $W_h = \frac{N_h}{N}$. Since this formula produced an n_h larger than the N_h for Trench C late phase, the n_h was reduced to the total number in the stratum (N_h) and the remainder of the samples were taken from Trench C early phase as calculated by the formula (Cochran 1977:104).

The formulae for presumed optimum allocation for proportions was used for estimating the required number of sample elements in each strata (Cochran 1977:108):

$$n \doteq n\frac{N_h\sqrt{P_h Q_h}}{\sum N_h \sqrt{P_h Q_h}}, \text{ where } P = \frac{A}{N}.$$

$P_h Q_h$ was estimated using $p_h q_h$ and P using $p = \frac{a}{n}$ where

a = the total density for the class of item of interest in the sample, e.g. total barley density and n = the total density of material in the sample, e.g. total grain density.

The notation used in these formulae follows Cochran (1977:90) and Orton (2000:210-211):

$_h$ = site phase h;

n = the sample size for a finite population;

n_0= the sample size for an infinite population;

N = the total number of contexts in the population;

N_h= the total number of contexts in the population of site phase *h*;

W_h= the site phase weight in the population;

P = the population proportion;

A = the total density for the class of item of interest in the population, e.g. total barley density;

$Q = (1 - P)$;

p =the sample proportion;

p_h= the proportion in the sample of site phase *h*;

$q_h = (1 - p_h)$;

S_h = the population standard deviation in site phase *h*;

s_h= the sample standard deviation in site phase *h*;

s_h^2= the sample variance in site phase *h*;

V = the required variance for the sample mean or proportion;

d = the accuracy/confidence level/margin of error required, i.e. a multiple of the standard error, the standard deviation of the sampling distribution (Agresti and Finlay 2009:110);

t = the t-score for the required confidence level (e.g. the t-score for a 95% confidence level is 1.96) (Agresti and Finlay 2009:119).

After the required sample size had been calculated, random numbers were obtained from an online random number generator (Haahr 1998-2012) and were used to select the required number of contexts from each trench phase. A summary of the samples chosen for analysis in each site phase is shown in table 31.

Table 31: A summary of the samples chosen for analysis in each site phase.

Year	2007	2007	2007	2007	2007	2007-2009
Trench	A	A	C	C	C	A & C
Trench phase	House 4 and eastern working area	Deposits post-dating Houses 3 & 4	House 1	House 2	Unphased	Total phased
N	26	24	31	25	48	106
Preliminary sample size	10	5	3	6	3	24
Sample size (n)	12	11	15	25	n/a	63
Sampling fraction	46%	46%	49%	100%	n/a	59%

7.2.2.3 Sub-sampling of large grain deposits

Whilst the majority of the bulk samples from the 2007-9 excavations contained only small concentrations of grains, there were several bulk samples that contained large quantities of cereal caryopses. Due to time constraints, it was not feasible to identify all the grain from these samples. Consequently, sample size formulae were used to calculate the minimum number of grains necessary to estimate the proportions of each species in each of the large samples (van der Veen and Fieller 1982). Samples with more than c. 300 grains were considered large enough to require sub-sampling. The following sample size formula for a finite population was used to calculate the number of grains required (van der Veen and Fieller 1982):

$$n = \frac{N}{\{1 + \frac{(N-1)}{P(1-P)}(d/Z_\alpha)^2\}}$$

In this formula, the notation is as follows:
n = the number of grains required in the subsample;
N = the total number of grains in the sample;
P = the population proportion of the main cereal species (barley)
d = the accuracy/confidence level/margin of error required, i.e. a multiple of the standard error, the standard deviation of the sampling distribution (Agresti and Finlay 2009:110);
Z_α = the z-score (number of standard deviations from the mean) for the required confidence level (the z-score for a 95% confidence level is 1.96 and therefore there is a 95% probability that normally distributed data lies within 1.96 standard deviations of the mean) (Agresti and Finlay 2009:80-82).

The population proportion was estimated using the proportions of barley in the other Orcadian Neolithic assemblages (table 43) and from the preliminary site sample (table 30). The lowest proportion of barley in any individual assemblage was from the Ness of Brodgar, which contained 81% barley. However, all the other assemblages with cereals in Orkney contained at least 92% barley and considering the small size of the Ness of Brodgar assemblage (59 grains), it is probable that the proportion of the minor component (oat) was an overestimate of the population proportion. Though the number of grains was low in the preliminary sample from the Braes of Ha'Breck prior to the analysis of the first large grain samples (165 identifiable grains), the lowest site phase proportion in the preliminary sample was 94% barley. This suggested that the Braes of Ha'breck assemblage conformed to the general Orcadian Neolithic pattern. However, in the sample size formula it was decided to use a conservative estimate of the population proportion and so the population proportion was set at 0.8 (80%), which was lower than the lowest barley proportion in any individual Orcadian Neolithic site (table 43). Following van der Veen and Fieller (1982:296), a 95% confidence level (Z_α) and 5% margin of error (d) were used in the formulae.

Where large samples contained an estimated number of grains of less than 1000, all the grains were counted and the actual number of grains was used in the sample size formulae. For samples with more than c. 1000 grains, the total numbers of grains in the sample was estimated using a riffle box to create a subsample fraction size of approximately 300 grains for counting. Random subsamples for counting and identification were produced using a riffle box, because experiments have shown that riffle boxes are effective in creating a representative simple random sample of grain (van der Veen and Fieller 1982). After one of the riffle box subsample fractions was completely counted, the subsample proportion of the total sample was used to estimate the total number of grains in the sample.

After the sample size was calculated using the formula, riffle box fractions that were greater than the required sample size where selected. Since the population proportions used in the analysis applies to identifiable grains only (van der Veen 1985:169) and based on the preliminary analysis, the proportion of indeterminate grains in the assemblage was high (c. 39% of the initial 275 grains identified were indeterminate), for each calculated riffle box fraction, the estimated number of identifiable grains was calculated using 40% as the estimated number of unidentifiable grains. If the estimated number of identifiable grains in the chosen riffle box fraction was higher than the required sample size, then all the grains were identified in the chosen riffle box fractions, but if it was lower then an additional riffle box fraction was added to the subsample for identification. Likewise, if after identification, there were a greater number of unidentifiable grains than estimated, additional riffle box fractions were identified until the required sample size was reached. Finally, the total number of grains identified in each category was multiplied by the subsample proportion to estimate the number of grains of each species in the total bulk sample.

7.2.3 Laboratory methods

All the residues in the selected sub-sample were fully sorted to 4mm by eye. In order to ensure high recovery rates of archaeobotanical remains from the samples and to reduce residue sorting time, a secondary reflot of the 2mm and 1mm dried residues was undertaken in the laboratory (van der Veen 1983; Wagner 1988:21) using the wash-over technique (Kenward et al 1980:9; Pearsall 2000:16) with a 1mm sieve. Considering that a 1mm sieve was used for the basal mesh in the original flotation system, in samples with poor flotation recovery rates it is probable that charred plant material <1mm will be underrepresented (ibid). However, previous research suggests that little additional information is gained from studying the <1mm fraction (Smith 1999:336) and so this fraction was not sorted. After reflotation, the reflots were air dried and combined with the flots prior to sorting.

The flots were separated into >4mm, >2mm and >1mm fractions using geological sieves and sorted using a Leica M80 stereo microscope under x7.5-60 magnification. Table 32 summarises the plant material sorted from each sieve fraction. All hazel nutshell was extracted from the 4mm and 2mm flots and counted, but due to the rarity of nutshell in the 1mm flot, nutshell was not removed from this fraction (see appendix 2). Uncarbonised plant macrofossils were not sorted from the samples or recorded due to the absence of waterlogged conditions at the site.

Table 32: Material sorted from each sample fraction. C: count; W: weigh; 4F: 4mm flot; 4R: 4mm residue; 2F: 2mm flot; 2R: 2mm residue; 1F: 1mm flot; 1R: 1mm residue

	4F	2F	1F	4R	2R	1R
Charcoal	CW					
Carbonised cereal grain/seeds	C	C	C	C	refloated: C	refloated: C
Tuber/ root/ parenchyma	C	C	C	C	refloated: C	refloated: C
Culm node	C	C	C	C	refloated: C	refloated: C
Culm base	C	C	C	C	refloated: C	refloated: C
Culm fragment	C	C	C	C	refloated: C	refloated: C
Nutshell	CW	CW		CW	refloated: CW	
Amorphous plant material (burnt peat)	CW			CW		
Other carbonised plant material	C	C	C	C	refloated: C	refloated: C
Uncarbonised plant remains						

All plant macrofossil identifications were made using botanical literature (Anderburg 1994; Beijerinck 1947; Berggren 1969, 1981; Cappers et al 2006; Dickson unpublished; Hather 1993, 2000a; Jacomet 2006; Long 1929; van der Veen 1992:22-25) and modern reference material from the Department of Archaeology, University of Durham. Basic criteria for the cereal grain identifications are given in table 33. To avoid multiple counting of fragmented cereal caryopses and rachis fragments, only grains with embryo ends were counted and rachis internodes, rather than rachis fragments were given a count of one (Jones 1987:313, 1990:92). The degree of preservation of each cereal grain was recorded using Hubbard and al Azm's (1990) preservation indices (table 34). Following van der Veen (1992:24) and Church (2002a), wild grass caryopses were separated into 'small grasses' and 'large grasses' and sedges were divided into 'biconvex' or 'trigonous' but not identified to genus or species. In this study, small grass seeds were defined as those with a total length less than 3mm and large grass seeds as those greater than 3mm in length. Both whole and fragmented seeds and tubers were counted, but they were quantified separately. Hazel nutshell >2mm was counted and used as a quantifiable component in the data analysis and was further recorded using the detailed methodologies outlined in appendix 2. Culm nodes and bases were separated into >2mm and <2mm fractions, to allow the approximate separation of cereal culm material, which is usually >2mm, from culm material deriving from wild grasses, which is usually <2mm (Church 2002b:44). Nomenclature follows Stace (1997), and ecological information was taken from Stace (1997), Clapham et al (1987) and Bullard (1995). Additional information on arable weeds also obtained from Long (1929) and McConnell (1930), with Ellenberg indicator values suitable for UK weed species taken from Hill et al (2008). Ethnobotanical information was obtained from the sources listed in appendix 1.

During sample sorting, fragments of charred parenchyma were separated into different types of fragment, according to the different categories of plant storage parenchyma present (Hather 2000a). As will be made apparent in the discussion of the results below, most of the material was probably not further identifiable, but some of the fragments may be identifiable with an SEM. Considering the wide scope of this PhD research, the lack of practical expertise of the author in parenchyma identification and the time available, the identification of this material was considered to be outwith the immediate confines of this research project. Consequently, material that could not be identified by gross morphology, but was considered suitable for further identification under SEM was separated, ready for future specialist analysis, but was not identified at this stage.

Table 33: Cereal identification criteria, based on Church (2002b), Dickson (unpublished), van der Veen (1992:22-23) and Jacomet (2006).

Cereal taxa	Criteria
Cereal indeterminate caryopsis	No identification criteria surviving (generally heavily fragmented and vesiculated). Embryo end present.
Avena sp.	Very shallow ventral groove with no dorsal ridge. Cross-section rounded, with a generally long and thin appearance.
cf. *Avena* sp.	Probable very shallow ventral groove with no dorsal ridge. Cross-section rounded, with a generally long and thin appearance.
Hordeum sp. caryopsis	Shallow ventral groove with no dorsal ridge. Cross-section morphology indistinct.
Hordeum naked caryopsis	Cross-section clearly rounded, with clear rounded appearance. Horizontal lines may be visible on dorsal and ventral sides. Embryo end shape indistinct/damaged/soil coated.
Hordeum cf. naked caryopsis	Cross-section appears rounded, with probable, but indistinct rounded appearance. Horizontal lines not visible on dorsal and ventral sides. Embryo end shape indistinct/damaged/soil coated.
Hordeum naked symmetric caryopsis	Cross-section rounded, with general rounded appearance and horizontal lines visible on dorsal and ventral sides (straight grain).
Hordeum naked asymmetric caryopsis	Cross-section rounded, with general rounded appearance and horizontal lines visible on dorsal and ventral sides (twisted grain).
Hordeum hulled caryopsis	Hulled material attached to grain or cross-section clearly angular, with general angular appearance. Embryo end shape indistinct/damaged/soil coated.
Hordeum cf. hulled caryopsis	Cross-section and general appearance quite angular but no hulled material attached. Embryo end shape indistinct/damaged/soil coated.
Hordeum hulled symmetric caryopsis	Hulled material attached to grain or cross-section clearly angular, with general angular appearance (straight grain).
Hordeum hulled asymmetric caryopsis	Hulled material attached to grain or cross-section clearly angular, with general angular appearance (twisted grain).
Triticum sp. caryopsis	Deep ventral groove with dorsal ridge.
Triticum aestivum L. caryopsis	Flat ventral surface, with a slight dorsal ridge, rounded cheeks and a general short, rounded appearance and blunt apex.
Triticum cf. *aestivum* L. caryopsis	Flat ventral surface, with a dorsal ridge and short, rounded appearance and blunt apex.
Triticum dicoccum Schübl. caryopsis	Flat or concave ventral surface, pronounced dorsal ridge and blunt apex. Narrower and longer than *T. aestivum* L., and with a more pronounced dorsal ridge
Triticum cf. *dicoccum* Schübl. caryopsis	Probable flat or concave ventral surface, pronounced dorsal ridge and blunt apex.

Table 34: Cereal grain preservation criteria (Hubbard and Al Azm 1990).

Preservation Index	Definition
1	Perfect
2	Epidermis virtually intact; rhachillae etc. observable
3	Epidermis incomplete; rhachillae, hairs etc. occasionally preserved
4	Fragments of epidermis remaining; other features virtually unobservable
5	Identifiable by gross morphology only
6	“Clinkered”

7.2.4 Data analysis

7.2.4.1 Levels of analysis

Two main levels of data analysis were undertaken: sample and site analysis. Site phase analyses were also undertaken to calculate the results for the site as a whole. The analyses that were undertaken at each of these levels depended on the research aims and the minimum numbers of identifiable components at each level. For instance, the onsite distribution of wild and domestic species was not considered an important research question and so these proportions were only calculated for the site as a whole and not for individual samples.

Conversely, as well as calculating the proportions of the different species and crop components for the site as a whole, the onsite distribution of cereal species and grain/chaff/seeds in different samples was considered important to identify whether any mixed crop assemblages were present on site (Jones and Halstead 1995:113) and for understanding which crop processing stages were represented (Jones 1990). Whilst few samples contained the minimum numbers of grains or grain/chaff/seeds required to calculate proportions for an infinite population to a reasonable degree of accuracy (384 identifications for proportions of 50%, 246 identifications for proportions of 80% or 138 identifications for proportions of 90% for a particular class of material in the sample; van der Veen and Fieller 1982), most of the small bulk samples (in terms of volume) were 100% samples of particular contexts. Moreover, using the minimum expected proportion of 80% for barley, the low density of grain per litre (mostly <10 grains per litre: table 36; figure 34a) suggests that in most cases the required volume of soil would have exceeded the total volume of soil within most small-medium contexts. Consequently, whilst the total number of grains or grains/seeds/chaff in each context is not known, it cannot be considered to be a truly infinite population. This means that proportions calculated using samples with less than 246 grains or 384 grains/seeds/chaff can be considered fairly reliable, provided that the total number of items is large enough to allow the calculation of proportions. Jones (1987) used 100 crop components as a minimum for crop content analyses, and van der Veen (1992) and Bogaard (2004) used 50 crop items as a minimum number for these analyses. In this analysis, samples with less than ten items were excluded from the calculations involving the proportions of different cereal species or crop content, to prevent low frequencies of particular items being overestimated in the overall calculations. It would have been preferable to only include samples with over 100 (rather than over ten) cereal grains/crop items in these calculations (cf. Jones 1987:313), but this would have severely restricted the number of samples available for consideration. Consequently, when plotting this data, the total number of grains/crop items in each sample was indicated, to highlight whether small sample sizes have produced misleading results.

Whilst basic analysis of the grain, seed and chaff content of the samples were possible, the weed seed frequency was inadequate in individual samples for the identification of detailed crop processing stages using the physical properties of the seeds (Jones 1984, 1987) or to identify detailed crop husbandry practices using the ecological characteristics of the potential weeds (Bogaard 2004). Bogaard (2002, 2004:62) suggests that 30 potential weed seeds identified to species (or species groups including a maximum of three species) are necessary per sample before such analyses can be undertaken. None of the bulk samples in the Braes of Ha'Breck assemblage contained more than 13 potential weed seeds identified to species (or two or three species groups) and there were only 11 potential weed species identified. It was therefore not possible to identify whether individual samples contained a mix of different processing stages (Jones 1987) or to identify detailed crop husbandry practices using multivariate techniques (cf. Bogaard 2004).

Consequently, the ecological characteristics of the potential weed seeds could only be considered on a presence/absence basis for the site as a whole. Note was made of whether each seed taxon identified to species was an annual or perennial plant and whether any woodland taxa were present in the assemblage (table 27). These factors can be used to indicate whether permanent or shifting cultivation was taking place: experimental studies suggest that weed seed assemblages from recently cleared plots receiving minimal tillage or weeding within woodland environments and are characterised by high concentrations of woodland and perennial taxa (Bogaard 2002; Bogaard and Jones 2007:307). Since there were a large number of non-species identifications in the assemblage, note was also made of whether most of the genus/family identifications were dominated by woodland species (table 27). Ellenberg values (Hill et al 2008) were also recorded for each of the identified seed species.

7.2.4.2 Data categorisation

A full list of each plant species and component included in each of the general categories used in the data analysis is listed in table 27. As in chapter 5, for the wild and domestic plant analysis, only edible fruits and nuts were included in the 'wild' category, and cereal chaff was excluded and oat grain included in the 'domestic category'. It should be noted that due to the absence of floret bases it is not possible to be certain whether the oat grain is a wild or domestic species. However, given that only 1 oat grain was recovered from the site, it will make little difference to overall results.

For the analysis of crop content, culm fragments and <2mm culm nodes/bases were not included as quantifiable components in the 'chaff' category, because they are more likely to derive from wild grasses than cultivated cereals (Church 2002b:44). Following Bogaard (2002, 2004) and van der Veen (1992) seeds from water plants and trees and shrubs were excluded from the potential 'weed seeds' category. The species considered to be possible arable weeds followed van der Veen (1992) and so species, which may have been arable weeds in the past, such as sedge, but are not usually considered to be arable weeds today were included in the 'weeds' category.

It would have been preferable to only include seeds identified to genus or species in this category to ensure that non-arable weed seeds were excluded. However, due to the high proportion of indeterminate seeds in the samples, it was felt that excluding indeterminate seeds and seeds identified to family only, would result in an inaccurate representation of the proportion of weed seeds relative to grain and chaff. As only a small proportion (16%) of the seeds identifiable to genus or species came from trees/shrubs (26 seeds) and none came from water plants, this approach was considered justifiable.
Since glume wheats, such as Emmer Wheat, are processed differently than free-threshing cereals, such as barley (Hillman 1981b), it has been suggested that the calculation of grain, seed and chaff proportions is not reliable for samples containing a mix of barley and wheat (Jones 1987:322, 1990:92). Yet, in this assemblage, wheat grains were extremely rare (11 grains) and so it is probable that the wheat was merely a contaminant of the barley crop (Jones and Halstead 1995) (see section 7.4.8). Considering the high proportion of barley in the samples, it is also proposed that the majority of the indeterminate grains were barley grains (see sections 7.3.2 and 7.4.8). Consequently, the inclusion of wheat and indeterminate grain in the 'grain' category was considered justified for this analysis (cf. Bogaard 2004:64; Jones 1990:92; van der Veen 1992:94).

7.2.4.3 Individual sample analyses

The first stage in the analysis was to calculate the densities of each component in each bulk sample by dividing the total for each component by the total volume of the sample. These densities were used in the site phase and site analyses described in sections 7.2.4.4 and 7.2.4.5. In addition, proportions were calculated for each context. The standard error cannot be calculated for individual features because only a single bulk sample was taken from each context (Orton 2000:166). In effect, the standard error was 0, since each bulk sample was treated as the total population of the context.

To assess whether 2-row barley (*Hordeum distichum* L. emend. Lam.) or 6-row barley (*Hordeum vulgare* L. emend. Lam.) was represented in the samples, the proportion of straight to twisted grains was calculated (van der Veen 1992:23). In addition, where possible van der Veen (1992:82)'s crop processing ratios 2 and 3 were applied to the data set: $RI:BC$ and $WS:C$,

where
RI = the number of barley rachis internodes
BC = the number of barley caryopses
WS = the number of potential weed seeds
C = the number of cereal caryopses.

Within a whole ear of 6-row barley, the expected $RI:BC$ is 1:3= 0.3 and for 2-row barley, 1:1= 1 (ibid). When a ratio in an archaeological sample is greater than the expected ratio, this indicates the presence of early processing waste (e.g. from winnowing or coarse sieving), whereas when the ratio in the sample is less than the expected ratio, this suggests that the products of later crop processing stages are present (ibid). Similarly, when the number of cereal grains is much greater than the number of weed seeds, a cleaned product is probably represented (ibid). If there are fewer grains than weed seeds in the sample, this suggests that crop processing waste is present (ibid).

7.2.4.4 Site phase analyses

Site phase analyses were conducted in order to calculate the results for the site as a whole. Firstly, each site phase was treated as a separate population (Drennan 1996:237) and the formulae for simple random sampling were employed to calculate the means and proportions for each site phase separately. As discussed in section 7.2.2.2, densities of archaeological material (per litre of soil) were used in all calculations to avoid the use of poor cluster samples and to enable the use of simple random sample formulae (Banning 2000:80; Lee 2012). Following Orton (2000:210), the mean grain density of each population was estimated using the formula:

$$\hat{\bar{Y}} = \bar{y} = \frac{\sum_{1}^{n} y_i}{n}$$

where

$\hat{\bar{Y}}$ = the mean grain density in the population;

$\bar{y}$ = the mean grain density in the sample;

y_i = the ith grain density;

n = the number of contexts in the sample.

The standard error (Drennan 1996:129; Orton 2000:210) was estimated as:

$$SE = \left(\sqrt{1 - \frac{n}{N}}\right)\frac{s}{\sqrt{n}}$$

where

SE = the standard error of the estimate of the population mean;

s = the sample standard deviation;

n= the number of contexts in the sample;

N = the number of contexts sampled in each site phase.

The margin of error was then calculated at the 95% confidence level for each mean by multiplying the standard error by the appropriate t-score, depending on the degrees of freedom of the sample (Agresti and Finlay 2009:119). The degrees of freedom were calculated as n -1 for each site phase.

All population proportions were estimated using the formula (Orton 2000:211):

$P = p = \frac{a}{n}$, using $\times\frac{100}{1}$ to convert to percentages when required,

where

P = the population proportion;

p = the sample proportion;

a = the total density for the class of item of interest in the sample, e.g. total barley density;

n = the total of density of material in the sample, e.g. total grain density.

The standard error was calculated using the formula (Drennan 1996:141):

$$SE = \sqrt{\frac{pq}{n}\left(1 - \frac{n}{N}\right)}$$

where

SE = the standard error of the estimate of the population proportion;

p = the sample proportion;

$q = 1 - p$;

n = the number of contexts in the sample;

N = the number of contexts sampled in each site phase.

The margin of error was then calculated at the 95% confidence level for each proportion by multiplying the standard error by 1.96 (Agresti and Finlay 2009:116).

Though the overall aim of the data analysis was to use the site phase calculations to calculate the means and proportions for the site as a whole (see section 7.2.1), differences between the 4 site phases were also of interest. Since the sample size calculations were utilised to calculate the required sample size for calculating the proportions for the site as a whole, the sample size was inadequate to use a Chi-squared test to compare the proportions between the different site phases. The minimum criteria for performing a Chi-squared test is that none of the expected values calculated for each category is less than 1 (Drennan 1996:197). Since at least one of the expected values was less than 0.1 for each of the proportion calculations, the minimum criteria for this analysis was not met. Likewise, the margin of error was considerably larger than the desired margin of error (>0.1) for the grain per litre for many of the site phases and therefore it was considered that individual site phase means could not be reliably compared using an analysis of variance calculation. A larger sample size from each site phase would be required to allow the accurate comparison of the different site phases. Due to the large number of samples from the site, time precluded the analysis of a larger sub-sample from each site phase at this stage. Future analysis of material from the site should aim to allow these calculations to be conducted to compare the different site phases.

7.2.4.5 Site analysis

The means and proportions calculated for each site phase were then used to estimate the means and proportions for the site as a whole. Following Cochran (1977:91), the mean grain per litre for the site as a whole was estimated using the formula:

$$\bar{y}_{st} = \frac{\sum_{h=1}^{L}(N_h \bar{y}_h)}{N}$$

where

$\bar{y}_{st}$= the estimate of the population mean for the site as a whole using stratified sampling;

$\bar{y}_h$= the mean grain per litre in the sample for site phase h;

N_h = the total number of contexts in the population of site phase h;

N = the total number of contexts in the whole population.

The variance of $\bar{y}_{st}$ was calculated as (Cochran 1977:92; Orton 2000:212):

$$V(\bar{y}_{st}) = \frac{\sum_{h=1}^{L} N_h (N_h - n_h) \frac{s_h^2}{n_h}}{N^2}$$

and the standard error as (Orton 2000:212):

$$SE_p = \sqrt{\frac{(\sum_{h=1}^{L} N_h (N_h - n_h) \frac{s_h^2}{n_h}}{N^2}}$$

where

$V(\bar{y}_{st})$= the variance of the population mean for the site using stratified sampling;

SE_p = the standard error for the estimate of the population mean for the site;

N_h = the total number of contexts in the population of site phase h;

N = the total number of contexts in the whole population;

n_h= the total number of contexts in the sample of site phase h;

s_h^2= the variance of the sample mean for site phase h.

The margin of error was then calculated at the 95% confidence level by multiplying the standard error by the appropriate t-score (approximately 2.0 for a sample size of 63) (Agresti and Finlay 2009:119).

Following Cochran (1977:107), the proportions outlined in section 7.2.1 were estimated for the site as a whole using the formula:

$$P_{st} = \sum \frac{N_h p_h}{N}$$

where

P_{st} = the estimate of the population proportion for the site using stratified sampling;

N = the total number of contexts in the whole population;

N_h = the total number of contexts in the population of site phase h;

p_h = the proportion in the sample of site phase h;

The variance of P_{st} was calculated as (Cochran 1977:107):

$$V(P_{st}) = \left(\frac{1}{N^2}\right)\left(\sum \frac{N_h^2 (N_h - n_h)}{(N_h - 1)} \frac{p_h q_h}{(n_h - 1)}\right)$$

and the standard error as:

$$SE_p = \sqrt{\left(\frac{1}{N^2}\right)\left(\sum \frac{N_h^2 (N_h - n_h)}{(N_h - 1)} \frac{p_h q_h}{(n_h - 1)}\right)}$$

where

$V(P_{st})$= variance of the population proportion;

SE_p =the population standard error for all site phases together;

N_h= the total number of contexts in the population of site phase *h*;

n_h= the total number of contexts in the sample of site phase *h*;

p_h= the proportion in the sample of site phase *h*;

$q_h = (1 - p_h)$.

The margin of error was then calculated at the 95% confidence level for each proportion by multiplying the standard error by 1.96 (Agresti and Finlay 2009:116).

7.3 Results

7.3.1 Assemblage composition

The full archaeobotanical results from the Braes of Ha'Breck are presented in appendix 4 (tables 50-52) and a summary of the results is given in tables 35-39 and figures 34-42. Overall, cereal grain and chaff density was very low for most samples (figure 34). However, there were several individual samples containing medium-large grain deposits in Trench C. Most samples were dominated by cereal grain, together with a moderate-low frequency of seeds and parenchyma fragments. Chaff was extremely rare in all samples (figures 34-36). Though some of the smaller samples contained between 30-70% seeds, all of the samples with more than 100 quantifiable components contained over 88% grain (figure 36). This suggests that the seed component is overrepresented in the samples with a low number of quantifiable components. The low chaff frequency is also indicated by the ratio of the barley rachis internodes to barley grain, which was less than or equal to 0.3 for all samples (appendix 4, table 50). Likewise, for most samples with more than ten identifications, the ratio of seeds to grain shows that the number of cereal grains was much greater than the number of weed seeds (appendix 4, table 50). Edible fruits and nuts were scarce in all samples and there were no notable concentrations of this material. Overall, approximately 89% of the assemblage was composed of domestic plant species (figure 37) and only two of the individual samples contained more wild than domesticated species. Since both of these samples contained fewer than 50 quantifiable components, these proportions cannot be considered to be reliable.

Table 35: The results from the sub-sampled grain deposits. The total numbers of grains identified in each category were multiplied by the subsample proportion to estimate the number of grains of each species in the total bulk sample. C: caryopsis.

Sample	24	24	38	38	41	41	88	88	124	124
Context	414	414	406	406	427	427	436	436	418	418
Fraction identified	62.5%	100%	75%	100%	50%	100%	75%	100%	50%	100%
Cultivated species										
Avena										
cf. *Avena* sp. (C)	0	0*	0	0*	0	0*	0	0*	0	0*
Hordeum										
Hordeum sp. (C)	56	94.9*	97	133.1*	94	198.6*	65	86.25*	125	261.41*
Hordeum naked (C)	41	69.4*	32	43.9*	56	118.3*	58	76.96*	60	125.48*
Hordeum cf. naked (C)	0	0*	10	13.7*	0	0*	1	1.33*	3	6.27*
Hordeum naked symmetric (C)	36	61*	30	41.2*	38	80.3*	30	39.81*	29	60.65*
Hordeum naked asymmetric (C)	6	10.2*	3	4.1*	5	10.6*	1	1.33*	6	12.55*
Hordeum hulled (C)	0	0*	0	0*	0	0*	1	1.33*	0	0*
Hordeum cf. hulled (C)	0	0*	0	0*	1	2.1*	0	0*	1	2.09*
Hordeum cf. hulled asymmetric (C)	1	1.7*	0	0*	0	0*	0	0*	0	0*
Hordeum hulled symmetric (C)	0	0*	0	0*	0	0*	0	0*	0	0*
Hordeum hulled asymmetric (C)	0	0*	0	0*	0	0*	0	0*	0	0*
Triticum										
cf. *Triticum* sp. (C)	0	0*	0	0*	0	0*	0	0*	1	2.09*
Triticum sp. (C)	2	3.4*	0	0*	0	0*	0	0*	0	0*
Triticum dicoccum Schübl. (C)	2	3.4*	0	0*	0	0*	0	0*	0	0*
Cereal indeterminate (C)	52	88.1*	126	172.9*	133	281*	153	203.01*	509	1064.46*
Total grain	196	332	298	409	327	691	309	410	734	1535
Identifiable grain	144	244*	172	236*	194	410*	156	207*	225	471*

Table 36: Mean grain per litre for each site phase at the Braes of Ha'Breck.

Year	2007	2007	2007	2007	2007	2007	2007-2009	2007-2009
Trench	A	A	A	C	C	C	A & C	A & C
Trench phase	House 4 and eastern working area	Deposits post-dating Houses 3 & 4	Deposits post-dating Houses 3 & 4 (without outlier)	House 1	House 1 (without outlier)	House 2	Total phased	Total phased (without outliers)
N	26	24	23	31	30	25	106	106
Sample size (n)	12	11	10	15	14	25	63	63
Volume of soil (l)	98	216.5	189.5	82.6	82.2	189	586.1	558.7
Total number of grains	28	278	86	305	239	3974	4585	4327
Mean grain density ($\bar{y}$)	0.28	1.04	0.43	13.62	2.8	33.23	9.9	8.44
Standard Error	0.1	0.5	0.1	7.8	0.8	0	2.28	0.23
Margin of Error	0.17	1.02	0.23	16.73	1.68	0	4.6	0.5

Table 37: Summary of the cereal results from the Braes of Ha'Breck, Wyre, Orkney. C: caryopsis; CN: culm node; CB: culm base; CF: culm fragment; RI: rachis internode; BC: barley caryopses. For full results see appendix 4.

Year	2007-2009	2007-2009	2007-2009	2007-2009	2007-2009	Total
Trench	A	A	C	C	C	A & C
Trench phase	House 4 and eastern working area	Deposits post-dating Houses 3 & 4	House 1	House 2	Unphased	All phases
Total number of samples (N)	26	24	31	25	48	154
Number of samples examined (n)	12	11	15	25	3	66
Sample volume (l)	98	216.5	82.6	189	22.5	608.6
Avena						
cf. *Avena* sp. (C)		1				1
Hordeum						
Hordeum sp. (C)	3	43	76	853	157	1132
Hordeum naked (C)	7	22	18	479	55	581
Hordeum cf. naked (C)			4	11	14	28
Hordeum naked symmetric (C)	8	79	40	325	53	505
Hordeum naked asymmetric (C)		9	7	39	7	62
Hordeum hulled (C)				2		2
Hordeum cf. hulled (C)		1	1	5	1	8
Hordeum cf. hulled symmetric (C)			1			1
Hordeum cf. hulled asymmetric (C)				2		2
Hordeum hulled symmetric (C)		1	1			2
Triticum						
cf. *Triticum* sp. (C)			1	3		4
Triticum sp. (C)				4		4
Triticum dicoccum (C)				3		3
Cereal indeterminate (C)	10	122	156	2248	186	2721
Total grain	28	278	305	3974	473	5058
Grain per litre	0.29	1.28	3.69	21.03	21.02	8.31
Chaff						
Indeterminate (2mm CN)	1	3	3			7
Indeterminate (1mm CN)	1	16	9	14		40
Indeterminate (2mm CB)	2	10	5	12		29
Indeterminate (1mm CB)		43	10	36		89
Indeterminate (2/1mm CF)	3	2	4	31		40
Hordeum vulgare L. emend. Lam. (RI)			7	9		16
Hordeum sp. (RI)				2		2
Cereal indet (RI)			1	2		3
Total chaff	3	13	16	25	0	57

Table 38: Summary of the fruits and seed results from the Braes of Ha'Breck, Wyre, Orkney. NF: nutshell fragment; FST: fruit stone fragment; S: seed; FR: fruit; N: nut/nutlet; A: achene; C: caryopsis; F: fragment; g: grams. For full results see appendix 4.

Year	2007-2009	2007-2009	2007-2009	2007-2009	2007-2009	Total
Trench	A	A	C	C	C	A & C
Trench phase	House 4 and eastern working area	Deposits post-dating Houses 3 & 4	House 1	House 2	Unphased	All phases
N	26	24	31	25	48	154
n	12	11	15	25	3	66
Sample volume (l)	98	216.5	82.6	189	22.5	608.6
Edible fruits and nuts						
Corylus avellana L. (4mm NF)		15F		6F		21F
Corylus avellana L. (4mm NF)		0.49g		0.25g		0.74g
Corylus avellana L. (2mm NF)	1F	62F	2F	11F		76F
Corylus avellana L. (2mm NF)	0.01g	0.46g	0.01g	0.17g		0.65g
Crataegus monogyna Jacq. (FTF)		1				1
Empetrum nigrum L. (S)	7		2	14		23
cf. *Empetrum nigrum* L. (S)				1		1
Seeds						
Brassica sp. (S)		2		1		3
Brassicaceae (S)	1	2				3
Carex sp. (trigonous) (N)	3	3	4	7		17
cf. *Carex* sp. (trigonous) (N)	1	1				2
cf. *Carex* sp. (biconvex) (N)	1					1
Chenopodium sp. (S)			1	4		5
cf. Chenopodiaceae (S)			1			1
Fabaceae (S)				1		1
Galium aparine L. (N)		2				2
Montia fontana L. (S)				1		1
Montia fontana L. ssp. *fontana* (S)				1		1
Montia cf. *fontana* L. (S)				1		1
Plantago lanceolata L. (S)			1	1		2
Poaceae (small) (C)		4	1	7		12
Poaceae (large) (C)				2		2
Polygonaceae (A)				1		1
Polygonum aviculare L. (A)		1				1
cf. *Rosa* sp. (A)		2				2
Ranunculus sp. (A)		1				1
Ranunculus cf. *bulbosus* L. (A)		3				3
Rumex sp. (A)		1		17	1	19
Rumex crispus L. (A)		3		2		5
Rumex cf. *crispus* L. (A)	1			2		3
Rumex crispus L./*obtusifolius* L. (A)				5		5

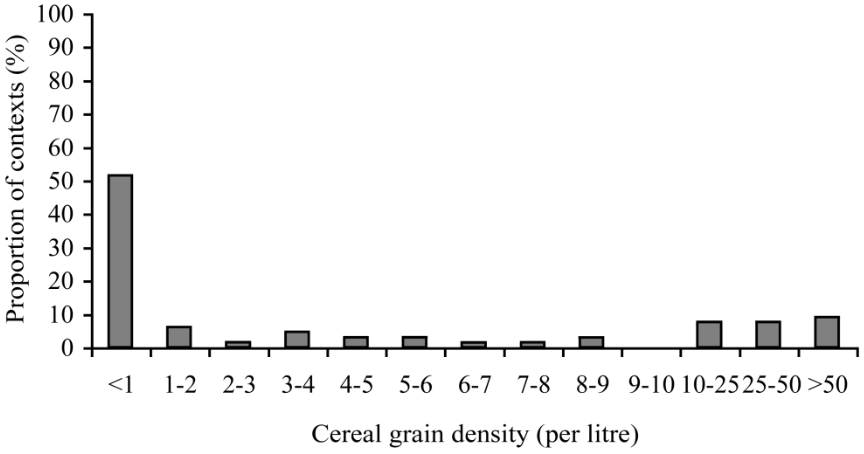
Year	2007-2009	2007-2009	2007-2009	2007-2009	2007-2009	Total
Trench	A	A	C	C	C	A & C
Trench phase	House 4 and eastern working area	Deposits post-dating Houses 3 & 4	House 1	House 2	Unphased	All phases
N	26	24	31	25	48	154
n	12	11	15	25	3	66
Sample volume (l)	98	216.5	82.6	189	22.5	608.6
Rumex cf. *crispus* L./*obtusifolius* L. (A)				1		1
Rumex acetosella L. (A)		1				1
Rumex cf. *acetosella* L. (A)		1				1
Rumex cf. *acetosa* L. (A)					1	1
Rumex obtusifolius L. (A)				8		8
Rumex cf. *obtusifolius* L. (A)				7		7
Sinapis arvensis L. (S)	5	20	12	7		44
Sinapis arvensis L. (FR)		1F	1F	1F		3F
cf. *Sinapis arvensis* L. (S)		3	2		1	6
Spergula arvensis L. (S)				1		1
Indeterminate (S/FR/N/C)				128		128
Indeterminate (S)	14	69	20	276	1	380
cf. fungal sclerotia		5		2		7
Total seeds	26	119	42	353	4	544

Table 39: Summary of tuber/root results from the Braes of Ha'Breck, Wyre, Orkney. F: fragment; RT: root tuber; B: bulbil; R: root; T: tuber; RH: rhizome; ST: stolon. For full results see appendix 4.

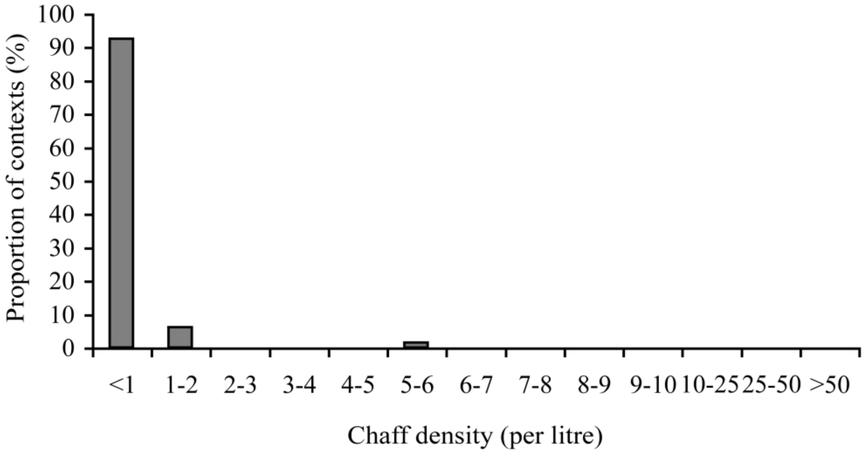
Year		2007-2009	2007-2009	2007-2009	2007-2009	2007-2009	Total 2007-2009
Trench		A	A	C	C	C	A & C
Trench phase		House 4 and eastern working area	Deposits post-dating Houses 3 & 4	House 1	House 2	Unphased	All phases
N		26	24	31	25	48	154
n		12	11	15	25	3	66
Sample volume (l)		98	216.5	82.6	189	22.5	608.6
Species	Plant part						
cf. *Ranunculus ficaria* L.	RT/B				1		1
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH				1		1
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH		10F		5F		15F
Indeterminate (cf. secondary root/tuber)	4mm T/R		1F		1F		2F
Indeterminate (cf. secondary root/tuber)	4mm T/R				1		1
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH		2F		1F		3F
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH			1F			1F
Indeterminate (glassy/vesicular)	2mm T/R/RH		10F	12F	14F	6F	42F
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH		172F	6F	35F	5F	218F
Indeterminate (cf. secondary root/tuber)	2mm T/R				3F		3F
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH	2	2	1	2		7
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH		2				2
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH				4F		4F
Indeterminate (glassy/vesicular)	1mm T/R/RH	2F	44F	9F	11F	10F	76F
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH	1F	411F	10F	134F	1F	557F
Indeterminate (cf. secondary root/tuber)	1mm T/R		2F		1F		3F
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH				1F		1F
Total (whole and fragments)		5	656	39	215	22	937

Figure 34: (a) Cereal grain densities for the site, (b) cereal chaff densities for the site and (c) cereal grain densities for each trench phase for the Braes of Ha'Breck assemblage.

(a)



(b)



(c)

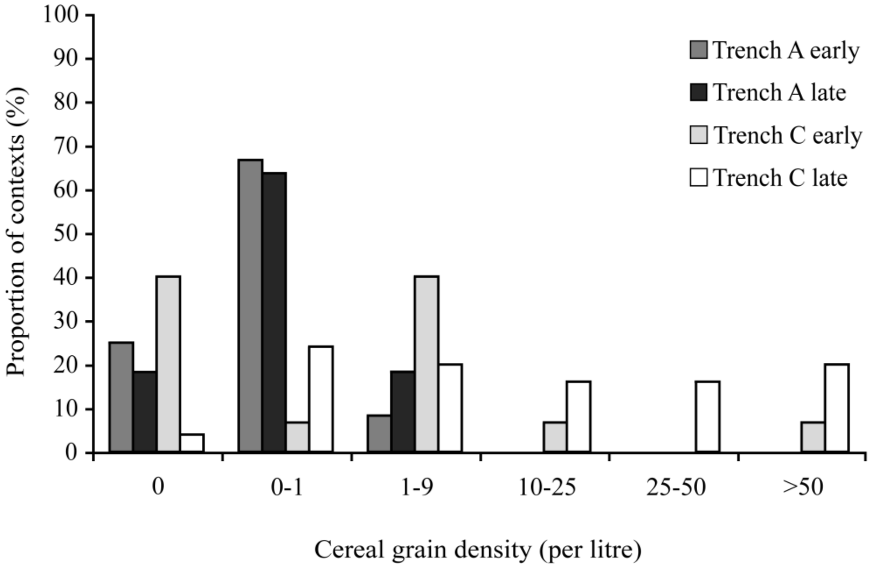
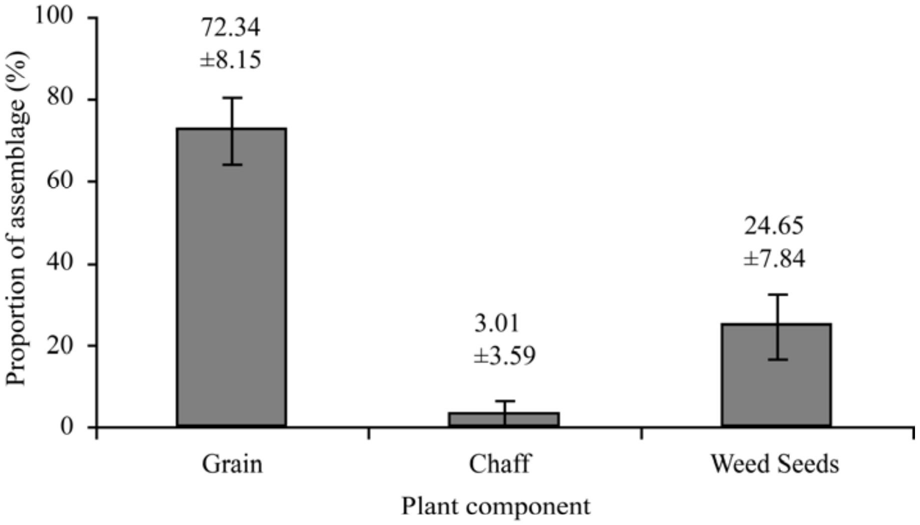


Figure 35: Relative proportions of (a) grain, chaff and potential weed seeds, and (b) grain, rachis and potential weed seeds in the Braes of Ha'Breck assemblage.

(a)



(b)

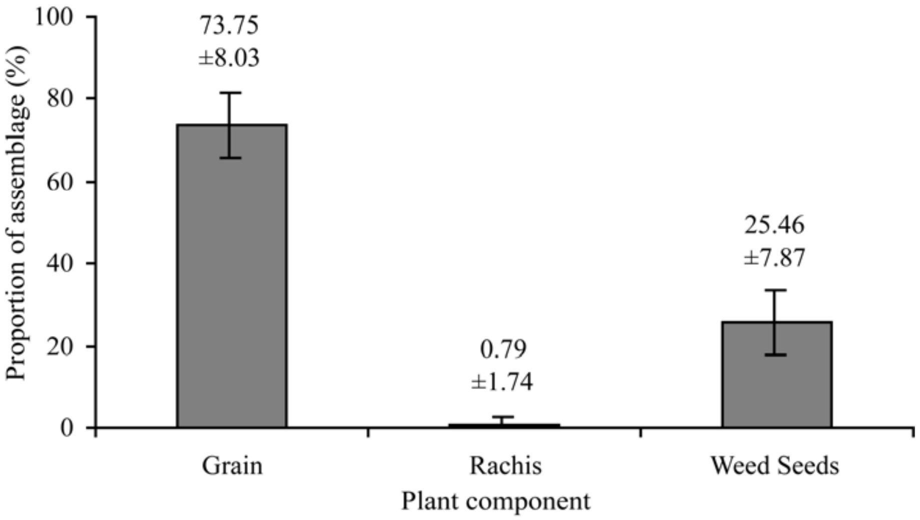


Figure 36: Relative proportions of (a) grain, chaff and potential weed seeds, and (b) grain, rachis and potential weed seeds in each sample with more than 10 quantifiable components in the Braes of Ha’Breck assemblage.

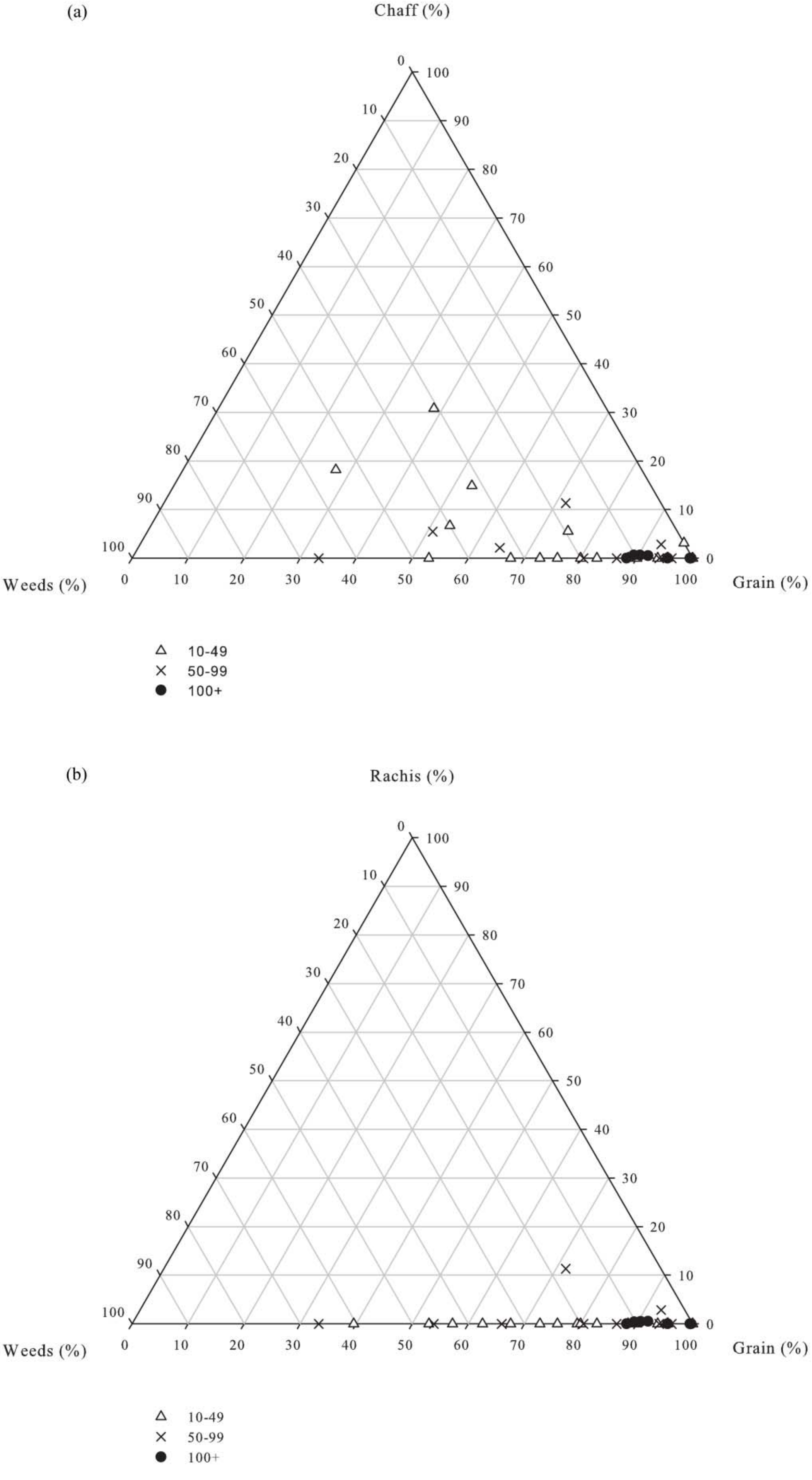
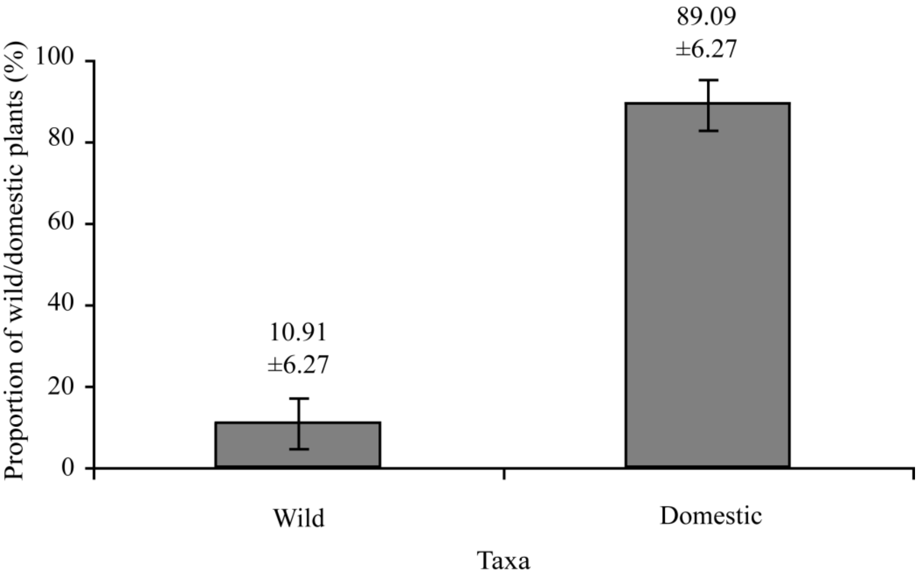


Figure 37: Relative proportion of wild and domestic plants in the Braes of Ha'Breck assemblage.



7.3.2 The cereals

The cereal assemblage was poorly preserved, with about 86% of the cereal caryopses falling within the worst three classes of preservation on Hubbard and al Azm's (1990) preservation scale (figure 38). Poor preservation precluded the identification of a large proportion of the grains to species level and about half of the assemblage consisted of indeterminate cereal grains (figure 40).

However, viewing the identifiable grain from the samples as a whole (figures 39 and 40), barley completely dominated the assemblage and only 12 wheat grains and a single oat grain were recovered (table 37). The majority of the barley grains identified to species level were naked barley, with only 15 hulled barley grains identified (table 37). A greater proportion of the naked barley grains were symmetric than asymmetric (figure 40c), which suggests the predominance of 2-row barley rather than 6-row barley. However, considering the poor preservation of the assemblage, the presence of 6-row barley rachis fragments and the absence of the diagnostic 2-row barley rachis fragments, this is far from conclusive, especially since twisted barley grains are often smaller than the straight grains and may be sieved out during processing (Milles 1986a:119). All of the wheat grain sufficiently well preserved to allow further identification was Emmer Wheat. Oat is rare on British Neolithic sites and is usually considered to be the wild variety (*Avena fatua* L.) rather than the cultivated variety (*Avena sativa* L.; Holden and Rankin 1995:119). However, since no oat floret bases were present in the samples, it was not possible to verify whether the oat grain was wild or cultivated. The cereal chaff was dominated by culm nodes and bases, and rachis internodes were only present in five samples (table 37; appendix 4, table 50).

Figure 38: Cereal grain preservation in the Braes of Ha'Breck assemblage.

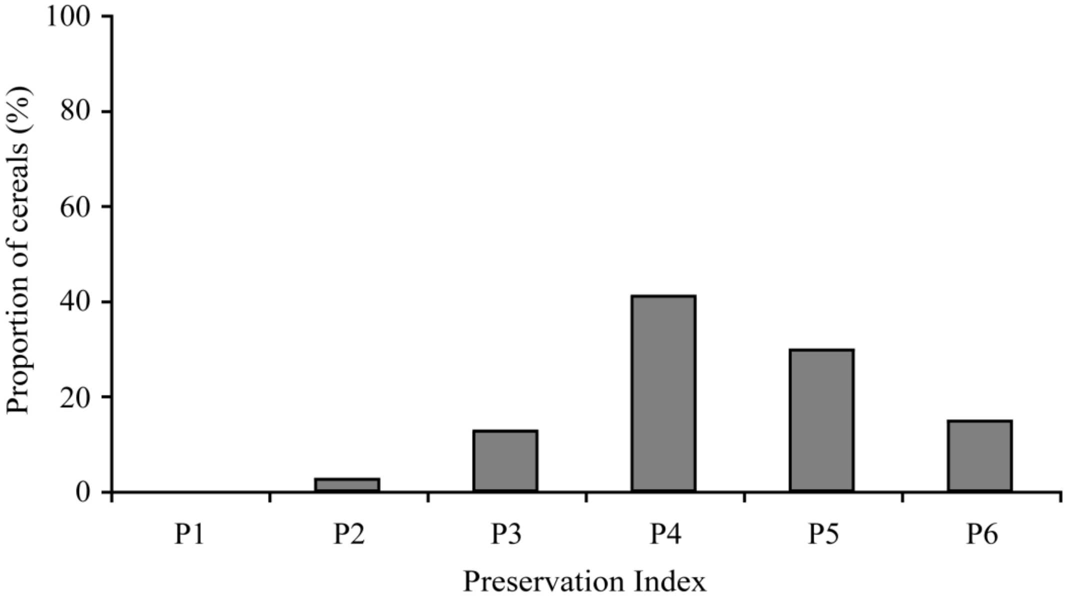
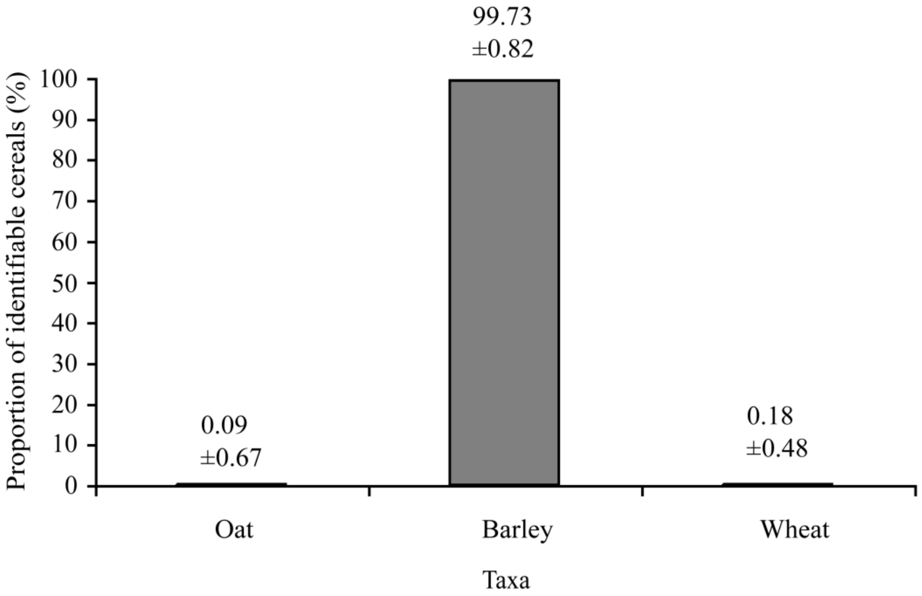


Figure 39: (a) Relative proportion of wheat, oat and barley in the Braes of Ha'Breck assemblage and (b) relative proportion of wheat and barley in each sample with more than 10 quantifiable components in the Braes of Ha'Breck assemblage.

(a)



(b)

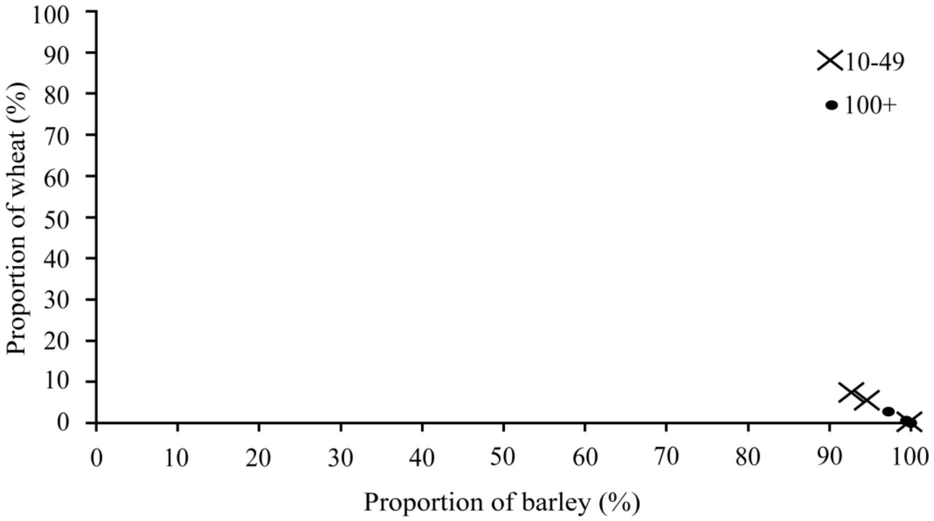
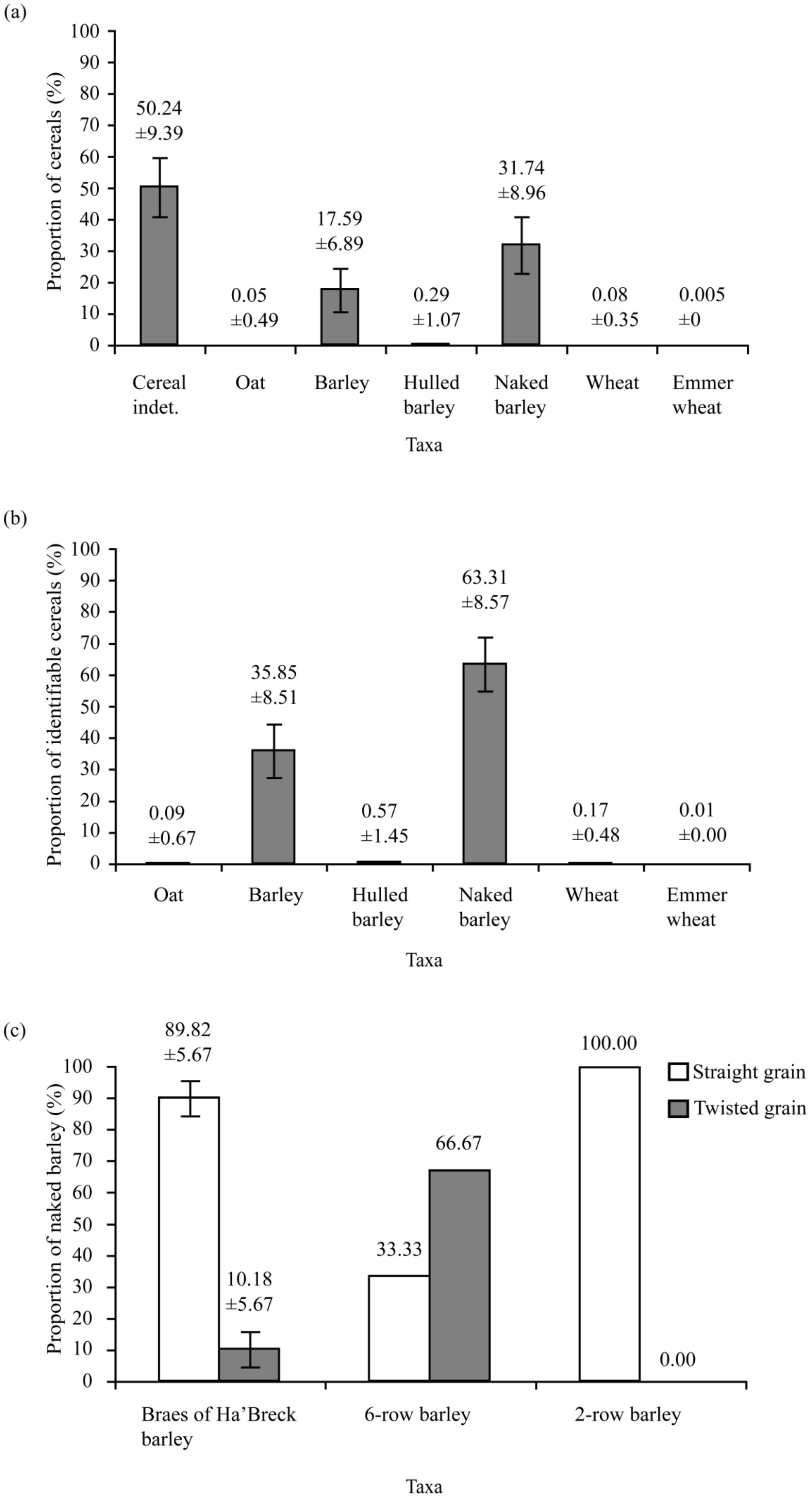


Figure 40: Relative proportion of cereal taxa in the Braes of Ha'Breck assemblage: (a) proportion of cereals, (b) proportion of identifiable cereals, and (c) proportion of straight and twisted naked barley grains compared to the proportions of straight and twisted barley grains in 6-row and 2-row naked barley.



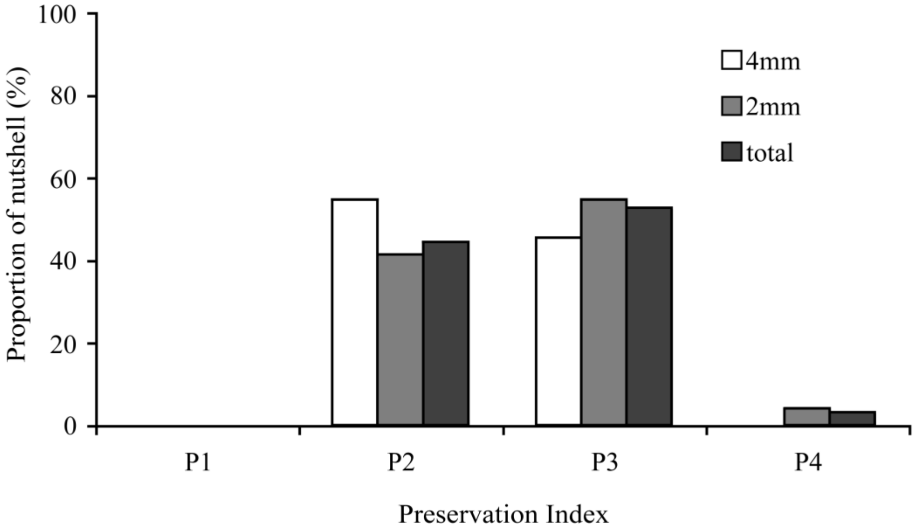
7.3.3 Edible fruits and nuts

Wild edible fruits and nuts were represented by occasional hazelnut shell fragments and Crowberry seeds, together with a single Hawthorn fruit stone fragment (table 38). The overall results of the hazelnut shell quantification are shown in table 38 and the results of the nutshell quantification are discussed in detail in appendix 2. Hazelnut shell was extremely scarce in the assemblage, and quantification suggests that the fragmented nutshell represents approximately 6-11 whole hazelnuts (see appendix 2). The preservation of the hazelnut shell was variable, with 56% of the hazelnut fragments falling within the worst two classes of preservation (P3 and P4) and 44% of the fragments being classed as fairly well-preserved (P2) (figure 41a). There appeared to be little difference between the preservation of hazelnut shell in the 4mm and 2mm fractions.

Overall the nutshell was highly fragmented (figure 42) and no complete shells were recovered. Only 22% of the nutshell fragments were derived from the 4mm sieve fraction and about 93% of fragments examined represented <12.5% of a whole nutshell (figure 42). However, there were several large fragments in the >4mm fraction, as indicated by the approximately equal mass of nutshell in the 4mm and 2mm fractions and the fact that 32% of the 4mm nutshell represents >12.5% of a whole nut. Consideration of the mean percentage of worn edges per fragment shows that most of this fragmentation was caused prior to excavation and sample processing (figure 41b). There appears to be little difference in the level of modern fragmentation between the 4mm and 2mm flots (figure 41b).

Figure 41: Hazelnut shell preservation in the Braes of Ha'Breck assemblage: (a) preservation of hazelnut shell in the 4mm and 2mm flot/residue fractions, (b) level of modern hazelnut shell breakage in the 4mm and 2mm flot/residue fractions, as indicated by the mean proportion of worn and unworn nutshell edges.

(a)



(b)

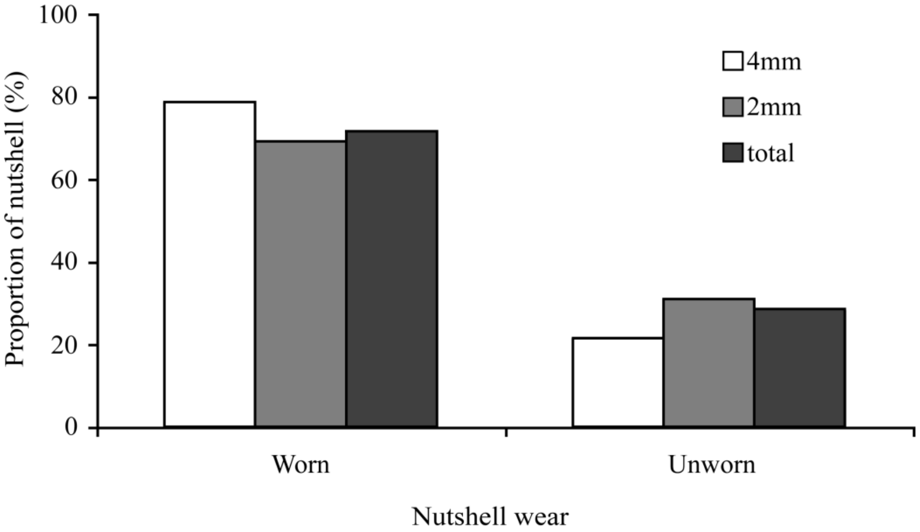
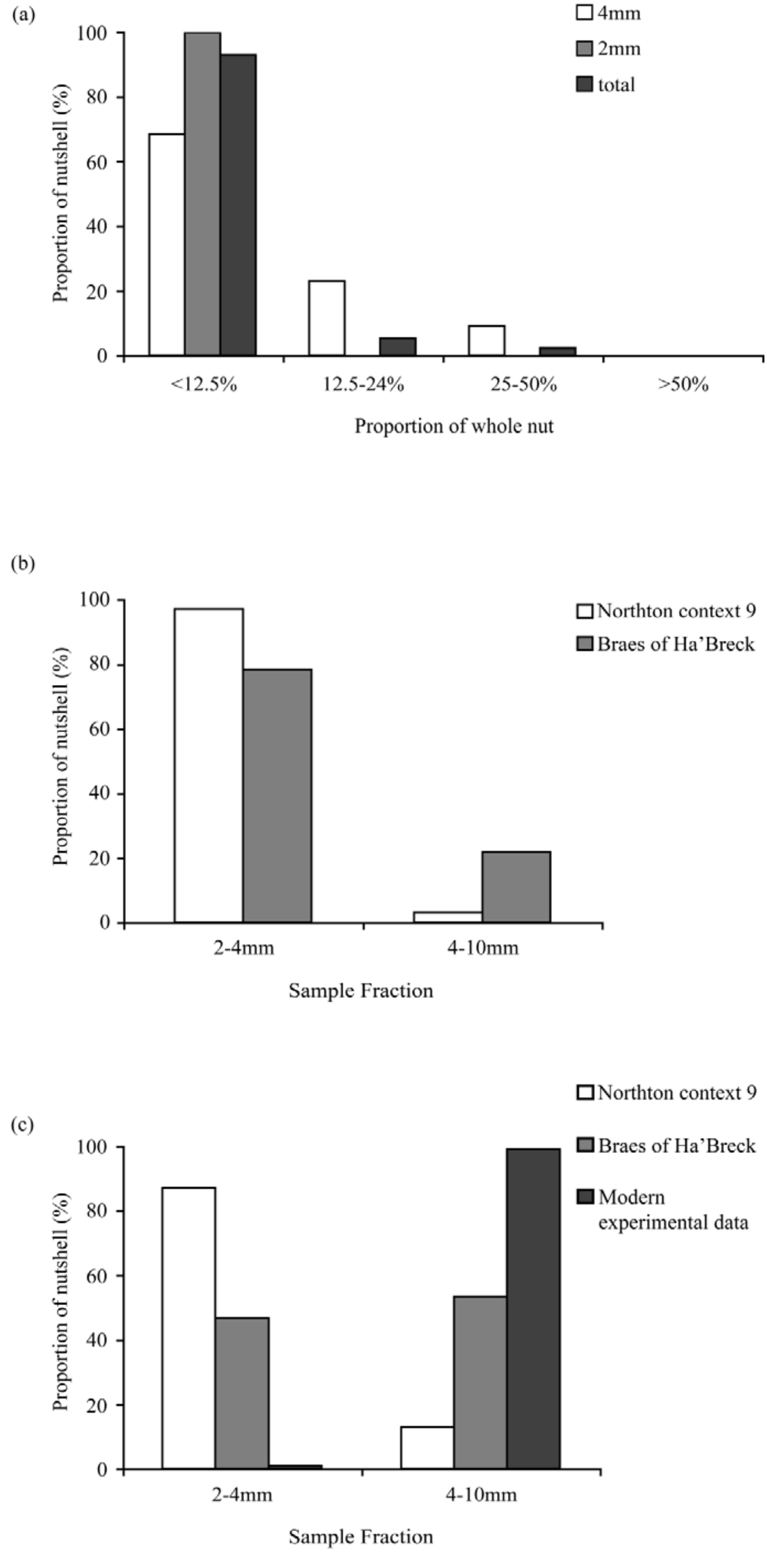


Figure 42: Hazelnut shell fragment sizes in the Braes of Ha'Breck assemblage: (a) relative proportion of hazelnut shell in each fragment size category for the 4mm and 2mm flot/residue sieve fractions, (b) relative proportion of hazelnut shell in different sieve fractions, calculated using the total number of fragments >2mm, (c) comparison of the relative proportion of hazelnut shell in different sieve fractions in the Braes of Ha'Breck assemblage, Northton 2010 context 9 (see chapter 6), and modern experimental data from Carruthers (2000), calculated using the total mass of fragments >2mm.



7.3.4 Seeds

The seed assemblage was also extremely poorly preserved and very few seeds could be identified to species level (table 38). The most frequent taxa in the assemblage were: docks (*Rumex* sp./ *Rumex crispus* L./ *Rumex acetosella* L./ *Rumex acetosa* L./ *Rumex obtusifolius* L.), Charlock, sedges and members of the grass family. All other families and genera were represented by fewer than ten identifications (table 38).

7.3.5 Parenchymatous plant remains

Only a single whole Lesser Celandine root tuber/bulbil was identified (table 39). This root tuber/bulbil was identified using low-powered microscopy only, on the basis of its characteristic 'club'-like shape (Hather 1993:22-23; Mason and Hather 2001:417). It is probable that a root tuber rather than a bulbil is represented, since the parenchymatous material was greater than 5mm in length (Hather 2000a:14-15). Since no definite bulbils were recovered it is not possible to be certain which subspecies - ssp. *bulbilifer* Lambinon or ssp. *ficaria* - is present (Stace 1997). Where the epidermis was exposed the interior of the root tuber appeared glassy and vesicular, suggesting that it was probably wet prior to charring (Hather 1993:22-23).

Several fragments of possible secondary root were identified by the presence of rhexigenous formed radial cavities surrounded by glassy tissue (Hather 2000a:65). Although examination under an SEM may confirm that these fragments are derived from secondary roots, further taxonomic identification of this material is probably not possible because the diagnostic characteristics will have been lost during charring (ibid:62). However, the presence of this material is important for understanding the taphonomy of the assemblage, since these radially orientated cavities only form when secondary roots are charred in a fresh state (ibid; Hather 1993:4).

Likewise, there were numerous glassy/vesicular/vitreous parenchyma fragments also present within the samples, with large concentrations present in several samples. As with the secondary root fragments, most of these fragments are probably too poorly preserved for further taxonomic identification, but the state of preservation suggests that this material was wet prior to charring. It is also possible that some of these fragments are extremely poorly preserved wood charcoal. The remainder of the parenchymatous tissue fragments in the assemblage could not be classified using light microscopy, and were simply counted as indeterminate fragments. Some of these fragments may be further identifiable under an SEM, but much of this material is too small and poorly preserved to allow further identification.

7.4 Discussion

7.4.1 Sample formation processes

The archaeobotanical remains from the earliest phase of trench A were recovered from negative features which formed part of house 4 and from general occupation levels associated with the working floor which was external to this structure. In contrast, the charred remains from the later phase of trench A were derived from external secondary midden and occupation deposits which may have been originally deposited during the use of house 3 or perhaps during the use of house 5 (see section 7.1.6.2). In trench C, the samples were mostly derived from pits, postholes and slots, which formed part of the structure of houses 1 and 2, with individual samples from both phases representing general occupation levels within the structures. There were also a number of samples taken from the *in situ* hearths from house 2. Therefore, with the exception of the hearth deposits in house 2, all of the examined samples were derived from secondary contexts, away from the probable primary location of charring within domestic hearths (cf. Church and Peters 2004; Miksicek 1987:224-5).

There are several mechanisms that could have resulted in the deposition of the archaeobotanical remains within the negative structural features in houses 1, 2 and 4. The archaeobotanical remains may have become incorporated within the packing material used to support the posts or orthostats in these structures. In this case, the material would predate the construction of these structures and would relate to earlier activity on the site. However, it seems more likely that the carbonised material was derived from the surrounding floor deposits, and accumulated after the removal or decay of the posts or orthostats. Though plant material from the pits and scoops, could similarly have been accidentally incorporated from the surrounding floor deposits, deliberate deposition for storage or rubbish disposal or a combination of several of these origins is also possible (Miksicek 1987:226). In contrast, the midden deposits probably contain deliberately discarded waste material, such as hearth sweepings. The material in the general occupation levels most likely represents material accidentally spread across the floors from domestic hearths as a result of trampling or accidental discard (cf. Church and Peters 2004).

7.4.2 The origins of the wild plant remains

In the Neolithic and later periods, archaeobotanical seed assemblages are often argued to primarily derive from arable fields (e.g. Bogaard 2004; Hillman 1981b; Jones 1987; van der Veen 1992:104). However, as discussed in chapters 2-6, wild plant remains can arrive on site as a result of a range of natural and anthropogenic processes. In addition to the accidental harvesting of arable weeds, two further origins for carbonised wild plant remains are important in the Orcadian Neolithic: the gathering of wild plants for consumption and the collection of turf/peat and animal dung for use as a fuel. The harvesting and use of plants for other purposes, such as fodder, raw materials for crafts, dyeing, bedding and construction, is also probable, but these functions are less likely to result in the carbonisation of seeds on domestic hearths and are difficult to identify in the archaeobotanical record (Hurcombe 2000). The following section will discuss the likelihood that the wild plant remains in the assemblage from the Braes of Ha'Breck represent arable weeds, wild foodstuffs or fuel remnants. A summary is shown in table 40.

Table 40: Potential origin of the non-domestic remains in the Braes of Ha'Breck assemblage. S: seed; FR: fruit; N: nut/nutlet; A: achene; C: caryopsis.

Species	Collection for human consumption?	Arable weed?	Turf/peat burning?
Corylus avellana L. (N)	*		
Crataegus monogyna Jacq. (FR)	*		
Empetrum nigrum L. (FR)	*		*
Brassica sp. (S)		*	
Brassicaceae (S)		*	
Carex sp. (N)	*	*?	*
Chenopodium sp. (S)	*	*	
Chenopodiaceae (S)	*	*	
Fabaceae (S)	*	*	
Galium aparine L. (N)		*	
Montia fontana L. (S)		*	*
Montia fontana L. ssp. *fontana* (S)		*	*
Plantago lanceolata L. (S)	*	*	*
Poaceae (C)	*	*	*
Polygonaceae (A)	*	*	
Polygonum aviculare L. (A)	*	*	
Ranunculus sp. (A)		*	
Ranunculus cf. *bulbosus* L. (A)			
cf. *Rosa* sp. (A)	*		
Rumex sp. (A)	*	*	*
Rumex crispus L. (A)	*	*	*
Rumex acetosella L. (A)	*	*	*
Rumex cf. *acetosa* L. (A)	*	*	*
Rumex obtusifolius L. (A)	*	*	*
Sinapis arvensis L. (S)	*	*	
Spergula arvensis L. (S)	*	*	

7.4.2.1 Arable weeds?

Unless otherwise stated, ecological information used in the following discussion was taken from Stace (1997), Clapham et al (1987), Bullard (1995), Long (1929) and McConnell (1930). Most of the identified seeds can be found on arable land and/or waste ground: docks, Charlock, Cleavers, cabbages/cabbage family (*Brassica* sp./Brassicaceae), grass family, knotweed family (Polygonaceae), Knotgrass, Corn Spurrey and goosefoot (Chenopodiaceae/*Chenopodium* sp.) species. Likewise, Blinks (*Montia fontana* L.) and some vetch/tare family species occasionally occur as arable weeds. A few buttercups (*Ranunculus* sp.) are sometimes associated with cultivated or open ground, but Bulbous Buttercup (*Ranunculus bulbosus* L.) is not amongst these species.

Though sedges are not normally considered to be arable weeds today, it is possible that they may have been more commonly found as arable weeds in the past before modern drainage techniques were implemented (van der Veen 1992:75). van der Veen (1992:75-6) has convincingly argued that sedges were arable weeds in Iron Age English archaeobotanical assemblages because of the abundance of *Carex* sp. seeds in Iron Age assemblages and their occurrence in Iron Age granary deposits in England and Denmark. There seems no reason why this may not also have been the case in Neolithic Britain. This is emphasised by the fact that an Inter-war guide for farmers (McConnell 1930:276), includes several sedge species on a list of arable weeds in Britain. Similarly, Ribwort Plantain is mostly found in grassland environments today, but Long (1929:104) considered it to be a very common arable weed and Behre (1981:235) notes that it is a quick recoloniser of fallow land in arable systems using rotation.

Having said this, most of the taxa recovered from the samples could also have grown naturally in a range of environments, which would have been locally prevalent in Wyre and Rousay in the Neolithic (see section 7.1.4.5). For instance, sedge species usually grow in a range of damp grassy places, such as fens, bogs, damp machair, heathland and beside rivers/lochs and Blinks plants are usually found in wet and damp places. Grasses, vetch/tare family, goosefoot family, knotweed family (Polygonaceae), docks and buttercups are particularly suggestive of grassland environments. Docks can also be found growing on heaths, blanket bog, fens, open places in woods and on damp ground and buttercups can also grow in woods, streamsides, fens and machair. Species in the grass and vetch/tare family are found in a very wide range of other environments, including woods and scrub, heathland, fens, rocky and stony places, on mountain slopes, screes and ledges and on sand-dunes, shingle and cliffs by the sea. Goosefoot family species are also common in maritime environments, such as sandy, pebble or shingle beaches, salt-marshes, saline areas and estuaries. Cabbage family plants can also be found in a range of grassland, wet, mountain and maritime environments. Cleavers is a common weed, but it is also often found growing in maritime shingle, bushes and scrub. Knotgrass also grows on the coast and very occasionally, Corn Spurrey may grow on maritime turf. Though cabbages and Charlock probably did not grow in the wild on Orkney and were probably introduced with the cereal crop into the area, they could have grown as weeds on rough ground around the settlement rather than on arable plots.

Several of the wild species recovered from the samples are indicators of wood and scrub environments and cannot be considered to be arable weeds: Hazel, Hawthorn, Rose and Lesser Celandine. Lesser Celandine also grows in grassland environments and Rose on woodland-borders. Equally, heathland species, such as Crowberry, do not occur in arable environments.

In summary, the non-domestic seed assemblage appears to be dominated by arable weeds and indicators of rough ground, with rare heathland plants also present. The remains of edible woodland fruits and roots/tubers were also present in small quantities. The majority of the potential arable weed species could also have derived from wild habitats, which would have been present in the local environment.

7.4.2.2 Collection for human consumption?

Three species with edible fruits and nuts were recovered in the Braes of Ha' Breck assemblage, all of which may have been deliberately collected for consumption: hazelnuts, Hawthorn and Crowberry. The collection, processing and consumption of the first two of these species have been discussed in detail in chapters 2 and 6 and so this information will not be repeated again here. Crowberries can be eaten both raw and cooked and have been widely used for food historically and in the present day in Britain, Scandinavia, Russia and North America (Hedrick 1919:253; Marles et al 2000:171; Mears and Hillman 2007:274; Milliken and Bridgewater 2004:45; Moerman 1998:209-210; Pierpoint Johnson 1862:225; Voronina 2000:177). Several authors note that they are fairly insipid (Hedrick 1919:253; Pierpoint Johnson 1862:225), but the flavour intensifies after cooking (Irving 2009:135). However, they have also been said to cause headaches and nausea if eaten in large quantities (Irving 2009:135; Pierpoint Johnson 1862:225).

Likewise, there is considerable ethnographic and historic evidence for the consumption of the seeds of many goosefoots, docks, sedges, members of the Fabaceae family, as well as Ribwort Plaintain, Charlock, Knotgrass and Corn Spurrey: the evidence for the use of these taxa is presented in chapters 2 and 6. Of particular interest, however, is the relative abundance of Charlock seeds in the assemblage. This species was used in the 19th century in Orkney to make bread in the summer before the autumn harvest when grain was scarce (Milliken and Bridgewater 2004:37).

In addition, the seeds from grasses may also have been gathered for food. Most grass seeds are edible and are easy to gather in large quantities, though like cereals, they are time consuming to process (Ebeling 1986:195-8; Irving 2009:325; Mears and Hillman 2007:328; Moerman 1998). Interestingly, False Oat-grass (*Arrhenatherum elatius* (L.) P.

Beauv. Ex J. & C. Presl.) caryopses were traditionally used to make bread on Orkney (Darwin 1996:120). The hips of Rose (*Rosa* sp.) were important foods for recent hunter-gatherer groups in North America (Moerman 1998:482-486) and they were eaten historically in Britain during the Second World War to prevent vitamin-C deficiency due to their extremely high vitamin-C content (Mears and Hillman 2007:203; Milliken and Bridgewater 2004:35). The flesh of the rosehips could be eaten raw or stewed, after the irritant seeds were disposed of, perhaps onto a domestic hearth (Mears and Hillman 2007:203; Moerman 1998:482-486).

The other species are less likely foodstuffs because the leaves or roots were the main part consumed rather than the seeds. For instance, though the roots of Bulbous Buttercup are edible when cooked (Hedrick 1919:483; Hogg and Johnson 1864), it is unlikely that the seeds would also have been gathered during root collection because roots are generally gathered after the plant has flowered (Cameron 1977:56). Cabbages, such as Black Mustard (*Brassica nigra*) and Wild Turnip (*Brassica rapa*), have principally been gathered for their leaves and roots, though their seeds have been used as a traditional condiment in Britain (Irving 2009:81-4; Mabey 1997:154; Moerman 1998:128). Blinks has not been collected for food historically in Britain or North America, but the leaves and stems have traditionally been used in salads in Spain and Portugal (Carvalho and Morales 2010:157; Irving 2009:260; Tardío 2010:218). Though the shoots, leaves and stems of Cleavers can be eaten and the nutlets were traditionally used to make a hot drink in Britain (see chapter 6), the nutlets were not a major foodstuff. Since salad plants are picked before the seeds set (Cameron 1977:56; Hill 1941:11), it is unlikely that the seeds of Cabbages, Cleavers and Blinks would have been deposited on site. Also, Cabbages are not considered to grow in the wild on Orkney (Bullard 1995; Clapham et al 1987) and so these seeds probably represent arable weeds introduced with the cereal crop.

Overall, with the exception of the seeds of cabbages, Blinks, Cleavers and Bulbous Buttercup, all of the other seeds recovered from the site could have been deliberately collected for consumption. The most probable foodstuffs were hazelnuts, Hawthorn and Crowberry, which would not have grown as arable weeds (section 7.4.2.2). Although Crowberry is often eaten by animals and birds (Lang 1987:152), and could have been naturally deposited, the seeds are consistently present throughout the site and so this seems unlikely. The other seeds are less likely foods: all were recovered in low frequencies and many of these species may have been naturally growing around the settlement. It is therefore possible that several of these species, particularly Cleavers, could have been brought into domestic houses accidentally attached to human hair or clothing.

7.4.2.3 Turf/peat/dung burning?

Historically, the main sources of fuel in Orkney were, peat, turf and dung, because of the scarcity of wood (Fenton 1978:206-213). Whilst wood would have been available for fuel in the Neolithic period (see section 7.1.4.5), it is likely that peat/turf and dung would also have been burned. Large volumes of ash are produced when peat and turf are burnt as fuel (Church et al 2005, 2007b; Peters et al 2004; Simpson et al 2003) and ash-rich deposits have been found abundantly on Neolithic settlements in Orkney, such as at Skara Brae (Childe 1931), Rinyo (Childe and Grant 1938-9), Tofts Ness (Dockrill et al 2007) and Pool (Hunter et al 2007) (see section 7.4.9.1 for further discussion). At the Braes of Ha'Breck a number of contexts were noted to be ash-rich during the excavation, particularly in and around the hearths. Whilst no samples from the Braes of Ha'Breck have yet been analysed for soil micromorphology, it should be noted that wood charcoal was present in small quantities in most samples across the site. Even if woodland was generally available in Neolithic Orkney (section 7.1.4.5), in the small island setting of Wyre, woodland may not have been plentiful or easily accessible, and so peat/turf and dung may have been particularly important fuels.

The archaeobotanical analysis of post-Medieval roof turfs and experimental analyses of modern burnt peat and turf samples has shown that peat/turf burning results in the deposition of distinct combinations of archaeobotanical material (Church et al 2007b; Dickson 1998). Several features of the Braes of Ha'Breck assemblage are indicative of the burning of peat/turf as a fuel. The abundant small culm nodes, culm bases and indeterminate roots/tubers/rhizomes, and the seeds of Crowberry, sedges, grasses, Blinks, Ribwort Plantain and docks may all be derived from the burning of peat and turf as a fuel (ibid). The very poor preservation of the cereal assemblage supports the idea that peat/turf was burned in the hearths at the Braes of Ha'Breck (Church and Peters 2004:108), as does the abundance of indeterminate parenchyma fragments, which were charred in a fresh state (see section 7.3.5). It is important to recognise that Crowberry, sedges, grasses and docks were amongst the most frequent taxa identified. This may suggest that most of the seed assemblage was derived from the burning of peat/turf.

7.4.2.4 Summary of the origins of the wild plant remains

Thus, most of the wild seeds could have originated from at least one source (table 40). The only certain non-arable species, which could have been collected for human consumption, were hazelnuts, haws and rose seeds. Most of the potential arable weeds could either have been collected for human consumption or may have been burned as part of peat/turf as a fuel. The only exceptions to this are the cabbage, Cleavers and Bulbous Buttercup seeds, which were probably not collected for food or with a fuel source. However, the absence of large concentrations of edible wild seeds in the assemblage points against the idea of deliberate exploitation of any particular seed species for food (cf. Bogaard 2004:66). Considering the relative abundance of the seeds which could have arrived on site as a result of turf/peat burning, together with the abundant evidence for peat/turf burning on other Neolithic sites in Orkney (see section 7.4.9.1), it seems likely that peat/turf burning was a significant source for the seeds recovered from the site. The poor preservation of the seeds, parenchyma and grain in the samples supports this interpretation, since archaeobotanical remains charred on fires using peat/turf tend to be extremely poorly preserved (Church and Peters 2004).

7.4.3 Crop husbandry practices

As discussed in section 7.2.4.1, detailed studies of crop husbandry practices (cf. Bogaard 2004) could not be undertaken for the Braes of Ha'Breck assemblage because of the low weed seed content. However, it is arguable that even if the seed content had been adequate, detailed weed ecological analyses could not have been reliably undertaken, because, as previously discussed, many of the seeds from this assemblage may have been derived from the burning of turf/peat rather than crop processing. Whilst it may be possible to argue that wild seeds present infrequently in an assemblage are more likely to be arable weeds than deliberately collected foods (cf. Bogaard 2004:66) and it is potentially possible to identify samples contaminated by seeds deriving from a non-arable source using multivariate techniques (Charles 1998; Jones 1987:321), it seems probable that specific models would be required to identify contamination by the burning of peat or turf. Seeds derived from peat/turf burning may occur in similar frequencies to arable weeds and many species associated with peat/turf burning are common arable weeds. Future studies should be applied to address this issue experimentally.

Of the potential arable weeds that were identified to species, most are indicators of well-lit, moist, non-saline conditions and weakly basic-moderately acidic soils (table 41). The Ellenberg values for nitrogen are very mixed, with 55% of the species indicative of soils that are more or less infertile to intermediately fertile and 45% of species from intermediately fertile to extremely rich conditions. Therefore it cannot be conclusively said whether manuring was implemented. None of the remains identified to species were woodland species and though some of the seeds identified to genus or family included species that grow in woodlands, none of these family or genera were dominated by species that grow mainly in woodlands (table 27). The assemblage contained a mix of perennial and annual taxa (table 27 and 41). Though, not conclusive, due to the low numbers of identifiable seeds, the potential non-arable source of the seeds and the presence of a range of perennial taxa, this pattern is consistent with the idea that fixed, rather than shifting cultivation was taking place (Bogaard and Jones 2007:307). The presence of cereal culm bases within the assemblage may suggest that the crop was harvested by uprooting (Hillman 1981b:149).

Table 41: Ellenberg values for light (L), moisture (F), reaction (R), nitrogen (N) and salt tolerance (S) for potential arable weeds identified to species level. Ellenberg values were taken from Hill et al (2008). s: seed; n: nut/nutlet; a: achene.

Species	Ellenberg values for light (L)	Ellenberg values for moisture (F)	Ellenberg values for reaction (R)	Ellenberg values for nitrogen (N)	Ellenberg values for salt tolerance (S)	Annual/ Perennial?
Galium aparine L. (n)	6: Between semi-shade and generally in well-lit places	6: Between moist and damp soils	7: Indicator of weakly acid to weakly basic conditions; never found on very acid soils	8: Between richly fertile and extremely rich situations	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Annual
Montia fontana L. (s)	7: Plant generally in well-lit places, but also occurring in partial shade	9: Wet site indicator, often on water-saturated, badly aerated soils	5: Indicator of moderately acid soils, only occasionally found on very acid or on neutral to basic soils	3: Indicator of more or less infertile sites	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Annual/ Perennial
Plantago lanceolata L. (s)	7: Plant generally in well-lit places, but also occurring in partial shade	5: Moist site indicator, mainly on fresh soils of average dampness	6: Between moderately acid to weakly basic conditions	4: Between more or less infertile and intermediately fertile sites	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Perennial
Polygonum aviculare L. (a)	7: Plant generally in well-lit places, but also occurring in partial shade	5: Moist site indicator, mainly on fresh soils of average dampness	6: Between moderately acid to weakly basic conditions	7: Plant often found in richly fertile places	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Annual
Rumex crispus L. (a)	8: Light-loving plant rarely found where relative illumination in summer is less than 40%	6: Between moist and damp soils	7: Indicator of weakly acid to weakly basic conditions; never found on very acid soils	6: Between intermediate and richly fertile sites	2: Species occurring in both saline and non-saline situations, for which saline habitats are not strongly predominant	Perennial

Species	Ellenberg values for light (L)	Ellenberg values for moisture (F)	Ellenberg values for reaction (R)	Ellenberg values for nitrogen (N)	Ellenberg values for salt tolerance (S)	Annual/ Perennial?
Rumex acetosella L. (a)	7: Plant generally in well lit places, but also occurring in partial shade	5: Moist site indicator, mainly on fresh soils of average dampness	4: Between acidic and moderately acidic soils	3: Indicator of more or less infertile sites	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Perennial
Rumex cf. *acetosa* L. (a)	7: Plant generally in well lit places, but also occurring in partial shade	5: Moist site indicator, mainly on fresh soils of average dampness	5: Indicator of moderately acid soils, only occasionally found on very acid or on neutral to basic soils	4: Between more or less infertile and intermediately fertile sites	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Perennial
Rumex obtusifolius L. (a)	7: Plant generally in well lit places, but also occurring in partial shade	5: Moist site indicator, mainly on fresh soils of average dampness	7: Indicator of weakly acid to weakly basic conditions; never found on very acid soils	9: Indicator of extremely rich situations	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Perennial
Sinapis arvensis L. (s)	8: Light-loving plant rarely found where relative illumination in summer is less than 40%	5: Moist site indicator, mainly on fresh soils of average dampness	7: Indicator of weakly acid to weakly basic conditions; never found on very acid soils	7: Plant often found in richly fertile places	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Annual
Spergula arvensis L. (s)	7: Plant generally in well lit places, but also occurring in partial shade	4: Between dry and moist soils	5: Indicator of moderately acid soils, only occasionally found on very acid or on neutral to basic soils	5: Indicator of sites of intermediate fertility	0: Absent from saline sites; if in coastal situations, only accidental and non-persistent if subjected to saline spray/water	Annual

7.4.4 Crop processing

As previously mentioned, the seed content was inadequate to undertake a classification of crop processing stages represented in individual samples based on the physical properties of weed seeds (Jones 1984, 1987), and the mixed taphonomy of the seed assemblage means that this technique is unsuitable for this assemblage (sections 7.4.1 and 7.4.2). A comparison of the relative proportions of grain to chaff and seeds shows the abundance of grain and the dearth of chaff (both rachis and culm bases/nodes) and seeds within the assemblage (figures 35 and 36). This suggests that the assemblage represents a crop in the final stages of processing or a fully processed crop, with the majority of the chaff and seeds having been removed by threshing, raking, winnowing and sieving (Hillman 1981b). The assemblage contains very small quantities of both large seeds (e.g. large grass seeds, Cleavers, vetch/tare family) and small seeds (e.g. Knotgrass, Blinks, goosefoot species, cabbages, docks, Corn Spurrey, sedges, small grass seeds) (van der Veen 1992:207). The very small quantities of chaff and seeds may represent incomplete sieving during crop processing or the presence of waste material from the final sieving or hand sorting stages. Hillman (1981b) proposes that the final sieving would remove small seeds and chaff fragments and that any remaining coarse contaminants would be scooped off the surface of the grain retained in the sieve after shaking. Having said this, if most of the seeds were remnants of collected wild foods or the burning of peat/turf, then it is unlikely that this final sieving stage is represented in the assemblage.

There are several explanations that could explain the rarity of chaff in the samples. Firstly, barley rachis survives poorly when exposed to fire compared to grains, and so the proportion of chaff in the samples may be underrepresented (Boardman and Jones 1990). Considering the poor preservation of the cereal grain in the assemblage (figure 38), the chances of chaff survival would have been low.

Secondly, it is possible that the assemblage is a fully processed crop and that the chaff was used for other purposes, which did not involve close contact with fire. Cereal straw can be utilised for a range of functions, including animal fodder, bedding, basketry, thatching and rope making (Fenton 1978; Park 2004; Staniforth 1979; van der Veen 1999). In Orkney, oat was traditionally favoured for straw baskets and rope because it is stronger and more durable than barley straw (Fenton 1978:260, 264; Park 2004:1) and barley straw was considered unsuitable for thatching (Staniforth 1979:142). Since other natural materials, such as heather, can be used to make these products (Fenton 1978) it is possible that barley straw would have been mainly used for fodder in the Neolithic.

Another possibility is that all of the initial processing stages occurred away from domestic hearths. Two main factors affect how much cereal straw and chaff was charred: (1) which processing stages were conducted in bulk immediately after harvest and which where undertaken piece-meal as required before cooking and, (2) where the initial bulk processing occurred. With free-threshing cereals, such as barley, it is probable that all of the initial processing (threshing, raking, winnowing and initial sieving) was undertaken immediately after harvesting, as the grain becomes instantly separated from the chaff (Bogaard and Jones 2007:303; Hillman 1981b; Jones 1987:322). In contrast, glume wheats, such as Emmer Wheat, split into spikelets and so additional pounding, winnowing and sieving is required to separate the grain from the glumes (ibid). These later glume wheat processing stages would usually be conducted on a daily basis, in domestic houses, rather than immediately after the initial processing (ibid). At the Braes of Ha'Breck and elsewhere in Orkney, only barley was cultivated. Consequently, all of the processing prior to preparation for cooking, except perhaps final sieving and hand sorting to remove weed seeds the same size as the grain, would have taken place immediately after harvest and would not have been processed daily beside a hearth (Bogaard and Jones 2007:303; Hillman 1981b; Jones 1987:322; Stevens 2007:379). Thus, the chances of barley chaff preservation are considerably reduced compared to glume wheat chaff, and barley chaff would only be preserved if the initial processing was conducted close to a hearth (Bogaard and Jones 2007:303; van der Veen and Jones 2006:219).

Hillman (1981b:138) argues that in wet climates, threshing, winnowing and sieving would have been undertaken inside. Yet, as the climate was probably slightly drier in the Neolithic than at present (see section 7.1.4.3), it is possible that all of the initial processing was conducted outside and that only cleaned grain was brought onto the settlement. It should be noted that even into the 1960s, when the climate was more inclement, grain was sometimes winnowed outside on Shetland (Fenton 1978:370 and 373). Alternatively, processing could have occurred in a dedicated grain processing structure, with two opposing doors creating a draft for winnowing similar to those used in recent times on Orkney (Fenton 1978:372). The main processing floors of these structures were used for winnowing and threshing and so lacked hearths (ibid:376). Since all the structures at the Braes of Ha'Breck contained hearths in the central floor area, there would have been insufficient space within these buildings for threshing, and none of the structures had opposing doors to create a draft for winnowing. It is probable that the initial crop processing was conducted outside and rachis fragments would rarely be brought in close proximity to domestic hearths. Therefore outdoor processing may be responsible for the lack of barley chaff in the assemblage.

A final possible explanation for the dearth of chaff in the samples is that the grain was imported from neighbouring islands and not grown or processed at the site at all. The existence of a uniform material culture, the widespread use of similar styles of chambered tombs and houses across Orkney shows that the different Orkney islands were not isolated communities (see section 7.1.5.2) and it is therefore possible that there was some degree of trade between different farms for different food resources. Certainly, the use of boats would have made cereal transport between different farms viable in Orkney.

Having said this, the usual model for Neolithic farming in Britain and elsewhere in Europe is one of small-scale, mixed, self-sufficient subsistence farming, with cereal cultivation conducted in small intensive 'garden-sized' plots (Barclay 2003a:148; Bogaard 2004, 2005; Guttmann 2005; Jones 2005). The existence of cereal trade networks would imply that there was some degree of site specialisation and that some sites were producing a surplus of grain, as in Iron Age Britain (van der Veen and Jones 2006:217). There is little evidence that this was the case. The small quantities of similar plant and animal remains which have been recovered from most Neolithic Orcadian sites (tables 25 and 42), are suggestive of self-sufficient communities, which exploited a range of wild and domestic resources and did not specialise in the production or gathering of any particular resource.

A more likely scenario is that different farms could have co-operated in the planting and harvesting of a single crop, which was later redistributed amongst the different sites. This would fit with the idea that the entire crop was processed seasonally, immediately after harvesting in Neolithic Britain (Stevens 2007:379). If this was the case, the implication would be that arable production was taking place on a very small-scale to enable the full processing of the crops in the field at harvest time or that there was cooperation between different farms in the planting and harvesting of a larger crop.

Several models have been proposed to identify producer and consumer sites in the archaeobotanical record. Hillman (1981b:142) proposes that an assemblage from a producer site would contain evidence for the full processing sequence, whereas a consumer site would be characterised by an absence of processing waste from the early stages of processing. In contrast, M. Jones (1985) suggests that assemblages from consumer settlements would have more processing waste than grain, because little processing would have occurred at these sites, and so there would be fewer opportunities for the grain to become carbonised compared to producer sites. He also suggests that the grain would be more valuable at consumer sites, and so greater care would have been taken to avoid accidental grain carbonisation (ibid). According to Hillman's (1981b:142) model, therefore, the Braes of Ha'Breck would be a consumer site, whereas M. Jones's (1985) model would suggest that the Braes of Ha'Breck was a producer site.

There are several problems with these models: the waste products and grain from the early stages of processing are unlikely to come in contact with fire and large grain losses are likely to be avoided at both site types (G. Jones 1987:322; van der Veen 1992:94-9; van der Veen and Jones 2006). Consequently there is no reason why an assemblage from producer site would have more grain than a consumer site, and producer sites may lack evidence for the early stages of processing because of a lack of carbonisation of the waste products of these stages (ibid). Additionally, as previously discussed, barley chaff survives relatively poorly compared to grain when exposed to fire (Boardman and Jones 1990). Considering the difficulties in distinguishing between producer and consumer settlements it is impossible to reliably evaluate whether the rarity of chaff at Braes of Ha'Breck indicates that the site was a producer or consumer settlement. The analysis of the onsite pollen samples and the pollen core, which was taken from a small basin mire c. 250m from the site, will help to resolve whether the cereals were grown on Wyre in the Neolithic.

7.4.5 Crop processing and carbonisation

As just discussed, the extreme rarity of chaff and seeds in the assemblage suggests that all of the samples were charred after the major phases of processing had been completed. The following section will outline the main stages of the processing sequence that could have resulted in the carbonisation and preservation of the assemblage.

7.4.5.1 Drying for storage?

Grain may have been dried prior to storage to prevent spoilage of the crop or to stop further spoilage if some of the grain had already started to germinate in the field as a result of a wet harvest (Fenton 1978:375; Hillman 1981b; van der Veen 1989:303). Experiments conducted by Reynolds (1979:75-6) in Southern England suggest that drying was unnecessary if the crop was to be pit stored and used for replanting, provided that the temperature was low during the storage period, that the pit was in a location where the subsoil inhibits lateral water movement and the pit was sealed with an impermeable material. However, though the climate was drier in the earlier Neolithic on Orkney than today (see section 7.1.4.3), the climate would still have been fairly wet compared to other regions. Consequently, considering that grain was routinely dried in Orkney and Shetland for storage in the recent past (Fenton 1978:374-387), it seems likely that drying may still have been necessary prior to storage in Neolithic Orkney.

It is possible to identify crops charred accidentally during drying or storage by the presence of high-density grain deposits (van der Veen and Jones 2006:222). Whilst the grain density was low across most of the site, there were several notable concentrations from house 2. A large (1535 grains), dense (154 grains/litre) concentration of grains was recovered from an ashy spread immediately adjacent to the hearth in house 2 (sample 124) and several medium sized grain deposits were derived from other hearth contexts (samples 24 and 70) and the fills of negative structural features in house 2 (samples 41, 88 and 108). It is therefore possible that some of these contexts contain the remains of crop drying accidents.

7.4.5.2 Storage?

Stevens (2007:383) argues that there was a lack of structures suitable for storage in Neolithic Britain and consequently little grain was stored for consumption. Yet, grain could have been stored in pits within the structures, in inbuilt recesses in the walls of the structures, in the roof space of structures, or perhaps in dedicated storage barns (Fenton 1978:370-372; Jones and Rowley-Conwy 2007:401; Reynolds 1979:75-6; Rowley-Conwy 2000:44). Rowley-Conwy (2000) contends that the roof spaces of rectangular houses would have been ideally suited for cereal storage, because upper floors would have been possible in such structures, and the heat and smoke from the fire would have created a suitably dry atmosphere for storage, with the rising smoke helping to prevent insect attack. Outdoor storage is also a possibility, perhaps in pits (Jones and Rowley-Conwy 2007:401), although it is interesting that in the 19th-20th centuries in Scotland, grain was often stored outside in ‘corn bykes’, thatched structures made entirely of straw (Fenton 1978:370-371). No contexts from outdoor pits are represented in the examined samples and as an outdoor straw structure would leave no trace in the archaeological record and would only be set alight in exceptional circumstances, only indoor storage can potentially be detected in the assemblage.

However, whilst it is highly probable that grain was being stored during the phases examined in this research and it is possible that some of the dense deposits represent the remains of small grain stores that were accidentally burnt, the contexts of recovery point against the accidental charring of a stored product *in situ*. With the exception of one sample, all the medium-large grain deposits are from postholes or cuts for structural features, general occupation levels or hearth deposits (NB: though it is likely that the unanalysed dense grain deposit in the earlier phases of structure 3 was a burnt store). The single dense grain sample (sample 38), which was recovered from a pit, may represent the remains of a small burnt-store, but as only 409 grains were recovered, other depositional mechanisms seem more likely. Having said this, pit storage could result in the small-scale accumulation of carbonised grains if the pit was burnt annually to cleanse it before the storage of each years harvest (Hillman 1981b:138). Therefore, pit storage of carbonised grain remains a possibility, but there is little evidence in the examined samples for the remains of a stored product accidentally charred *in situ*.

7.4.5.3 Food preparation stages?

With the exception of the large grain concentrations in house 2, the low-medium grain densities across the site are suggestive of small-scale cooking accidents, since only a small amount of grain would have been lost during these final processing stages (Stevens 2007:379; van der Veen and Jones 2006:222). There are four main grain preparation and cooking processes that could have been used to transform the grain into an edible product: flour milling, roasting, boiling or malting and brewing. In the following section, the likelihood that each of these processes was undertaken at the Braes of Ha'Breck will be considered, with reference to the possible point at which carbonisation could have occurred.

7.4.5.3.1 Flour milling and breadmaking?

It is possible that the barley grain at the Braes of Ha'Breck was ground into flour or groats using querns to make bread, dumplings or porridge (Hillman 1985:21-22). A fragment of a saddle quern was found in house 5 and 2 quern rubbers were recovered from house 3, one of which was deposited within the thick layer of charred grain (A. Thomas pers. comm.). Though only present in very low frequencies, quern stones, quern rubbers/grinders and 'cobble tools' have also been recovered from most other Orcadian sites (table 45). Many of these tools may have been used for grinding a range of different materials, including wild seeds and minerals/shell for pottery temper, as well as for grain grinding (Clarke 2006:45, 2007a:354; Fenton 1978:388; Inskeep 1983; Ritchie 1983:54-6).

If the grain was used for flour or groat production, the grain could have been accidentally charred whilst it was dried/roasted prior to grinding. In the recent past, the grain was usually dried or roasted before grinding because it makes the grain easier to grind and grinding soft grain can be very time-consuming (Fenton 1978:375). The grain could be dried/roasted in a pot on the fire, using the hand or a piece of wood to occasionally turn the grain until brown or by rolling heated stones over the grain in a pot containing straw (Fenton 1978:375, 395). The grain could also be dried directly on hot stones (Hillman 1981b:137). Fenton (1978:395) notes that grains were often accidentally charred during this process and discarded because of their bitter taste.

7.4.5.3.2 Roasting or boiling?

Considering the rarity of quern stones and rubbers in Neolithic Orkney, it is possible that the grain was often processed for consumption without grinding (Clarke 2006:121; Stevens 2007:383). Once separated from the chaff, the grains could have been consumed whole like ‘popcorn’ directly after roasting (Hillman 1981b:137, 1985:21). As previously mentioned, small-scale grain roasting could be undertaken in a pot or on hot stones over the fire or by rolling hot stones into the pot containing the grain, and this could result in accidental charring of some or all of the grain (Fenton 1978:395). Dehusked barley grain can also be cooked whole by mixing with other ingredients and boiled as part of a soup or broth (Fenton 1978:396; Hillman 1985:19). However, boiling is unlikely to result in much grain carbonisation, unless the grains were accidentally dropped in the fire whilst they were transferred to the pot.

7.4.5.3.3 Malting and brewing?

It has been argued that barley was predominantly used for malting and brewing in Neolithic Britain (Dineley and Dineley 2000b). If grain was used for making malts and ales, the main stage that the grain could become carbonised and preserved was during the drying of malted grain (ibid). Experiments undertaken by Dineley and Dineley (2000b) and Dineley (2004:5-10) successfully demonstrate that malting and brewing can be undertaken using simple technology, that would have been readily available in Neolithic Orkney. It should be noted though, that Dineley (2004) used hulled barley, rather than naked barley, in her experiments, which was not the main species used at the Braes of Ha’Breck, or elsewhere in Neolithic Orkney or Scotland (see chapter 5). Having said this, despite the fact that naked barley is currently favoured for human consumption and hulled barley for brewing and animal fodder (Lister and Jones 2012:2), naked barley can be used for malt and ale production (Agu et al 2008; Bhatty 1996).

However, Dineley’s application of her ideas to specific archaeological structures in Orkney is unconvincing (Dineley 2004; Dineley and Dineley 2000a, b). For instance, her suggestion that house 8 at Skara Brae was used for grain processing (ibid) is possible, but as no archaeobotanical samples are available from this structure, this cannot be evaluated.

Also, the presence of the hearth in the centre of this structure (Childe 1931), means that it is not ideally suited to winnowing, threshing or malting, which would have required a flat open area (Fenton 1978). Equally, though stone-lined drains and large pottery vessels with lids may have been useful for brewing (Dineley 2004; Dineley and Dineley 2000b), this evidence is circumstantial and the mere presence of these features/artefacts does not show that brewing was taking place.

Furthermore, there are several major problems with Dineley's interpretation of the archaeobotanical evidence for malting and brewing. Firstly, she suggests that it may be possible to detect malting in the archaeological record through the identification of grains that lack embryos (Dineley 2011:103). However, Dineley (2011) fails to recognise that post-depositional processes can severely affect archaeobotanical assemblages. Once charred, embryos are very fragile and post-depositional processes may destroy the embryos. This is particularly problematic for naked barley grain, which lacks an adhesive husk. Modern experimentation with naked barley has shown that the germination rate is lower for naked barley compared to hulled barley, because the exposed naked barley embryo is easily damaged (Dickin et al 2012). At the Braes of Ha'Breck, the naked barley was poorly preserved (figure 38) and most grains lacked embryos. In fact, most Neolithic naked barley grains examined by the author have lacked embryos. This reflects the generally poor preservation of most Neolithic assemblages and the fact that most Scottish Neolithic samples are dominated by naked rather than hulled barley.

Secondly, Dineley and Dineley (2000b) argue that the presence of sprouted grains in Neolithic archaeobotanical assemblages may provide evidence for malting. Germinated grains have been identified in a number of post-Bronze Age contexts in Europe, many of which have been suggested to provide evidence for malting and brewing (e.g. Bouby et al 2011; Stika 1996, 2011; Van der Veen 1989). Indeed, some sprouted hulled barley grains were recovered from the Neolithic phases of the Orcadian site of Pool (Bond 2007a), but as only a couple of grains from the whole assemblage had germinated (J. Bond pers. comm.), this doesn't provide evidence for malting. Accidental sprouting can occur as a result of wet weather during the harvest season or dampness whilst in storage, and so the identification of sprouting does not provide conclusive evidence for malting (Stika 1996:81; van der Veen 1989:303-4). In those contexts where germinated grains have been identified and malting has been suggested, the samples have been recovered from 'closed' contexts, often associated with kilns or drying structures, and the assemblages have been dominated by large quantities of uniformly germinated grains. No samples that meet these criteria have been analysed from the Braes of Ha'Breck, nor have any been identified at other Neolithic sites in Orkney.

Furthermore, Dineley and Dineley (2000b:151) and Dineley (2008:30) argue that unmalted grain was very difficult to dehusk and grind into flour and that malted grain is much easier to dehusk and grind. Yet, naked barley grain becomes detached from the chaff during threshing and winnowing and does not require additional processing to remove the hulls, and hulled barley can be dehusked easily after parching (Fenton 1978; Hillman 1981b). Also, as previously discussed, barley can be cooked for consumption in a number of ways without grinding (section 7.4.5.3.2).

Finally, whilst it is possible that some barley was used for brewing in Neolithic Orkney, it is unlikely that this was its major function, given that barley was the only crop grown on Orkney. Indeed, even in the 17th-20th centuries, barley was used for multiple purposes in Orkney (Fenton 1978).

7.4.6 *Summary of crop processing*

The rarity of chaff in the deposits either suggests that the early stages of crop processing were not conducted inside the houses at the Braes of Ha'Breck or that the chaff was underrepresented due to its low chance of survival in domestic hearths. Most of the charred grain was probably derived from small-scale cooking accidents, with some grain also occasionally preserved accidentally during drying accidents to prepare the grain for storage or perhaps as a result of the accidental charring of small-scale grain stores. Grain was probably processed and used in a number of different ways, predominantly by roasting or boiling, but perhaps also to a lesser extent by grinding into flour or malting and brewing.

7.4.7 The relative importance of wild and domestic plants

As discussed in chapter 5, the proportion of domestic species in archaeobotanical assemblages does not necessary directly relate to the importance of cereal cultivation within the economy (see chapter 5). However, considering the extreme scarcity of wild fruits and nuts in the Braes of Ha'Breck assemblage and that hazelnut shell (the main collected wild species) is likely to be over represented (Jones 2000b:80; Jones and Rowley-Conwy 2007:400), it is probable that domestic plants were more important than wild plants in the economy at the site.

The importance of cereals within the Neolithic economy at the Braes of Ha'Breck is also highlighted by the large size of the cereal assemblage. There are only two other cereal assemblages in Scotland (Wideford, Orkney and Balbridie, Aberdeenshire) that have a greater number of grains than the subsample so far analysed from the Braes of Ha'Breck (see chapter 5). Also, whilst not analysed as part of this research, the samples taken from the earliest phase of house 3 contain hundreds of thousands of charred cereal grains, which may represent the remnants of a substantial grain store, burnt *in situ* within the structure. This suggests that the assemblage from the Braes of Ha'Breck is comparable in size to the assemblage from Balbridie, Aberdeenshire. It is therefore one of the largest cereal assemblages in Neolithic Scotland.

Moreover, though the grain densities in most individual samples are low at the Braes of Ha'Breck, low concentrations of grain are consistently present across the whole site and there are several medium-high density grain deposits in the negative features from house 2. Consequently, the overall grain density for the site (9.9 grains per litre; table 36) is higher than all the other Neolithic Orcadian sites and most British sites (where the volume is available), which generally have very low concentrations of grain (<4 grains per litre; chapter 5; Bogaard and Jones 2007). The relatively high overall grain density at the Braes of Ha'Breck is probably a reflection of the permanent habitation at the site and the longevity of site use (Stevens 2007:379), together with the chance occurrence of a number of crop drying or storage accidents (Rowley-Conwy 2004:90; van der Veen and Jones 2006:223). Though in radiocarbon terms, the structures can be considered contemporary, the existence of multiple phases of structures on the site suggests the settlement may have been in use for multiple human generations. This, together with the evidence of large-scale storage in house 3 (figure 33), shows that arable production was taking place on a significant scale at the site.

7.4.8 The arable economy

The Neolithic inhabitants of the Braes of Ha'Breck grew a barley monoculture. Though several samples contained wheat, all of these samples had over 90% barley, which is consistent with Jones and Halstead's (1995) definition of a monocrop (>90% of a single species) (figure 39). The low number of wheat and oat grains recovered suggests that these species were both contaminants of the barley crop. Though the assemblage contained a mix of hulled and naked barley, hulled barley was extremely rare in the assemblage as a whole and only four samples contained less than 90% naked barley. However, these 4 samples all had a very small samples size (less than 12 grains) so these percentages cannot be considered reliable.

7.4.9 Plant use in Neolithic Orkney

A summary of the results from Neolithic Orkney is shown in tables 42-44.

Table 42: Summary of plant macrofossils from Neolithic Orkney. The dominant cereal group is highlighted in bold for each site (excluding cereal indet.). P: present.*:based on 2004-2006 samples only (excavation and analysis is ongoing); **= not included in data analysis because the sample composition suggests that the whole assemblage from phase 2 is derived from turf/peat burning (Rowley-Conwy forthcoming).

Site name	Cereal grain	Oat	Barley species	Hulled barley	Naked barley	Wheat species	Emmer Wheat	Cereal rachis	Cereal-sized culm nodes/ bases	Hazelnut shell	Crab Apple	Other wild fruits and nuts	Other seeds	Total volume of samples (l)	Total number of grains	Grain density	Total number of identifiable grains
Early Orkney Neolithic																	
Isbister	6		24		**32**		1					8	232	200kg	63		57
Knap of Howar	22				**10**					1					32		10
Knowes of Trotty	2		**21**		6							2	108	1173.75	29	0.02	27
Pool	86		**25**	2	**25**					5			166	55	138	2.51	52
Stonehall	116		**117**	1	42							3	16		276		160
Tofts Ness	302		257	**364**	137			18	102			1	927	271	1060	3.91	758
Wideford	3387		**1950**		1688	15							8		7040		3653
Late Orkney Neolithic																	
Barnhouse	21	1			**227**			2		30	4	17	5002	864.9	249	0.29	228
Bookan														30.5	0		0
Crossiecrown midden													2		0		0
Maeshowe													39		0		0
Ness of Brodgar *	57	11	**33**	3	12							5	59		116		59
Pool	306		83	**141**	99	9	5	10	25	1		67	2821	325	643	1.98	337
Skara Brae (phase 1)	16			4	**307**		28	2							355	0.02	339
Skara Brae (phase 2)**												877	29961	14240	0		
Stonehall	8		**3**		1							6	345		12		4
The Howe													P		0		0
Total	4329	12	2513	515	2586	24	34	32	127	37	4	100	39686	16960.15	10013		5684

Table 43: Summary of the proportions of the main plant groups in plant macrofossil assemblages from Neolithic Orkney. *:based on 2004-2006 samples only (excavation and analysis is ongoing).

Site name	Oat (%)	Barley (%)	Wheat (%)	Hulled Barley (%)	Naked barley (%)	Wild (%)	Domestic (%)	Grain (%)	Chaff (%)	Seeds (%)	Grain/litre
Early Orkney Neolithic											
Isbister	0.00	98.25	1.75	0.00	100.00	11.27	88.73	21.36	0.00	78.64	
Knap of Howar	0.00	100.00	0.00	0.00	100.00	3.03	96.97	100.00	0.00	0.00	
Knowes of Trotty	0.00	100.00	0.00	0.00	100.00	6.45	93.55	21.17	0.00	78.83	0.02
Pool	0.00	100.00	0.00	7.41	92.59	3.50	96.50	45.39	0.00	54.61	2.51
Stonehall	0.00	100.00	0.00	2.33	97.67	0.00	100.00	94.52	0.00	5.48	
The Howe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	
Tofts Ness	0.00	100.00	0.00	72.65	27.35	0.09	99.91	50.31	5.70	44.00	3.91
Wideford	0.00	99.59	0.41	0.00	100.00	0.00	100.00	99.89	0.00	0.11	
Late Orkney Neolithic											
Barnhouse	0.44	99.56	0.00	0.00	100.00	17.00	83.00	4.74	0.04	95.22	0.29
Bookan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Crossiecrown midden	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	
Maeshowe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	
Ness of Brodgar *	18.64	81.36	0.00	20.00	80.00	4.13	95.87	66.29	0.00	33.71	
Pool	0.00	95.85	4.15	58.75	41.25	9.56	90.44	18.38	1.00	80.62	1.98
Skara Brae (phase 1)	0.00	91.74	8.26	1.29	98.71	0.00	100.00	99.44	0.56	0.00	0.02
Stonehall	0.00	100.00	0.00	0.00	100.00	0.00	100.00	3.36	0.00	96.64	
The Howe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	
Total %	0.21	98.77	1.02	16.61	83.39	1.39	98.61	20.08	0.32	79.60	0.34

Table 44: Summary of the main seed species present in Neolithic Orcadian assemblages (seed categories with more than 50 identifications from more than 1 site). P: present; C: consumption; W: arable weed; F: fuel (peat/turf), EN: early Neolithic; LN: late Neolithic.

Site	*Brassica* sp./*Sinapis* sp.	*Carex* sp.	*Chenopodium* sp.	Cyperaceae (excluding *Carex* sp.)	*Danthonia decumbens* (L.) DC./*Danthonia* sp.	*Empetrum nigrum* L.	*Juncus* sp./*Luzula* sp.	*Lychnis flos-cuculi* L.	*Montania fontana* L./*Montania* sp.	*Plantago* sp.	Poaceae (excluding *Danthonia decumbens* (L.) DC.)	*Polygonum* sp.	*Potentilla* sp.	*Ranunculus* sp.	*Rumex* sp.	*Stellaria media* (L.) Vill.	Indet seeds	Other seeds (excluding edible fruit seeds)	Total
Potential seed purpose	C/W	C/W?/F	C/W	C?/W?/F	C?/W?/F	C/F	W?/F	F	W/F	C/W/F	C/W/F	C/W	F	W/F	C/W/F	W	n/a	n/a	n/a
Grassland/ heathland/ fen plant?	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	n/a	n/a	n/a
Braes of Ha'Breck (EN)	53	20	5			24			3	2	14	1		4	51		380	11	544
Isbister (EN)		16	6	4		8			2			4			64	102	2	32	232
Pool (EN)	6	33		5	13				77	1	15		2	5	5			4	166
Stonehall (EN)		5	6			3									5				16
Tofts Ness (EN)	44	14	5	100	155	1		3	40	1	108	10	8	27	278	48		86	927
Wideford (EN)															6			2	8
Barnhouse (LN)		2615		24	1167	17	273	7	19	21	334	1	90	210	1	10	121	109	5002
Crossiecrown (LN)					2														2
Knowes of Trotty (EN)		70	1	3	6	2				1	2			3	7	4	3	8	108
Maeshowe (LN)		1			2						34							2	39
Ness of Brodgar (LN)		30	5		10	5			1		2			1	1	3	5	1	59
Pool (LN)	21	136	2	183	225	67		17	1661	73	256	1	25	6	87	90		38	2821
Skara Brae (phase 2) (LN)	448	8511	4	61	10785	243	778	450	7953	577	166	45	2	125	16			40	29961
Stonehall (LN)		108	25	48	38	6			24	15	15		14	21	18	1		18	345
The Howe (LN)	P						P		P		P							P	P
Total	572	11559	59	428	12403	376	1051	477	9780	691	946	62	141	402	539	258	511	351	40230

7.4.9.1 Seeds

The seed assemblages from Neolithic Orkney were overwhelmingly dominated by heathland, damp grassland and fen species (table 44). The most frequently recovered species from all the sites were sedges, Blinks, grasses, particularly Heath-grass (*Danthonia decumbens* (L.) DC.), and rushes/wood-rushes (*Juncus* sp./*Luzula* sp.). Ribwort Plantain, buttercups, especially Lesser Spearwort (*Ranunculus flammula* L.), docks, Crowberry and Ragged-Robin (*Lychnis flos-cuculi* L.) seeds were also abundant in several assemblages.

Few definite arable weeds were recovered. The most frequently occurring arable weed seeds were Common Chickweed (*Stellaria media* (L.) Vill.) and cabbage/charlock/mustard (*Brassica* sp./*Sinapis* sp.), which do not occur in heath/grassland environments and were probably accidentally harvested with the cereal crop. Goosefoot species and Knotgrass species (*Polygonum* sp.), are also common arable weeds and they do not grow in heathland/grasslands, but they were only recovered in very low frequencies from all sites. Though it is not the main habitat for most of the seeds recovered from the Orcadian Neolithic assemblages, several of the taxa (*Rumex* sp., *Montia fontana* L., *Ranunculus* sp.) occasionally occur as arable weeds. Equally, though several of the species (*Carex* sp., *Danthonia decumbens* (L.) DC., *Juncus* sp., *Luzula* sp., *Plantago lanceolata* L.) do not occur as arable weeds today, they may have been arable weeds in prehistory, before field drainage was improved and the use of the mouldboard plough was introduced in the Middle Ages, which eliminated perennial/biennial weeds (van der Veen 1992:75-6).

As at the Braes of Ha'Breck, many of the 'wild' seeds from Neolithic Orkney are edible, and several of the high concentrations of particular seeds could represent deliberately gathered foods, accidentally charred during processing or cooking (table 44). In addition to the edible plants discussed for the Braes of Ha'Breck (see section 7.4.2.2), the young sprouts of Soft Rush (*Juncus effusus* L.) are also edible (Moerman 1998:282), as are the shoots, stems and leaves of Common Chickweed (Grieve 1992:196; Irving 2009:246; Mabey 2001:28-9; Pierpoint Johnson 1862:53). However, as the seeds are not noted to be edible, it is unlikely that these species are derived from this source, as these plant parts are gathered before the seeds develop (Cameron 1977:56; Hill 1941:11). Likewise, wood-rushes, Ragged-Robin, Tormentil/Creeping Cinquefoil/Marsh Cinquefoil (*Potentilla erecta* L./*reptans*/*palustris* (L.) Scop.), buttercups and Blinks are unlikely foodstuffs, as none of the consulted references mentioned that the seeds were edible (see appendix 1). Similarly, though most grass seeds are edible (Ebeling 1986:195-8; Irving 2009:325; Mears and Hillman 2007:328; Moerman 1998), none of the consulted sources mentioned that Heath-Grass could be eaten. Though sedge seeds are edible (section 6.4.3), other cyperaceae taxa, such as spikerush species, are usually gathered for their roots or sap rather than the seeds (Moerman 1998:208). Therefore, it is unlikely that these seeds represent deliberately collected foods.

In fact, the overall composition of the seed assemblages from Neolithic Orkney, suggests that most of the seeds were derived from grasslands and heathlands, and were probably carbonised during the burning of turf/peat as a fuel (Church et al 2007b; Dickson 1998). Several of the main species recovered, such as Ragged-Robin and Tormentil/ Marsh Cinquefoil are unlikely to be derived from any other source. The turf/peat fuel origin of most of the seeds in Orcadian Neolithic assemblages is emphasized by the fact that 'weed' seeds are rare in Scottish Neolithic archaeobotanical assemblages as a whole (chapter 5), and it is mainly on the Northern and Western Isles that medium-large seed assemblages have been recovered. This implies that different taphonomic processes were involved in creating these assemblages than most mainland sites. Tubers/roots were also present in several Orcadian assemblages, including the Braes of Ha'Breck (section 7.3.5), Barnhouse (Hinton 2005), Pool (Bond 2007a) and Skara Brae (Dickson and Dickson 2000:53-4; Rowley-Conwy forthcoming), which may also derive from turf/peat burning. Therefore, the abundance of heathland/grassland taxa in the seed assemblages, suggests that peat and turf burning may have been a common practice in Neolithic Orkney.

Moreover, large volumes of ash are produced when peat and turf are burnt as fuel (Church et al 2005, 2007b; Peters et al 2004; Simpson et al 2003) and ash-rich deposits have been found abundantly on Neolithic settlements in Orkney, such as at Skara Brae (Childe 1931), Rinyo (Childe and Grant 1938-9), Tofts Ness (Dockrill et al 2007) and Pool (Hunter et al 2007). Childe (Childe 1931:25) and Childe and Grant (Childe and Grant 1938-9:29) were the first to argue that the ash at Skara Brae and Rinyo was derived from the burning of peat as a fuel. Recent analysis of soil micromorphological samples from Skara Brae shows that peat/turf fuel residues did indeed make up a large component of the midden material within the settlement, but that both wood and peat/turf ash were found in the external midden (Simpson et al 2006b). The burning of animal dung as a fuel is also a possibility (Bottema 1984; Charles 1998), though at Skara Brae it appears to have been deposited in the external midden without being burnt (Simpson et al 2006b). At Pool and Tofts Ness, the majority of the excavated contexts were made up of fuel residues. The comparison of the excavated soil from Pool to experimental samples of modern burnt peat/turf implies that these fuel residues primarily derive from the burning of turf and/or 'loch peat' (desiccated loch sediments; Hunter et al 2007:22-23). Magnetic susceptibility measurements from the ash deposits also confirms the idea that turf/peat was burnt at Tofts Ness, although the recovery of charred seaweed fragments suggests that a range of fuels were probably burnt at this site (Dockrill et al 2007:15).

The widespread use of turf/peat as a fuel supports the idea that woodlands were in decline in Neolithic Orkney (section 7.1.4.5). Whilst woodlands would have been available for exploitation (section 7.1.4.5), considering the relative scarcity of wood at this time, it is probable that wood would have been favoured for larger constructions, such as houses and fences rather than for firewood. Turf/peat burning appears to have been undertaken during both the earlier and later Neolithic on Orkney (table 44). However, the presence of several large seed assemblages dominated by heathland/grassland species in the later Neolithic, such as at Barnhouse, Skara Brae phase 2 and Pool, provides a slight indication that this may well have been a practice which increased in the later Neolithic. It is probable that declining woodland availability in the later Neolithic would have necessitated an increase in the use of peat/turf as a fuel. Future analysis of the proportions of native and non-native species in the charcoal assemblages from Orcadian Neolithic sites should provide evidence to confirm or refute this suggestion.

7.4.9.2 Cereals, fruits and nuts

Edible fruits and nuts were extremely rare in Orcadian Neolithic assemblages. As previously discussed, only 97 hazelnut fragments were recovered from the Braes of Ha'Breck. Hazel nutshell was even sparser at the other Orcadian sites, with a total of 37 fragments found in all the other assemblages (table 42). The only species to be recovered consistently on most sites was Crowberry, which suggests that it may have been an important foodstuff in Neolithic Orkney. However, as discussed for the Braes of Ha'Breck, the abundance of this species in Neolithic Orcadian assemblages could also reflect the probable widespread use of peat/turf as a fuel. All other discoveries of fruits and nuts were restricted to single sites: a couple of Crab Apple pips were recovered from Barnhouse and a single Hawthorn fragment was present in the Braes of Ha'Breck assemblage. A notable concentration of Wild Strawberry (*Fragaria vesca* L.) seeds was also recovered from Skara Brae phase 2, but considering the composition of this assemblage, it is probable that these seeds were derived from peat/turf burning, and it is unlikely that they represent a deliberately collected foodstuff (Rowley-Conwy forthcoming). In contrast, cereals were much more frequent in Neolithic Orcadian assemblages (tables 42 and 43). Therefore, considering the scarcity of edible fruits/nuts and the abundance of cereals, it is clear that cereal cultivation was far more important than wild plant collection in Neolithic Orkney.

7.4.9.3 The Orcadian arable economy

The dominance of naked barley at the Braes of Ha'Breck conforms to the general Orcadian Neolithic economic strategy (tables 42 and 43). As in mainland Scotland (see chapter 5), several assemblages in Orkney contained a mix of hulled and naked barley and it is probable that the seed first imported into Orkney contained a mix of these two species. There are several assemblages from mainland Scotland containing hulled barley, which predate the earliest archaeobotanical evidence for agriculture in Orkney (c. 3600 cal BC), for instance at Balbridie (Fairweather and Ralston 1993), Claish Farm (Barclay et al 2002), Dubton Farm (Cameron 2002) and Eweford (Lelong and Macgregor 2007). The results of cereal growth experiments suggest that naked barley has similar agronomic characteristics to hulled barley, except that naked barley has a lower emergence rate than hulled barley (Choo et al 2001; Dickin et al 2012). This may be due to the fact that the embryo is exposed in naked barley and so there is an increased risk of damage to the embryos (ibid). Consequently, when naked and hulled barley are grown together as a maslin, the hulled barley outcompetes the naked barley and the proportion of naked barley decreases in each successive generation (E. Dickin pers. comm.; Choo et al 2001:1025). In order to preserve naked barley as a single crop, it is necessary to harvest the hulled barley separately or remove any remaining hulled barley from the naked barley seed to be replanted each year (E. Dickin pers. comm.; Choo et al 2001:1025). Considering that several naked barley dominated assemblages in Orkney contained a small amount of hulled barley, this implies that the maintenance of a naked barley monocrop must have been a deliberate crop management strategy.

The only sites on Orkney where hulled barley was dominant were Tofts Ness and Pool, Sanday, where there appears to be an increase in hulled barley between the early and later Neolithic phases (Bond 2007a, b). If this is a genuine increase in hulled barley during the use of the site, rather than a consequence of the poor preservation of the assemblage (see chapter 5), this has important implications for understanding barley management in Neolithic Orkney. Since hulled barley naturally outcompetes naked barley (Choo et al 2001; Dickin et al 2012), the increase in hulled barley during the Neolithic occupation at Pool implies that hulled barley was not systematically removed from the naked barley crop. It is difficult to explain why hulled barley would have been favoured on Sanday at these site phases. Hulled barley must be pounded to remove the husks from the grain

(Hillman 1981b:136), which would have increased processing time. Also, recent research suggests that the yield potential of the two varieties of barley is similar, once the husk has been removed from hulled barley (Dickin et al 2012) and as the *nud* gene, which distinguishes naked and hulled barley only effects the adhesion of the husks to the grains (Taketa et al 2004), the two species should have a similar disease resistances (E. Dickin pers. comm.). Similarly, Bond (2007b:157) points out that fungal diseases are most likely to affect the barley during anthesis, when spores can become trapped between the glumes and the pericarp. Since anthesis occurs before the glumes fuse to the hulled grain, the *nud* gene should confer no additional protection against fungal infection (ibid).

One possible reason for the increase in the use of hulled barley at these site phases is that the adherence of the husks to the grains may prolong seed storage (Bond 2007b:157). Experiments suggest that naked barley stores less well than both 2-row and 6-row hulled barley (Briggs 1978:394). This suggests that growing hulled barley would have been an advantage over naked barley cultivation in damp climates, especially considering that grain survival is reduced after wet harvests (Bond 2007b:157; Briggs 1978:394). The increase in hulled barley could have been a result of deliberate human selection for grain storability. Alternatively, it is possible that a succession of wet harvests, which would reduce grain survival (ibid) – could have significantly reduced the viable naked barley grain within the seed crop.

Having said this, it is possible that the results of this experiment simply reflect the fact that naked barley has a lower emergence rate than hulled barley. Also, though this seems like a good explanation for the overall chronological change from naked to hulled barley in prehistory on Orkney, it does not explain the use of both crops together at Pool and Tofts Ness in the Neolithic. In the late Neolithic at Pool, the proportion of hulled to naked barley was 59:41, whereas at Tofts Ness the proportion was 73:27. The composition of these two assemblages conforms to Jones and Halstead's (1995) classification of a 'maslin' or mixed crop, which can be anywhere from 50:50 to 80:20 for each species. These ratios may not represent a deliberate strategy to grow both crops simultaneously in the same fields; it is possible that the two species were grown and processed separately and subsequently became mixed or that the ratios represent a mixture of different crops grown in different years. Nevertheless, the proportions do suggest that both crops were used at these sites.

One possibility is that there may have been a particularly high hulled barley component in the naked barley seed crop in a particular year or succession of years, and it may not have been viable to spend additional time removing the hulled barley from the naked barley crop. Alternatively, maybe the hulled and naked barleys were utilised for different purposes at Pool and Tofts Ness. For instance naked barley may have been favoured for human consumption because dehusking is not necessary and hulled barley for cattle fodder, since the grains would not fall out of the glumes during storage in the ear (Lister and Jones 2012:2).

7.4.9.4 Cereal cultivation methods in Orkney

In central Europe, Neolithic cultivation techniques have been identified indirectly through the analysis of the ecology of archaeobotanical weed seed assemblages (Bogaard 2004). However, the potential of identifying detailed cultivation strategies using archaeological seed assemblages in Orkney, as elsewhere in Scotland, is low because large weed assemblages are rare (see chapter 5). Also, most Orcadian archaeobotanical assemblages are unsuitable for weed ecological studies because they usually have an extremely mixed taphonomy, frequently deriving from a number of different episodes of discard (Church 2002c:71), and though some large Neolithic seed assemblages exist, it is likely that most of the seeds derive from the burning of turf/peat as a fuel rather than the accidental charring of weed seeds growing with the arable crop (Church et al 2007b; Dickson 1998).

However, a range of other evidence can be used to understand Neolithic cultivation techniques on Orkney. For instance, physical evidence for cereal cultivation has been discovered at several sites. The discovery of shallow ard marks in Neolithic horizons at the Links of Noltland, Tofts Ness and Pool shows that the ground was tilled with light ards, which created shallow furrows in the soil by scratching the surface, but without turning the soil (Clarke and Sharples 1990:73; Dockrill et al 2007:16; Hunter et al 2007:33). Less conclusive evidence of arable land use is also provided by the identification of possible boundary ditches, which may have been used to define the edges of arable fields at Pool, Links of Noltland and at Stromness (Clarke and Sharples 1990:75; Hunter et al 2007:33; Stevens et al 2005:391). At the Links of Noltland and Pool, the ditches contained numerous stones, which may have been the remains of a base for a seaweed fence or wedging stones for a wooden fence (Clarke and Sharples 1990:75; Hunter et al 2007:33). This evidence is difficult to date precisely, but the ard marks and fence lines at Pool and the fence line at Stromness appear to date to the mid 4th millennium cal BC (Hunter et al 2007; Stevens et al 2005). The ard marks at Tofts Ness were cut into the subsoil below the basal soil, which was sealed by midden material radiocarbon dated to the later Neolithic (3360-2920 cal BC) (Guttmann et al 2006). The Links of Noltland evidence has not been radiocarbon dated, but is associated with later Neolithic Grooved

Ware settlement. Current evidence suggests therefore that ard cultivation may have taken place from the earliest Neolithic on Orkney.

Artefactual evidence also provides evidence for tillage methods. Two main classes of artefact associated with cereal cultivation have been recognized in Neolithic assemblages on Orkney: ard points and flaked stone bars (table 45). Clarke (2006) argues that stone ard points were not utilised in Orkney until the Bronze Age, when they were introduced from Shetland. This position seems difficult to maintain considering the ard marks have been discovered at several sites. Though Clarke suggests that bone ard points may have been used, no diagnostic bone ards have been recovered from Neolithic assemblages. Equally, in recent years, a stone ard point was recovered from house 5 at the Braes of Ha'Breck (Thomas pers. comm.) and several were also recovered from Neolithic phases at the Links of Noltland (McLaren 2011). Flaked stone bars have so far only been identified at the Links of Noltland in the Neolithic (table 45). These tools are thought to be used for mattocking and hoeing the soil prior to cultivation with an ard (Clarke 2006:30). A possible whale bone hoe was also recovered from the Knap of Howar (table 45), which may have been used for a similar purpose.

There is also some zooarchaeological evidence that suggests that cattle may have been used for ploughing the land for cultivation. Pathological evidence from Pool provides evidence for arthritis in several cattle bones, which is usually considered to have developed during traction (Bond 2007c:233-4). At the Links of Noltland, pathological legions associated with repetitive actions are present on several cattle bones and some cattle bones also had well-developed muscle insertions (Fraser 2011:45). Both of these features may have developed as a result of traction, but since they may also have been caused by other factors, this evidence is inconclusive (ibid). Whilst ard marks have been noted at several sites, evidence suggests that these marks were created by light ploughs which gently scratched the soil surface and so humans may well have ploughed the land by hand (Clarke and Sharples 1990:73; Fraser 2011:45).

There is also evidence that suggests that Neolithic plots in Orkney may have been fertilised with midden material. For example, domestic refuse was abundant in the cultivated later Neolithic soils at Links of Noltland, Orkney (Clarke and Sharples 1990:73). Initial analysis of soil micromorphological thin sections from the cultivated soils associated with these ard marks suggests that the soils were mainly amended with turf and domestic midden material, with animal manures also used during the later phases of cultivation (McKenna and Simpson 2011). Similarly, Bond et al (1995:127) suggest that midden material was also applied to the buried soils associated with the Neolithic settlement at the Bay of Stove.

Table 45: Artefacts recovered from Neolithic settlement sites in Orkney with potential cultivation or grain processing functions. P: present; *: Post-excavation analysis not yet completed, preliminary analysis only.

Site	Ard points	Flaked stone bars	Quern stones/ grinding stones	Cobble tools	Knap of Howar style quern rubbers/ grinders	Quern rubbers/ grinders	Other	Reference
Barnhouse			P	P				Clarke 2005
Braes of Ha'breck	P		P			P		Antonia Thomas pers. comm. *
Crossiecrown				P	P			Clarke 2006
Green			P			P		Miles 2009 *
Knap of Howar			P	P	P		possible whale bone hoe	Ritchie 1983; Clarke 2006
Links of Noltland	P	P		P				McLaren 2011; Clarke 2006
Pool			P	P	P			Clarke 2007a
Rinyo						P		Childe and Grant 1946-7
Skara Brae			P	P				Childe 1931; Clarke 2006
Stonehall			P	P	P			Clarke 2006
Tofts Ness				P	P			Clarke 2007b
Wideford			P	P	P			Clarke 2006

It has also been argued that cereals may have been grown directly on midden heaps in Orkney rather than on manured fields (Guttmann 2005; Guttmann et al 2004, 2006). At Tofts Ness, Orkney, a Neolithic soil was sealed beneath later midden deposits dated to 3360-2920 cal BC (ibid). Both the soil and midden had similar particle size, quantities of peat/turf fragments and phosphate concentrations (ibid). Guttmann et al (2004, 2006) contend that an area of midden had been flattened and used as a small arable ‘garden-sized' plot, covering an area, c. 10-20 m^2 (ibid). At the Knap of Howar, Ritchie (1983:45) suggests that the 500m^2 midden may have been deliberately levelled to allow small-scale cultivation. In light of the evidence from Tofts Ness, Guttmann (2005:232) proposes that the ard marks at Pool and the Links of Noltland may also represent midden cultivation.

However, Guttmann et al's (2006) discussion of the results from Tofts Ness is misleading. Outwith the area covered by the Neolithic midden deposits, there is an extensive area of midden *enhanced* soils, which may have extended over 1-2 hectares (Dockrill et al 2007:37; Guttmann et al 2004:61). It seems probable that the small highly midden-rich deposit identified by Guttmann et al (2004, 2006) was a restricted area, which could represent the location from which the midden material was spread to the surrounding fields. Also, considering that the area Guttmann et al (2004, 2006) argues to be a cultivated midden lies directly beneath later midden deposits, it is possible that there has been some degree of contamination of this deposit with material from the overlying midden. Similarly, no ard marks have been noted at the Knap of Howar (Ritchie 1983) and at Pool, it is probable that the agricultural soils were removed as part of a later pre-construction phase of clearance across the site, and so the midden material may have accumulated after the cultivation of the area had ended (Hunter et al 2007:65).

Furthermore, the direct growth of cereals on midden heaps is improbable because the cereal species grown in the Neolithic would probably not have tolerated the very high nitrogen levels associated with middens. Initial small-scale experimentation with the growth of naked barley and Emmer Wheat suggests that these crops tend to become weak and lodge (fall over) when grown directly on midden material (Bishop et al unpublished data). This is because ancient varieties of cereals have much longer straw than modern varieties and so cannot cope with additional nitrogen inputs (Briggs 1978:302; Evans 1998:137-9; Mazoyer and Roudart 2006:386-7). In comparison, modern varieties are short, so nitrogen can be applied at a higher rate to increase yields (ibid). It therefore seems unlikely that Neolithic cereals grown on over-rich middens would have withstood the windy conditions on Orkney.

7.4.9.5 Crop processing in Orkney

There were no notable concentrations of cereal chaff in any of the Neolithic assemblages from Orkney. Consequently, there is no evidence that some sites were producer settlements and other sites consumer settlements (see section 7.4.4). The two most logical explanations for the rarity of chaff in Neolithic Orcadian assemblages is either that the chaff did not survive carbonisation (Boardman and Jones 1990) or that cereal processing was occurring outwith domestic houses, perhaps in the fields of cultivation (Stevens 2007).

7.5 Conclusions

The abundance of cereal grains and the rarity of wild plants in the Braes of Ha'Breck assemblage shows that cereal cultivation was an important aspect of the economy at the site. The Neolithic inhabitants of the Braes of Ha'Breck grew a monoculture of naked barley, which they would have deliberately maintained by rogueing out the hulled barley in the crop after each harvest. The composition of the assemblage suggests that the crops were probably cultivated in fixed plots and harvested by uprooting and the rarity of cereal chaff may suggest that the main stages of crop processing were conducted in the fields immediately after cultivation. The absence of evidence for the early stages of crop processing or economic specialisation at other Orcadian Neolithic sites suggests that this cultivation was most likely occurring close to the settlement at the Braes of Ha'Breck, perhaps using some of the stone ard points recovered from the site. Future analysis of pollen core taken from close to the settlement should help to confirm this suggestion.

The rarity of weeds and cereal chaff in the samples suggests that the assemblage represents a fully processed crop. Most of the charred grain was probably preserved as a result of small-scale cooking accidents, which may have occurred during the drying of the grain to enable easy grinding, during roasting prior to immediate consumption or perhaps less frequently during boiling or malting. The presence of several medium-high density deposits suggests that some of the grain was also occasionally preserved accidentally during drying to prepare the grain for storage or whilst being stored.

Definite edible wild species were restricted to very occasional remains of hazelnut, Hawthorn and Crowberry, and it is clear that wild plant collection formed only a minor component of the economy. A range of edible wild seeds were also identified, but the absence of large concentrations of particular taxa with edible seeds in the assemblage suggests that most of the seeds are more likely to have originated as arable weeds or from turf/peat burnt as a fuel. Though many of the seeds may derive from crop processing, consideration of the ecology of the identified taxa from the Braes of Ha'Breck and the other Neolithic sites on Orkney, suggests that turf/peat burning was probably a significant source for the seeds at the site.

Overall, the Neolithic Orcadian plant economy was overwhelmingly dominated by the cultivation of naked barley, together with the small-scale cultivation of hulled barley on some sites. The amendment of soils with domestic midden material appears to have been widespread in Neolithic Orkney, but it is unlikely that cereals were grown directly on midden heaps. Wild plant remains were extremely rare at all sites and plant gathering appears to have been an insignificant part of the economy. The abundance of heathland and grassland taxa in the seed assemblages, suggests that peat and turf burning may have been a common practice in Neolithic Orkney.

Chapter 8: Testing the models: plant gatherers, plant managers or agriculturalists in Mesolithic and Neolithic Scotland?

8.1 Chapter outline

This chapter will assess the overall nature of people-plant interaction in Mesolithic and Neolithic Scotland. The evidence and conclusions from chapters 2-6 will be used to test the models proposed in chapter 1 and the similarities and differences in the nature of plant exploitation between Mesolithic and Neolithic Scotland will be discussed.

8.2 Testing the models

As outlined in section 1.4, the plant exploitation models to be tested in this thesis were as follows (see table 1):

1) opportunistic and incidental wild plant use;
2) systematic and intensive wild plant use;
3) wild plant food management, husbandry or cultivation;
4) the cultivation of domestic plants.

8.2.1 Mesolithic Scotland

There are several factors that suggest that plant exploitation in Mesolithic Scotland was more than opportunistic and incidental. Firstly, hazelnut shell was present on most Mesolithic sites, showing that hazelnut exploitation was a widespread strategy (see chapter 2). The remains of other plant taxa were extremely scarce in archaeobotanical assemblages and at first sight, the utilisation of other plants appears to have been sporadic. However, arguably, the rarity of other plant species on Scottish Mesolithic sites was largely a consequence of taphonomic factors (see chapter 2). In particular, the relatively short longevity of use of many Mesolithic sites would have resulted in much lower rates of deposition compared to later periods. This problem is exacerbated by the small number of samples taken for archaeobotanical remains from most Mesolithic sites, with most assemblages consisting of fewer than 10 samples. Added to this is the high moisture content of many of the plants likely to have been exploited: leafy plants would not survive carbonisation and tubers and fruits, would only survive carbonisation well if they had been dried prior to consumption. Edible seeds would have survived charring relatively well, but on the sites where dry sieving rather than flotation was undertaken, large mesh sizes would have prevented the recovery of most small seeds, and as previously stated, seeds would rarely be recovered from sites with small numbers of samples because of the low density of plant remains on Mesolithic sites. It is therefore unsurprising that most Mesolithic samples contain a limited range and quantity of plant remains.

This is highlighted by the composition of the assemblages from sites where large-scale sampling has been undertaken. The samples from both Staosnaig and Northton contained a much broader array of species and quantity of remains than has been recovered from most other sites (see chapters 2 and 6). Both assemblages contained a notable quantity of hazelnut shell and Lesser Celandine root tubers/bulbils, together with a small quantity of edible seeds and fruit remains. Though the assemblage from Northton was smaller than the assemblage from Staosnaig, the composition of the Northton assemblage shows that the large-scale processing of samples can produce a sizable assemblage of plant remains even from Mesolithic sites with low-medium density plant deposits. Therefore taphonomic factors and poor recovery methods are responsible for the rarity of plant remains in most assemblages and the recovery of hazelnut shell from such a large number of Scottish Mesolithic sites suggests that plants were systematically exploited.

Secondly, the composition of the charcoal assemblages also provides evidence for the systematic selection and avoidance of particular plant species in Mesolithic Scotland (see chapter 3). Considering the abundance of Hazel and oak in the environment and in the charcoal assemblages, it is clear that the availability of these trees in the environment had a large effect on the species exploited for fuels. However, several species, which were abundant in the environment, such as birch, elm and Alder, appear to have been avoided for burning on domestic hearths, probably due to their relatively poor combustion qualities. This supports the idea that plant exploitation was systematic rather than random.

Thirdly, the existence of the high-density plant remain deposit at Staosnaig provides evidence for intensive plant use in Mesolithic Scotland and shows that hazelnuts and Lesser Celandine root tubers were collected and processed on a large-scale (see chapter 4). Though no Mesolithic hazelnut stores, accidentally charred *in situ* have so far been found in Scotland, it is highly likely that plant storage was undertaken because of the restricted period of hazelnut availability and the widespread recovery of hazelnuts on Mesolithic sites. Equally, the large, high-density deposit of hazelnuts at Staosnaig may well have been charred during drying or roasting for storage rather than for immediate consumption. Also, the most likely mechanism for the preservation of the moisture-rich Lesser Celandine root tubers/bulbils, Crab Apple and seaweed remains at Staosnaig and Northton was by charring during drying for storage (chapters 4 and 6). If these remains had been accidentally charred during cooking or were accidentally dropped in a fire, it is unlikely that they would have survived in an identifiable form. Thus, plants were exploited in a systematic and intensive manner in Mesolithic Scotland.

The question of whether wild plant management was undertaken in Mesolithic Scotland is less certain. As discussed in chapter 4, the seed assemblages are inadequate to identify wild plant management in the Mesolithic archaeobotanical record from Scotland. Considering the infrequency of natural fires in deciduous woodlands in North-West Europe, it seems probable that the palynological record provides evidence for human impact on the environment in Mesolithic Scotland through declines in major woodland taxa and increases in microcharcoal (see chapter 4). Yet, it is uncertain whether this activity reflects deliberate landscape manipulation, such as heathland and grassland burning to promote desirable plants or attract animals for hunting, or whether this is purely a reflection of the maintenance of natural clearings for settlements and the burning of domestic fires. Equally, there is little evidence to suggest that humans were responsible for the dominance of Hazel in the environment. In Britain, Hazel was probably not a fire-responsive species and its natural abundance in the environment suggests that woodland burning would have been unnecessary to promote hazelnut production. Thus, current evidence suggests that plant exploitation was systematic and intensive in the Scottish Mesolithic, but there is no clear evidence for wild plant management or husbandry.

8.2.2 Neolithic Scotland

Domestic plants were important resources in Neolithic Scotland. The consistent presence of cereal grains in most archaeobotanical assemblages (see chapter 5), together with abundant pollen evidence for cereal agriculture and woodland decline (Edwards and Whittington 2003; Tipping 1994), shows that cereal cultivation was widespread across Scotland throughout the Neolithic. However, the relative importance of wild and domestic plants in the economy varied both geographically and socially (see chapter 5).

8.2.2.1 The Northern Isles and the Outer Hebrides

Except in the first few centuries of the 4th millennium cal BC, when there is currently no evidence for 'Neolithic' practices in the Northern Isles and Outer Hebrides, cereal cultivation was the dominant subsistence strategy and wild plant exploitation was purely opportunistic and incidental (see chapters 5 and 7). Edible wild plant remains were extremely scarce in this area and many wild plant macrofossils were probably derived from the burning of peat and turf as a fuel rather than from wild plant collection (see chapter 7). In contrast to mainland Scotland, Hazel would have been comparably scarce, and possibly less productive than elsewhere due to the exposed environmental conditions. Consequently, a mixed wild-domestic plant subsistence economy may not have been a viable strategy. The discovery of a substantial charred grain store, together with several medium sized cereal deposits from the settlement at the Braes of Ha'Breck reinforces the idea that cereals were a key component of the economy and shows that cereals were stored on a large-scale (see chapter 7).

The domestic-orientation of the economy in the Northern and Western Isles is further emphasised by the existence of permanent stone and timber built settlements associated with evidence for manuring, field systems and ploughing. In addition to the abundant evidence for Neolithic soil amendment and ard ploughing on Orkney discussed in chapter 7, cultivation ridges have been identified beneath the main Callanish stone circle, on Lewis (Ashmore 1996:56) and extensive areas of Neolithic field walls and clearance cairns are associated with the settlement at Scord of Brouster, Shetland (Whittle et al 1986:45-58). Ard ploughing for cultivation was of a sufficient scale and duration to create lynchets at the Scord of Brouster (ibid) and the fields were amended with peat ash from domestic hearths (Romans 1986:131). This physical evidence for cultivation is difficult to date, but as mentioned in chapter 7, it is likely that some of the ard marks and field boundaries on Orkney date to the earliest Neolithic in the area. The cultivation ridges at Callanish are undated (Ashmore 1996:56) and the lynchets and amended soils at the Scord of Brouster date to the later Neolithic, but some of the field walls at the Scord of Brouster, originated during the earliest phase of settlement at the site (c. 3500 cal BC) (Whittle et al 1986:45-58). This evidence suggests that developed and stable agricultural systems existed in the Northern and Western Isles from the earliest Neolithic in this area. The identification of amended soils of probable later Neolithic date on both Orkney and Shetland shows that by the end of the Neolithic, farmers were implementing strategies to maximise the arable potential of their plots because manuring can dramatically increase crop yields (McConnell 1930:187-188; Reynolds 1981:110; Rowley-Conwy 1981:90-91). Therefore, settled communities focusing on the cultivation of domestic species were present in the Neolithic Northern and Western Isles.

8.2.2.2 North-East and Southern Scotland

The situation on mainland Scotland was considerably more variable. Most assemblages contained a combination of both wild and domestic plants in small quantities (see chapter

5). Considering the likely overrepresentation of wild species in archaeobotanical assemblages, it is difficult to be certain whether wild or domestic plants were more significant in the economies of many of these sites (see chapter 5). Though several assemblages in mainland Scotland contained only wild plant remains, most of these assemblages were derived from sites where a small number of features were sampled, or sites that could be attributed a ritual or specialised function (see chapter 5). These sites are therefore not representative of the general domestic economy. No notable concentrations of wild plant remains were recovered. Though several assemblages, such as Claish Farm, contained fairly large numbers of nutshell fragments, most of the nutshell was scattered throughout the contexts (Miller and Ramsay 2002), suggesting routine rather than intensive utilisation of hazelnuts.

There were also a number of sites where cereals dominated the assemblages. Most notably, the assemblage from Balbridie in Aberdeenshire, contained the remains of a substantial burnt cereal store, which suggests that for some groups, the cultivation of domestic plants was the predominant subsistence strategy (see chapter 5). In contrast to the Northern and Western Isles, physical evidence for cultivation on mainland Scotland is insubstantial. At Lairg in the Highlands, cultivated soils and ard marks have been identified beneath a Bronze Age cairn and house (McCullagh and Tipping 1998), and at North Mains, Strathallan, cultivation ridges amended with animal manure were discovered beneath a barrow and a flat cultivated soil was identified beneath the henge bank (Romans and Robertson 1983). There is also evidence for Neolithic cultivated soils beneath the henge bank at Broomend of Crichie, Aberdeenshire (Sheridan and Bradley 2007) and underneath the Bronze Age round cairns at Biggar Common, South Lanarkshire (Johnston 1997). Considering that traces of cultivation only survive beneath later undisturbed archaeological activity, it is likely that modern cultivation and development has removed most of the physical evidence for Neolithic cultivation in mainland Scotland.

Overall, the consistent presence of both hazelnuts and cereals on most sites suggests that a mixed plant subsistence economy based on both wild plant collection and cereal cultivation was the predominant pattern in many areas of mainland Scotland. Wild plant collection was probably systematic and intensive at some sites, but may only have been opportunistic and incidental at other sites. In this context, it should be noted that ethnographic evidence suggests that very few societies depend on farming for between 5-50% of their subsistence and so it is more likely that these economies would have been primarily based on agriculture or hunter-gathering rather than a complete mix of these two strategies (Rowley-Conwy and Layton 2011:853-4).

8.2.2.3 West coast mainland and Inner Hebrides

There is currently an absence of cereal grains from Neolithic sites in this region (see chapter 5). The only published Neolithic sites sampled for archaeobotanical remains in the area were Carding Mill Bay, a shell midden near Oban (see chapter 5), the pits and fence lines at Newton, Islay (McCullagh 1989a) and the cursus, pit alignment and pits at Upper Largie (Cook et al 2010). Only hazelnut shell and wild seeds were recovered from Carding Mill Bay (see chapter 5) and charcoal from Newton (McCullagh 1989a) and Upper Largie (Cook et al 2010). Charcoal and/or hazelnut shells have also been recovered from a number of other unsampled Neolithic sites in the area, including the settlements at Ardnadam (Rennie 1984) and Auchategan (Marshall 1978), Argyll and the chambered cairns at Monamore, Arran (Mackie 1964), Glenvoidean, Bute (Marshall and Taylor 1977), Crarae, Argyll (Scott 1961) and at Port Charlotte, Islay (Harrington and Pierpoint 1980). Considering this, the absence of archaeobotanical evidence for domestic plants may merely be a consequence of the small number of sampled sites and the difficulty of discovering settlements in environments dominated by moorland and where only occasional development occurs. There are several sites in the region where possible Neolithic cereal pollen has been recovered from c. 4000 cal BC (Bonsall et al 1999; Macklin et al 2000) and there is also physical evidence suggestive of arable cultivation. Fence lines have been found at Newton, Islay and on Arran, cultivated soils and ardmarks have been found associated with a linear field boundary at Brodick (Noble 2006:37-8) and at Machrie North and Kilpatrick stone field systems are present (Barber 1997:144-5).

However, it should be noted that wild grass and cereal pollen are difficult to distinguish (Behre 2007; Edwards 1998:73; Hirons and Edwards 1984:76; Tipping 1994:19) and 'cereal pollen' dated prior to the 5th millennium cal BC has been identified in all of the cores supposedly containing early Neolithic cereal pollen (Macklin et al 2000:113). The increase in cereal pollen in the early Neolithic is also associated with a dry phase, which in earlier periods has been suggested to be conducive to the spread of wild grasses around lakes near sampling sites (ibid). Therefore, without the identification of macroscopic remains of cereals in the region, this evidence remains uncertain. Also, though the fence lines at Newton date to the early Neolithic, their function is unclear and they may not relate to arable cultivation (McCullagh 1989a). Moreover, none of the field evidence for agriculture from Arran has been precisely dated and no radiocarbon dates are available from the field systems. At Kilpatrick the field banks predate peat formation at the site so it has been suggested that the field system is probably late Neolithic or Bronze Age in date (ibid:144). The field system at Machrie North was sunk into the same soil as a

Neolithic structure, which underlies a hill wash deposit cut by a pit filled with later Neolithic and Beaker pottery and charcoal radiocarbon dated to c. 2500-2170 cal BC (ibid:129). At Brodick, the boundary feature, which delimitated cultivated soils and ardmarks, contained early Neolithic pottery (Noble 2006:37-8), but as this site is unpublished, it is not known if the cultivation evidence relates directly to the date of the boundary feature. Consequently, all of this physical evidence for cultivation on Arran may date to the later Neolithic. The existence of early Neolithic pottery associated with early Neolithic radiocarbon dates at several sites in the area, for instance at Ardnadam (Rennie 1984) and Newton (McCullagh 1989a), indicates that culturally the 'Neolithic' had initiated in the region, but this does not necessarily imply that cultivation was an important component of the economy, since pottery may have been obtained by trade with farmers from other areas. The situation in this area is analogous to Norway, where palynological and archaeological evidence suggests that agriculture may have been practiced on a small-scale in the early Neolithic as part of the predominant hunter-gatherer economy, but did not become well established until the mid-late Neolithic (Hjelle et al 2006; Prescott 1996). Therefore, current evidence suggests that cereal cultivation may have been undertaken in some areas of Western Scotland in the early Neolithic, but was probably not a widespread part of the economic strategy in this region until at least the later Neolithic or Bronze Age. It is difficult to assess the scale of wild plant exploitation on the basis of the available archaeobotanical evidence.

8.2.2.4 Neolithic wild plant management?

The question of whether wild plants were managed in Neolithic Scotland is even more difficult to assess than for Mesolithic Scotland. Again wild seeds are relatively rare in Neolithic assemblages, and since many seeds may have originated as arable weeds or from peat/turf burning (see chapter 7), it is not possible to use archaeobotanical assemblages to look for evidence of wild plant cultivation. In the palynological record, there are examples of relatively small-scale, short lived woodland declines not associated with cereal pollen in Neolithic Scotland, which have been suggested to represent 'hunter-gatherer' impacts rather than early agricultural clearances (Edwards and Ralston 1984:26-30; Tipping 1994:20). At the same time, it has been suggested that the general fall in microcharcoal in some palynological sequences during the Mesolithic-Neolithic transition could represent an end to vegetation management after agriculture was adopted (Edwards 1988:262, 1998:74; Tipping 1997b:156). Yet, arguably it is not possible to distinguish hunter-gatherer and farmer impacts in the palynological record. The dating of most pollen sequences in Scotland is usually insufficiently tight to identify 'short-lived' clearances. Also, if agriculture was undertaken on a relatively small-scale (Barclay 2003a:148; Bogaard 2004, 2005; Guttmann 2005; Jones 2005), large woodland clearances would not have been necessary for agriculture and small-scale woodland declines could just as easily represent agricultural clearances as hunter-gatherer land management. Equally, the absence of cereal pollen is not a reliable indicator of the absence of agriculture because cereal pollen is only produced in very low quantities and does not travel far beyond the point of production (Behre 1981:227-8; Caseldine and Whittington 1975-6:38-9; Lowe and Walker 1997:169; Tipping 1994:19). Therefore, as with the Scottish Mesolithic, arguably it is currently not possible to identify wild plant management in Neolithic Scotland.

8.3 Continuity and change during the Mesolithic-Neolithic transition

The differing levels of investment in arable agriculture in different parts of Scotland in the Neolithic may be a reflection of the differing density of settlement in different areas in the Mesolithic (Armit and Finlayson 1992:672; Sharples 1992:326; Telford 2002:289), the extent of the indigenous adoption of agriculture, and the natural availability of wild resources in the environment.

8.3.1 The Northern Isles and Outer Hebrides

In Orkney, Shetland and the Outer Hebrides, where there is at present limited evidence for Mesolithic settlement (chapter 6; Cantley 2005; Gregory et al 2005; Lee and Woodward 2009a, b), it is possible that only small Mesolithic populations existed. Consequently, it is likely that a greater initial investment in an agricultural economy was necessary than elsewhere to make settlement viable for a larger population, especially considering the relative scarcity of wild plants, such as Hazel and Crab Apple, available for exploitation in these areas. The earliest radiocarbon dates for Neolithic agriculture in this region are also several hundred years later than in mainland Scotland (chapters 5 and 7) and there is evidence for the use of shell middens during early 4th millennium cal BC at West Voe, Shetland (Melton 2009). On the basis of current evidence, it appears that the initiation of agriculture may have been later than in other areas and the absence of evidence for continuity between Mesolithic and Neolithic settlements and subsistence suggests that incoming farmers may have been responsible for the transition to agriculture in this area.

Having said this, it is possible that changes in relative sea level since the early Holocene have destroyed evidence for early Neolithic settlement in the region (see chapter

7). Indeed, though there are problems in distinguishing cereal pollen from wild grass pollen, particularly in coastal areas where coastal grasses produce large pollen grains (Behre 2007; Edwards 1998:73; Hirons and Edwards 1984:76; Tipping 1994:19), it is important to note that cereal pollen which may date prior to c. 3600 cal BC has been identified in Orkney (e.g. Bunting 1996; de la Vega-Leinert et al 2000). Also, the discovery of radiocarbon dates in the late 4th millennium from the later shell midden at West Voe, Shetland (Melton 2009), suggests that marine resource utilisation was maintained to some extent in the Neolithic, despite the agricultural focus of the economy.

8.3.2 West coast mainland and Inner Hebrides

In contrast, there is abundant evidence for Mesolithic occupation and the exploitation of both marine resources and wild plants in the West coast of mainland Scotland and the Inner Hebrides (e.g. Affleck et al 1988; Mellars 1978; Mercer 1970-1, 1971-2, 1972-4, 1978-80; Mithen 2000; Mithen et al 2001; Searight 1990; Wickham-Jones et al 1990, 2004). This, together with the absence of Neolithic cereal remains and the continued use of Mesolithic shell middens into the Neolithic (Armit and Finlayson 1992:516-7, 1996; Mithen et al 2007; Sharples 1992:327; Telford 2002:300), may suggest a degree of continuity between the Mesolithic and Neolithic communities in this area (cf. Hjelle et al 2006; Prescott 1996) or perhaps that similar economic strategies were maintained by incoming groups to some extent (Bonsall et al 1999:3-4). Indeed, the abundance of ready available marine resources may have played a role in the extent of the uptake of agriculture by some indigenous peoples in this region (cf. Zvelebil and Rowley-Conwy 1986).

However, though not precisely dated, the evidence for field systems and ard marks on Arran (see section 8.2.2.3) could date to the early Neolithic and evidence for cereal pollen from the Oban area occurs from c. 4000 cal BC (Bonsall et al 1999; Macklin et al 2000). This may suggest that agriculture had initiated in some areas in the early Neolithic. Isotopic evidence from human bones also supports this evidence, showing that the Neolithic diet in this area was primarily based on terrestrial animals and C_3 plants rather than marine foods (Schulting and Richards 2002). Having said this, arguably the sample size analysed so far has been insufficient to make inferences about the whole population (Milner et al 2003) and it is not possible to distinguish wild and domestic plant exploitation using isotopic evidence. It should also be emphasised that, few Mesolithic human bones have been analysed and terrestrial plant and animal diets may also have been the dominant pattern for many individuals on the West coast mainland. If this is the case, then the Neolithic isotopic values would indicate continuity. Furthermore, due to the highly marine isotopic signature from these Mesolithic bones and the current uncertainties of the marine reservoir correction that should be applied to dates of this period, the calibrated dates have fluctuated across the Mesolithic-Neolithic transition in different publications (Milner and Craig 2009; Richards and Sheridan 2000; Schulting and Richards 2002). Consequently it is possible that several of the radiocarbon dates are contemporary with dates from the earliest Neolithic period (Schulting and Richards 2002). It should also be noted that the majority of the analysed Neolithic bones from West coast sites date to the period c. 3700-3400 cal BC (ibid) and so early 4th millennium is only represented by a very small number of analyses. Consequently, the current evidence is difficult to interpret, but it appears that there may have been two contemporary strategies in this area during the early Neolithic: predominantly indigenous groups maintaining a hunter-gatherer economy, apparently to a greater degree than elsewhere in Scotland, perhaps together with a small number of incoming or indigenous groups adopting agriculture from the earliest Neolithic. The sampling for archaeobotanical remains from any future excavations in this area is essential for understanding the nature of the Mesolithic-Neolithic transition in this region.

8.3.3 North East and Southern Scotland

In North East and Southern Scotland, abundant wild resources were available for exploitation and there is consistent evidence for Mesolithic settlement (e.g. Alexander et al 1997; Atkinson 2002; Boyd and Kenworthy 1991-2; Coles 1971; Johnston 1997; Macgregor et al 2001; Mackenzie et al 2002; Wickham-Jones and Dalland 1998a, b; Wordsworth et al 1985). Considering the variability of Neolithic settlement and archaeobotanical evidence in Southern and North East Scotland (see chapter 5), it seems probable that there was a mixture of indigenous adoption of agricultural practices into successful Mesolithic economic systems (Armit & Finlayson 1992:671), together with the movement of some established agricultural communities from elsewhere into the area (cf. Sheridan 2004; 2007). For instance, the similarities between the structural forms, artefactual evidence and archaeobotanical remains from the early Neolithic timber ‘halls’ (Ashmore 1996:32-3; Fairweather and Ralston 1993; Sheridan 2004:12, 2007) may suggest that these sites were established by incoming farming groups. It is also possible that some groups maintained an essentially hunter-gatherer existence and only obtained cereals by trade with neighbouring farmers, though the extent to which this is the case is difficult to assess because of the rarity of cereal chaff in Neolithic assemblages in Scotland (see chapters 5 and 7).

8.4 Conclusions

Therefore, wild plant exploitation was most probably systematic and intensive in the Mesolithic, but there is no clear-cut evidence to substantiate the suggestion that Mesolithic hunter-gatherers managed wild plants. In contrast, it has been suggested that Neolithic wild plant use varied in significance across Scotland, with wild plants apparently systematically exploited on the mainland, but only of sporadic importance in the Northern and Western Isles. The widespread presence of cereals in assemblages from across Scotland shows that cereals were an important component of the economy, but it is probable that the relative importance of wild and domestic plants varied considerably between different sites in mainland Scotland. In the Northern Isles and Outer Hebrides, the overwhelming dominance of cereals in the assemblages and the widespread evidence for manuring, field systems and ard marks attests to the central importance of cereal agriculture in the economy. The variability in the uptake of arable agriculture may be a reflection of the differing density of Mesolithic settlement and the natural availability of wild resources in the environment in different areas.

Chapter 9: Future research and conclusions

9.1 Chapter outline

This chapter will assess the future potential of the Scottish Mesolithic and Neolithic archaeobotanical resource and suggestions will be made for future research. The final section will conclude this thesis.

9.2 Future research

9.2.1 The collation and synthesis of archaeobotanical evidence

The collation of the archaeobotanical data for the reviews in chapters 2-5 has considerably enhanced understanding of plant use during the Mesolithic and Neolithic, but has highlighted the difficulty of accessing relevant specialist reports from Scotland. Whilst most published site reports included at least some information derived from specialist archaeobotanical reports, many did not include specialist reports or the tables of results in the final publications. This made it difficult or impossible to use the information from these sites without consulting the relevant archaeobotanist or archaeological unit that produced the report. Although all the individuals consulted were extremely helpful in providing unpublished material, in some cases, it proved difficult to access the relevant information, especially where the original archaeobotanists or excavators had retired. In the early stages of this research, an attempt was made to search the site archives of the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) in Edinburgh for relevant reports, but it was quickly discovered that the specialist reports were rarely kept with the site archives. The establishment of a central archive of specialist reports should be a future research priority. In particular, a comprehensive online database of environmental assessment reports and full archive plant macrofossil reports would be an extremely useful resource for future syntheses of environmental material of all periods.

The process of synthesising the archaeobotanical data from multiple sites has also revealed the lack of standardisation in the methodologies used by different authors and that many authors did not include a detailed description of the methodologies employed. In particular, sampling and quantification methods were frequently not noted and many publications did not include the volumes of the processed samples or contextual information that related to particular samples. This means that the results from different assemblages may not be directly comparable and that detailed analyses of site formation processes and the intensity of plant use at particular sites cannot be assessed. The development of standardised quantification methods between different authors and the full publication of archaeobotanical methodologies would aid future reviews of archaeobotanical material.

9.2.2 Mesolithic plant use in Scotland

There is considerable potential to develop understanding of Mesolithic plant exploitation in Scotland. Large Mesolithic plant macrofossil assemblages are extremely scarce in Scotland due to the lack of systematic sampling and flotation of Mesolithic deposits and the small sample sizes usually analysed. The consistent presence of plant remains on most sites, even where no sampling or minimal sampling has been undertaken, suggests that plant remains may be more common on Mesolithic sites in Scotland than has previously been supposed (see chapter 2). Moreover, the large-scale processing of bulk samples from Northton has shown that a considerable amount of information is missing from Mesolithic sites when little or no sampling is undertaken (see chapter 6). Since plant remains are typically only present in low densities on Mesolithic sites due to the more temporary nature of occupation than in later periods, it is essential that future excavations of Mesolithic sites, where possible, float more than the average (c. 20l) sample size used for later period sites. A potential problem with this suggestion is that sites or features are often only identified as Mesolithic after the material has been sampled and dated (Dunbar 2008:47; Johnson and Cameron Forthcoming:25; Suddaby 2007:68). This is particularly problematic for multi-period developer-funded excavations where there may not be further opportunity to take additional samples or identify additional Mesolithic features through radiocarbon dating. However, in research-driven excavations, there is usually opportunity to return to identified Mesolithic sites and take larger samples of material. Therefore, of key importance for understanding the nature of Mesolithic subsistence is the routine sampling, analysis and publishing of large archaeobotanical samples from Scottish Mesolithic sites, within an explicit research framework.

Further study is also required to identify wild plant management in the Mesolithic using palaeobotanical evidence (see chapter 4). In North America, the cultivation of ‘wild’ Goosefoot seeds has been identified by examining the changes in the thickness of the seed coats through time (Smith 1995b:187, 2006:12225, 2011:839). However, as just discussed, no large seed assemblages exist in Mesolithic Scotland and such an approach would only be possible if multiple large seed assemblages were available for analysis; further data collection is necessary before such techniques can be attempted. Future studies of charcoal assemblages from Mesolithic sites also provide the potential to identify woodland management, if the selection of particular sizes/ages of branches or periodic harvesting can be recognised (cf. Church et al 2007a). Similarly, as discussed in detail in chapter 4, wild plant management is extremely difficult to identify using palynological evidence. A possible way forward, is the use of fine resolution pollen analysis in closely spaced cores, since the frequency and duration of microcharcoal peaks in tightly constrained sequences can help to rule out natural and domestic fires (Simmons and Innes 1996). The identification of woodland management techniques, such as coppicing could also be progressed through studies of modern pollen rain from managed forests (Edwards 1998:74).

Future research should also aim to develop understanding of the types of roots and tubers consumed on Mesolithic sites in Scotland, as these may have formed a key component of the Mesolithic diet (see chapter 2). The processing of the samples from Northton has confirmed that useful taxonomic and taphonomic information can be gained using conventional archaeobotanical methods to identify edible tubers/roots into basic categories (see chapter 6). However, the full identification of suitable parenchyma fragments using an SEM, should also be a research priority for Northton and any future analysis of Mesolithic plant assemblages in Scotland. In addition, as noted by Hather (2000), to ensure that more complete parenchyma remains are recovered from Mesolithic assemblages, it is imperative that sub-samples for manual flotation are taken, if large volumes of soil are to be processed using a flotation tank (see also chapter 6).

Furthermore, the analysis of the hazelnut nutshell from Northton has shown that the detailed quantification and recording of nutshell is extremely important for understanding the nature of the onsite taphonomy and for comparison between different assemblages (see chapter 6 and appendix 2). The re-examination of existing nutshell assemblages using these techniques, as well as future assemblages, would help to assess the extent to which large-scale nut processing was taking place in Mesolithic Scotland. The interpretation of archaeological hazelnut shell would also benefit from further detailed preservation, fragmentation and quantification experiments. In particular, additional quantification experiments would be useful to establish the most accurate and time-efficient quantification methods and the appropriate correction factors needed to calculate the original numbers of nuts present in an assemblage. Experimental investigation of hazelnut fragmentation and preservation in reducing conditions in the laboratory would also be useful, as would the detailed quantification and recording of the fragment size and preservation of nutshell charred in roasting pits and experimental hearths.

9.2.3 Neolithic plant use in Scotland

There are also a number of key aspects of Neolithic plant use in Scotland that would benefit from further research. For instance, the problem of identifying the relative importance of wild and domestic plants in Neolithic archaeobotanical assemblages has been recognised by a number of authors (Jones 2000b; Jones and Rowley-Conwy 2007; Rowley-Conwy 2004). However, little experimental work has been undertaken to study the likely difference in percentage preservation of cereals and hazelnut shell charred in comparable conditions (Kingwell-Banham 2008). Future experimental study would help to address this problem. Added to this is the non-standardised methods used to quantify hazelnut shell between different archaeobotanists (see appendix 2). Frequently, the quantification methods used are not stated in archaeobotanical reports and so it is difficult to know to what extent this is an issue. The agreement of standardised methods for hazelnut quantification by archaeobotanists and the full description of the methods used would greatly enhance the comparability of different reports and enable reliable synthesis of future results.

Furthermore, the review in chapter 5 identified that the cultivation of wheat was primarily restricted to the early Neolithic, suggesting that there was a chronological change in the use of arable crops between the early and late Neolithic. However, this analysis used very broad dating categories and finer resolution is potentially possible. Also, the cereals from many sites have not been directly dated and it is possible that the 'old wood effect' may have caused some archaeobotanical assemblages to appear slightly earlier than their true age (Brown 2007:1050). Similarly, though there are over 100 radiocarbon dates from Scotland in the period c. 4250-3750 cal BC (Ashmore 2004a, b), Ashmore (2004a) considers most of these early 'Neolithic' dates to be unreliable or anomalous and suggests that the earliest adoption of agriculture in Scotland was during the period 3800-3700 cal BC. The precise compilation and analysis of all radiocarbon-dated cereals across Scotland and the radiocarbon dating of undated cereals would be invaluable for further investigating the chronological change in the use of different crop species. This would also enable the geographical and chronological origins and spread of agriculture across Scotland to be studied (cf. Brown 2007), and could potentially be used to identify differences in the speed of the uptake of farming and the degree of continuity during the Mesolithic-Neolithic transition between different areas of Scotland. Comparison with archaeobotanical evidence from neighbouring countries would also increase understanding of the origins of arable farming in Scotland.

Further study is also required to fully understand the scale and nature of cultivation in Neolithic Scotland. In central Europe, Neolithic crop husbandry practices have been identified through the analysis of the ecology of archaeobotanical weed seed assemblages (Bogaard 2004). However, compared to mainland Europe, weed seeds are relatively rare in archaeobotanical assemblages from Scotland (chapter 5). Though some large Neolithic seed assemblages exist in Atlantic Scotland, it is likely that most of the seeds in these assemblages derive from the burning of turf/peat as a fuel, rather than the accidental charring of weed seeds growing with the arable crop (see chapter 7; Church et al 2007b; Dickson 1998). A possible way forward would be the development of detailed models for identifying seed assemblages contaminated with turf/peat remains using discriminate analyses (cf. Jones 1987), through the analysis of the archaeobotanical content of experimentally charred turf/peat samples. Similarly, the understanding of Neolithic land use could also be enhanced through the high spatial resolution analysis of pollen from on-site samples in relation to off-site pollen sites located in close proximity to known Neolithic settlements (cf. Tipping et al 2009). More detailed dating of the Neolithic field systems on Arran and Shetland (see chapter 8) would also help to establish whether such features originated in the early Neolithic or whether this was a later Neolithic development. Considering the absence of archaeobotanical evidence for cereal grains in the Inner Hebrides in the Neolithic, the dating of the field systems on Arran should be a future research priority.

In addition, the analysis of the isotopic content of Neolithic cereal grains has the potential to identify whether manuring was practiced at particular sites. The isotopic analysis of experimental cereals has indicated that ∂^{15}N values increase in grain grown on amended soils (Bogaard et al 2007; Bol et al 2005; Fraser et al 2011; Kanstrup et al 2011) and recent studies have shown that elevated ∂^{15}N values in grains survive the carbonisation process and can be detected in archaeobotanical remains (Bogaard et al 2007; Kanstrup et al 2012; Lightfoot and Stevens 2011). The use of archaeobotanical remains to identify past manuring will be particularly important in areas, such as mainland Scotland, where *in situ* amended soils are likely to have been destroyed by later agriculture. However, the most promising way forward would be to analyse charred cereals from areas where soil amendment has already been demonstrated using soil micromorphological evidence, such as on Orkney, to establish a base line for ∂^{15}N values indicative of manured cereals in Neolithic Scotland. Also, since grain ∂^{15}N values are higher than straw values for cereals grown on manured soils (Kanstrup et al 2011), the comparison of ∂^{15}N values from Neolithic cattle and sheep/goat bones to cereal grains could also be used to suggest whether grain consumption was restricted to humans or whether humans and animals were consuming different plant components (Lightfoot and Stevens 2011).

The review in chapter 5 also revealed that cereal chaff was extremely rare in Neolithic assemblages in Scotland. Consequently different crop processing stages can be extremely difficult to identify and it is not possible to distinguish cereal producer and consumer sites (see chapter 7). It is also unclear how much processing was undertaken before cereals were stored and whether crops were stored within normal houses or elsewhere (see chapter 7). The results of the analysis of the probable burnt grain store from the Braes of Ha'Breck, Wyre (see chapter 7) could potentially be used to address this issue. If the assemblage represents a cereal store burnt *in situ*, perhaps in the roof of the structure (Jones and Rowley-Conwy 2007:401), it is likely that the assemblage will be better preserved than the other deposits on the site (see chapter 7) and if present, cereal chaff and seeds should be preserved (Church 2002c). Therefore, the future analysis of this deposit will be extremely important for understanding the site formation processes of the assemblage and, if the assemblage represents a burnt store, the processing stage at which the assemblage was stored. Additionally, if the assemblage is a burnt store, the seed component of the samples is likely to include a higher proportion of arable weed seeds than other contexts deriving from mixed hearth deposits where turf/peat may have been burnt as a fuel. The assemblage could therefore provide a key for understanding crop processing and storage in Neolithic Orkney.

The review of Neolithic assemblages in Scotland (chapter 5) has also shown that many assemblages contain a mixture of hulled and naked barley and that there are several assemblages where hulled barley was the main crop cultivated. It is questionable why some Neolithic farmers chose hulled rather than naked barley, because, unlike naked barley, hulled barley must be pounded to remove the husks from the grain (Hillman 1981b:136), which would have increased processing time. One possible reason for the use of hulled barley rather than naked barley is that the adherence of the husks to the grains may prolong seed storage, particularly in damp climates (Bond 2007b:157) and experimental evidence suggests that naked barley stores less well than hulled barley (Briggs 1978:394). However, it is possible that the results of this experiment simply reflect the fact that naked barley has a lower emergence rate than hulled barley (Choo et al 2001; Dickin et al 2012). Further experimentation is required to resolve this issue. This could be achieved through comparison of the relative emergence rates of hulled and naked barley grain that has been stored in conditions that cover a range of different moisture contents.

Similarly, the detailed review of Neolithic wood charcoal assemblages in Scotland would also enhance understanding of continuity and change in human fuel procurement strategies during the Mesolithic-Neolithic transition (cf. Out 2010). The analysis of the wood charcoal assemblages in Northern and Western Isles could also add significantly to the understanding of changing fuel procurement strategies in the region. Combined with the detailed analysis of the seed data from archaeobotanical assemblages providing evidence for the burning of turf/peat, wood charcoal and pollen data could be used to provide an integrated understanding of human impact on the woodlands in the area and changing fuel resource use, during a period of general woodland decline (Farrell et al 2013). Added to this, the detailed analysis of the wood charcoal from the Braes of Ha'Breck assemblage could be used to identify whether woodland management was taking place (cf. Church et al 2007a). Orkney is a key area to look for these patterns because of the identification of a shift in the major material used for construction during the Neolithic from wood to stone (Farrell et al 2013). In this respect, the wood charcoal assemblage from the Braes of Ha'Breck is particularly important because a shift from wood to stone has been identified during the occupation of this single site (ibid).

9.3 Conclusions

In conclusion, the review and analysis of the archaeobotanical remains studied in this thesis have added significantly to the understanding of people-plant interaction during the Mesolithic and Neolithic in Scotland. This study has shown that evidence for plant use was more widespread on Scottish Mesolithic sites and consequently more important in Mesolithic subsistence than has previously been recognised. The most frequently recovered edible species was hazelnut shell, which was recovered from most Mesolithic sites, suggesting that hazelnuts were systematically exploited for food. The identification of substantial quantities of well-preserved edible Lesser Celandine tubers at two of the only well sampled sites, suggests that this species was probably also an important aspect of the plant economy. A variety of edible fruits, such as Crab Apples and Hawthorn, and edible seeds, such as vetches/tares and Fat-hen have also been recovered from several sites, but there were no significant concentrations of these foodstuffs. Though only a narrow range and frequency of taxa were recovered in most Mesolithic assemblages, ethnographic evidence suggests that a greater variety of species would most probably have been exploited. It is likely that poor sampling strategies are partially responsible for the restricted range and frequency of edible taxa in most assemblages.

The large-scale processing of bulk samples from Northton has shown that a sizable assemblage of plant macrofossils can be produced even in medium-low density deposits. The assemblage was dominated by woodland and grassland species, in particular hazelnuts and Lesser Celandine root tubers/bulbils, which would have been abundant around the site. A variety of edible seeds were also present, including a notable quantity of vetch/pea seeds, but due to the low frequency of most of the identified seed taxa, it is difficult to rule out natural deposition on site. Using experimental data, it was estimated that the assemblage from Northton contained the remains of approximately 570-585 whole hazelnuts. However, considering the moderate density of the nutshell in the deposit (21.4 fragments per litre) and that the horizon may represent a palimpsest of activity, it is probable that the assemblage represents the routine consumption of hazelnuts, rather than the remains of a large-scale drying or roasting accident. The analysis of the assemblage from Northton has also shown that archaeobotanical analyses can provide important information for interpreting cooking practices and site formation processes on Mesolithic sites. The abundance of well-preserved culm material within the samples suggests that turf/peat or grassy vegetation was being used as part of a specific cooking or food preservation process, such as roasting/steaming over fire-cracked rocks. For instance, the abundance of fire-cracked rocks and the mixed preservation of the Lesser Celandine root tubers/bulbils may suggest that the root tubers/bulbils were accidentally charred during roasting/steaming using hot rocks and grassy vegetation.

The discovery of the high-density deposit of hazelnut shells and Lesser Celandine root-tubers at Staosnaig, Inner Hebrides shows that plants were sometimes processed on a large-scale in the Mesolithic. Though no burnt hazelnut stores have been identified and hazelnuts were only present in low-moderate frequencies in most assemblages, the presence of hazelnuts on most sites suggests that plants were routinely and systematically exploited and stored for food because hazelnuts were only available for a limited period in the autumn. Also, the most likely mechanism for the preservation of the moisture-rich Lesser Celandine and Crab Apple remains at Staosnaig and Northton was by charring during drying for storage because these taxa would not survive well if charred in a fresh state.

The comparison of the content of the charcoal assemblages to palynological evidence for Mesolithic woodland composition provides further evidence for systematic selection of wild plants in the Mesolithic. Though the main species collected for fuels on Mesolithic sites - oak and Hazel - were two of the main species available in the environment, several taxa, which would have been abundantly available, such as birch, elm and Alder, appear to have been deliberately avoided for burning. Therefore, it appears that species availability had a strong influence on the choice of fuels exploited, but that species with poor combustion qualities were deliberately avoided in favour of species with good burning properties.

It is currently not possible to assess whether Mesolithic or Neolithic people undertook wild plant management in Scotland using archaeobotanical assemblages due to an absence of large seed assemblages derived from wild plant collection. Whilst plant management has been suggested using palynological evidence for both periods, it is uncertain whether the indicators of human impact identified reflect deliberate vegetation management, the maintenance of natural clearings for settlement or vegetation clearance for cultivation.

The most common plant subsistence strategy in Neolithic Scotland was the cultivation of naked barley, supplemented by the collection of hazelnuts and on some sites, wild fruits, such as Crab Apple, Wild Strawberries, Crowberry, Hawthorn, Blackthorn, Blackberry, Bilberry, Bearberry and Cowberry. However, plant exploitation was geographically, socially and chronologically diverse. Though naked barley was the main barley crop, many plant assemblages contained a mixture of hulled and naked barley, and hulled barley was the most significant cereal in a number of specific assemblages. Emmer Wheat was important on many early Neolithic sites in Southern and North-East Scotland but was only a crop contaminant by the late Neolithic. The wetter climate in the later Neolithic was probably responsible for the decline in the use of wheat, because wheat is less tolerant of wet conditions than barley. Wheat was probably never a significant crop in the Northern and Western Isles because of the more marginal environment in this area.

The relative importance of wild and domestic plants in the economy is difficult to establish due to differences in the deposition, preservation, recovery and recording of cereals and wild plants. However, the importance of agriculture in the economy appears to have varied considerably between different sites and areas. In the Northern and Western Isles, settled agricultural communities were present and wild plant collection was an insignificant component of the economy. In contrast, a mixed plant subsistence economy based on both wild plant collection and cereal cultivation was probably the predominant subsistence strategy in mainland Scotland, though it appears that some apparently contemporary groups cultivated cereals on a large-scale, and others primarily focused on the collection of wild plants. The absence of cereals in Neolithic assemblages from the Inner Hebrides and the West coast mainland suggests a greater degree of continuity in Mesolithic and Neolithic subsistence strategies in this area than elsewhere in Neolithic

Scotland. However, it is also possible that the small number of sampled sites is responsible for this pattern. Differences in the importance of arable agriculture in each region may reflect the density of settlement in the Mesolithic and the natural availability of wild resources in the environment in each area.

The detailed study of the Neolithic plant remains and cultivation evidence from Orkney has provided important insights into Neolithic agricultural practices and fuel procurement strategies. Cereals appear to have been grown in fields fertilised with midden material and tilled using hoes and ards and the presence of culm bases in some assemblages implies that crops were sometimes harvested by uprooting. The extreme overall rarity of cereal chaff in the assemblages appears to suggest that the main stages of crop processing were conducted in the fields immediately after cultivation and that most of the charred grain was probably preserved on a small-scale during the drying of the grain to enable easy grinding or during roasting prior to immediate consumption. The presence of several medium-high density deposits at the Braes of Ha'Breck suggests that some of the grain at this site was also occasionally preserved accidentally during drying to prepare the grain for storage or perhaps during small-scale storage. Though naked barely was dominant in most assemblages, several assemblages contained a mix of naked and hulled barley. Since naked barley has a lower emergence rate than hulled barley, it is possible that the naked barley monoculture was maintained by weeding out the hulled barley in the crop after each harvest. In contrast to mainland Scotland, many of the assemblages from Orkney contained a much greater number of wild seeds. Though many of the seeds may derive from crop processing, consideration of the ecology of the identified taxa suggests that turf/peat burning was probably a significant source of seeds in Orcadian assemblages.

Overall, the available archaeobotanical evidence suggests that plant exploitation was systematic and intensive in Mesolithic Scotland. In contrast, the importance of wild plants in the Neolithic economy appears to have varied between regions, with most areas of mainland Scotland utilising wild plants on a systematic basis, but with wild plants only occasionally used in the Northern Isles. There is currently insufficient evidence to identify wild plant management in either the Mesolithic or Neolithic. Though the relative importance of wild and domestic plants was variable between different sites in the Neolithic, cereal cultivation was widespread across Scotland and formed a significant component of the economy at most sites. Therefore, the absence of evidence for wild plant management in the Mesolithic, the presence of cereal grains in most Neolithic assemblages and the abundant evidence for ard marks, manuring and field systems in environments conducive to their preservation, suggests that plant exploitation was more intensive in most areas of Scotland in the Neolithic than the Mesolithic, despite the continued use of wild plants on most sites.

Plant gatherers, plant managers or agriculturalists? The importance of wild and domestic plants in Mesolithic and Neolithic Scotland

VOLUME 2 OF 2

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Table of Contents for Volume 2

Appendix 1: List of ethnobotanical sources consulted.

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Appendix 2: Hazelnut quantification and preservation recording methodology

A2.1 Appendix outline

This section describes in detail the method that was utilised in chapters 6 and 7 to quantify and record the level of preservation of the hazelnut shell in the archaeobotanical assemblages from Northton and the Braes of Ha'Breck. Past methods of hazelnut shell quantification in archaeobotanical assemblages are also reviewed, in order to provide a rationale for the use of this method.

A2.2 Research aims

The overall aim of this method was to provide a more complete understanding of the taphonomy of the hazelnut shell in the assemblages examined in this thesis by accurately quantifying the nutshell and recording the state of preservation. The detailed research aims are to:

- provide an estimate of the number of hazelnuts represented by the fragmented nutshell;
- assess how the excavation and sample processing methods have affected the fragmentation of the assemblage;
- assess whether the preservation and level of fragmentation of the nutshell can reveal anything about the taphonomic history of the nutshell prior to excavation.

A2.3 Hazelnut quantification

A2.3.1 Introduction

There is currently no nationally or internationally agreed hazelnut shell recording methodology, and as a result, researchers have used extremely different methods to quantify hazelnut shell. For instance, Cressey (2004) counted and weighed the total number of fragments >4mm, whereas Carruthers (2000) measured the total mass of fragments >2mm. Other methods of hazelnut shell quantification include: counting the total number of nutshell bases (Tolar et al 2011:210), counting the number of fragments if more than 50% of a nut is present (Church 2002a), or counting the number of fragments in different size categories (<16mm^2, 16-60 mm^2, >60 mm^2) based on the surface area of the nutshell (Berihuete Azorín and Antonin 2012). In Scotland, the nutshell from several assemblages has been counted or weighed, but very few Mesolithic or Neolithic site reports provide precise details of exactly what has been included in these counts/weights and hazelnut fragments are frequently not quantified at all (see chapters 2 and 5). This causes severe problems for comparing the results of different assemblages and means that detailed analyses of Mesolithic and Neolithic hazelnut use in Scotland cannot be undertaken.

Some researchers have also attempted to use measures of hazelnut shell quantity to provide estimates of the original numbers of nuts represented by the fragments. For example, Carruthers (2000) used the average mass of nutshell from modern hazelnuts and the estimated total mass of hazelnut shell in the assemblage from Staosnaig to calculate the number of whole nuts represented (table 46). Using experimental data, Berihuete Azorín and Antonin (2012) propose a complex method of calculating the number of nuts, based on the number of fragments in different size categories (<16mm^2, 16-60 mm^2, >60 mm^2). Using the actual number of modern nuts in the experiment, they have established the appropriate correction factors which should be applied to each fragment size category to produce the correct total number of nuts (table 47). They compare the results of their method to two other methods: counting the total number of nutshell fragments >2mm and the number of nutshell bases and show that the different methods produce very different results (table 47).

Table 46: Modern hazelnut mass data from Wales (Carruthers 2000) and Spain/ Switzerland (Berihuete Azorín and Antonin 2012) and the mean shell mass of whole hazelnuts recovered from a Bronze Age hazelnut deposit from Arangas cave, Spain (López-Dóriga in press). Carruthers (2000) charred the nutshell at 300°C for 5 hours in anaerobic conditions, whereas Berihuete Azorín and Antonin (2012) charred the shells of 50 nuts in oxidizing conditions at 250ºC for 50 mins and the shells of 50 nuts in reducing conditions at 250ºC for 2 hours. The mean shell mass for Arangas cave was calculated using the mean shell mass for all the complete half shells in the deposit (López-Dóriga in press). Variances in the location of gathering or perhaps the charring conditions may account for the variance in mass for the shell of 1 hazelnut.

	Archaeological hazelnuts from Arangas cave, Spain (López-Dóriga in press)	Subfossil hazelnuts from mid Holocene palaeoenvironmental samples from the Isle of Wight (Scaife 1992)	Modern hazelnuts from Spain and Switzerland (Berihuete and Antolin 2012)	Modern hazelnuts from Wales (Carruthers 2000)
mass of shell from 100 nuts (g)	30	20.08	78	42
mass of shell from 1 nut (g)	0.3	0.2	0.78	0.42

Table 47: Results of hazelnut quantification experiment conducted by Berihuete Azorín and Antonin (2012). Rows 1-8 reproduce the results from Berihuete and Antolin (2012) figures 5 and 7 and the remaining rows show the results of calculations performed by the author. Method 1a: fragments were classified into different categories based on the surface area (<15 mm^2/15-60 mm^2/>60 mm^2) and then the number of nuts was estimated by first dividing the total number of fragments <15 mm^2 by 2, adding this to the total number of 15-60 mm^2 and >60 mm^2 fragments and dividing the result by 4. Method 1b: fragments were classified into different categories based on the surface area (<15 mm^2/15-60 mm^2/>60 mm^2) and then the number of nuts was estimated by first dividing the total number of fragments <15 mm^2 by 2, adding this to the total number of 15-60 mm^2 and >60 mm^2 fragments and dividing the result by 8. Method 2: the total number of fragments >2mm. Method 3: the total number of nut bases. The final 7 rows show the results of calculations that use the actual number of nuts in the experiment to calculate a correction factor to estimate of the total number of nuts for methods 2 and 3. The nut mass used in the calculations was 0.42 (Carruthers 2000).

Group	1	2	3	4	Total	Mean
Actual number of nuts	25	10	25	49	109	
Estimated number of nuts using method 1a (surface area in mm^2)	47	18	54	96	216	
Estimated number of nuts using method 1b (surface area in mm^2)	24	9	27	48	108	
Estimated number of nuts using method 2 (count >2mm nutshells)	191	73	226	464	954	
Estimated number of nuts using method 3 (count number of nutshell bases)	65	34	66	135	300	
Mass (g)	20.07	8.08	18.85	38.15	85.15	
Volume (ml)	55	12.5	40	100	207.5	
Mass per nut (g)	0.80	0.81	0.75	0.78		0.78
Volume per nut (ml)	2.2	1.25	1.6	2.04		1.90
Estimated number of nuts based on nut mass from Carruthers 2001	48	19	45	91	203	
Estimated number of nuts from method 2 divided by actual number of nuts	7.6	7.3	9.0	9.5		8.4
Total estimated number of nuts from method 2 divided by total actual number of nuts					8.8	
Method 2 results divided by 8.4	23	9	27	55	114	
Method 2 results divided by 8.8	22	8	26	53	108	
Estimated number of nuts from method 3 divided by actual number of nuts	2.6	3.4	2.6	2.8		2.8
Total estimated number of nuts from method 3 divided by total actual number of nuts					2.8	
Method 3 results divided by 2.8	23	12	24	48	107	

Other authors have used the number or mass of whole and half shells in contemporary archaeological or palaeoenvironmental samples to estimate the total number of nuts present. For example, López-Dóriga (In Press) used the nutshell mass from the half shells present within a Bronze Age deposit from Arangas cave, Spain to calculate the total number of whole nuts within the assemblage (table 46). Similarly, Scaife (1992:64) charred 30 hazelnuts obtained from mid-Holocene gravels and peats from the Isle of Wight and used the average mass as a standard to calculate the number of nuts present in the Mesolithic archaeological assemblage from Thatcham, Berkshire (table 46). In contrast, Holst's (2010) estimate was very approximate, with the number of nuts in the Mesolithic assemblage from Duvensee, Germany suggested on the basis of the number of whole nuts, half shells and large fragments in the assemblage.

Of these methods, López-Dóriga's (In Press) is probably the most accurate, as it does not rely on modern hazelnut data and it is specific to that particular assemblage of nutshells. However, this methodology is unsuitable for assemblages lacking half or whole shells, such as Northton or the Braes of Ha'Breck. Likewise, Scaife's (1992:64) analysis seems useful, since it uses probable contemporary hazelnuts as a standard. However, it is impossible to know whether these nuts are representative of hazelnuts in general from this period or whether ecological differences or human selection could have resulted in larger nuts being collected and deposited on Mesolithic sites (Scaife 1992:66). At any rate, since Scaife (1992) does not present the experimental data or charring conditions utilized in his analysis, this method cannot be reliably applied to other sites.

It is uncertain which of the other methodologies is the most reliable for estimating the number of whole nuts. Though Berihuete Azorín and Antonin (2012) have shown through experiment that their methodology is accurate, their results do not provide evidence that counting the nutshell >2mm or counting the number of nut bases are unreliable methods for estimating the number of nuts. As can be seen in table 47, similarly accurate results are produced for these two latter methods once suitable correction factors are applied. In contrast, Carruther's (2000) method is limited by the use of modern nutshell masses to calculate the number of nuts in archaeological assemblages. This is highlighted by the divergence in the nutshell masses measured for hazelnuts grown in different areas of Europe (table 46). Different carbonisation conditions could also account for the disparity in mass between these examples (ibid:409; Kingwell-Banham 2008) and again it is also possible that there is natural variation between hazelnuts in different areas of Europe. However, since there is no reason to expect that Mesolithic hazelnuts were significantly larger or smaller than at present, the values measured by Carruthers (2000) for the hazelnuts from Wales seems like a reasonable approximation for the nutshell mass for UK hazelnuts in the Mesolithic and Neolithic.

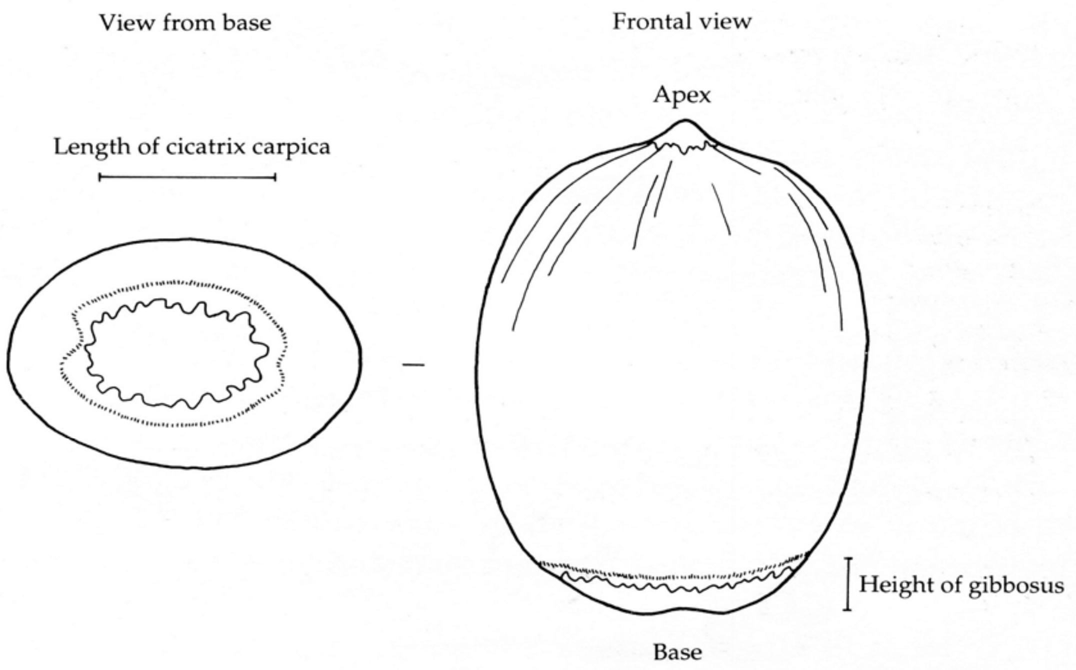
Considering the depositional and post-depositional factors involved in the preservation of nutshell in archaeobotanical assemblages (see chapter 2), it could be argued that providing a detailed method of hazelnut shell quantification to estimate the number of whole nuts is a pointless exercise. Yet, due to the extreme fragmentation of nutshell in many assemblages, it can often be difficult to assess whether very large or very small quantities of nuts are represented. Converting the amount of nutshell to a number of nuts can therefore provide a useful figure for characterising an assemblage. For instance, it is important to know whether the amount of nutshell recovered is likely to represent the mass gathering and processing of nuts onsite or the casual charring of a handful of nuts during the consumption of a tasty snack! In practice, medium-low levels of nut exploitation are probably impossible to differentiate, but it should in theory be possible to identify when large-scale nut processing and consumption have taken place.

A2.3.2 Quantification methods

In order to provide results comparable to as many different assemblages as possible, multiple methods were used to quantify the hazelnut shell at Northton and the Braes of Ha'Breck. The first methods employed for both sites were to count and weigh the fragments. However, the exact methods used to do this differed slightly due to the vastly different sample sizes and nut concentrations in the two assemblages. In the samples from the Braes of Ha'Breck, nutshell was extremely scarce in the 4mm and 2mm fractions and scanning of the 1mm flots and residues suggested that little nutshell was present (see chapter 7). Consequently, though it was possible to count and weigh all the fragments in the 4mm and 2mm fractions, it was not considered worthwhile to remove nutshell from the 1mm sample fractions. In contrast, nutshell was extremely abundant in the samples examined from Northton and because only 2 samples from the same context were examined, it made sense to subsample the 1mm fractions from the larger of these samples and weigh, but not count, the nutshell (see chapter 6). Likewise, all of the nutshell from the 2mm fractions was sorted and weighed, but because the fragments were so numerous, the time available precluded counting all of the fragments. In order to estimate the number of fragments in the 2mm fractions, a 12.5% subsample of the 2F nutshell and a 25% subsample of the 2R nutshell was created using a riffle box and the number of fragments was counted (a smaller subsample of the 2F was used because there was approximately twice as much hazelnut shell in the 2F than the 2R). As a result an estimate of the number and mass of fragments >2mm was produced for both sites and additionally an estimate of the total mass of fragments >1mm was produced for Northton. Moreover, since the 4mm, 2mm and 1mm sieve fractions were quantified separately, it was possible to determine not only the estimated number of nuts represented by the fragments, but the degree of fragmentation of the nutshell.

The 3rd method used was to count the total number of fragments >4mm with nutshell bases and with apexes (figure 43). Whilst fragments <4mm may have had bases or apexes, it was thought that counting these fragments would greatly overestimate the number of bases/apexes because even the bases/apexes could split into many tiny fragments. The final nutshell quantification method utilised was to estimate the proportion of a whole hazelnut represented by each fragment (12.5%/12.5-24%/25-50%/>50%) based on the shape and curvature of the fragment and presence/absence of bases/apexes. In practice, all the fragments <2mm were <12.5% of a whole hazelnut and so it was only necessary to estimate the shell percentages for the >4mm fraction. The use of all these methods should maximise the comparability of the results to past and future analyses at other sites.

Figure 43: Anatomical features of hazelnuts used for quantification (After Carruthers 2000:411).



Estimates of the number of nuts represented by the fragments were also calculated using several different methods. Method 1 used the total mass of fragments >1mm and Carruthers's (2000) estimate for the mass of shell from 1 nut to calculate the total number of nuts. The second estimate for the number of whole nuts is based on the number of fragments with nut bases or apexes >4mm, using the larger number from these counts to estimate the number of nuts. The third method used the number of fragments >2mm and the correction factor of 8.8, which was calculated using the results of Berihuete Azorín and Antonin's (2012) experiments (table 47). The final method employed was based on Berihuete Azorín and Antonin's (2012) experimental method 1b (table 47). Although their method involved measuring the surface area of the fragments using mm^2 square graph paper, it was reasoned that their categories were approximately the same as using 2mm and 4mm sieves to separate the fragments, since a fragment with a surface area $>16mm^2$ would be approximately >4mm in length/breadth and a fragment with a surface area $<16mm^2$ would be <4mm in length/breadth. Consequently the number of fragments in the 2mm and 4mm sieve fractions were used in Berihuete Azorín and Antonin's (2012) formula in place of the $<16mm^2$ fragment number and the $16\text{-}60\ mm^2 + >60\ mm^2$ fragment numbers respectively. Finally, the total mass and number of fragments per litre were also calculated to provide an estimate of the nutshell density.

A2.3.3 Results

Despite the similarity of the results produced in Berihuete Azorín and Antonin's (2012) experiment for methods 1b-3 when suitable correction factors were used (table 47), comparable results were not produced when these methods were applied to the 4 Atlantic Scottish Mesolithic/Neolithic assemblages (table 48). As can be seen in table 48, when the correction factor of 8.8 (from table 47) is applied to the number of fragments >2mm from Northton, the result is slightly under double (1029) the result produced using Carruther's (2000) method for the >1mm nutshell (573). This suggests that the nutshell in the Northton assemblage is much more fragmented than the nutshell in Berihuete Azorín and Antonin's (2012) experiment and shows that using the number of fragments to estimate the original number of nuts is not a reliable method. Similarly, considering the large mass of nutshell present in the assemblage, the maximum apex/base count >4mm (37) does not appear to provide a reliable estimate of the number of nuts.

Having said this, when Berihuete Azorín and Antonin's (2012) formula for method 1b is applied to the number of fragments in the >2mm and >4mm sieve fractions from Northton (table 48), a very similar result is produced (583) to Carruther's (2000) method for the >1mm nutshell (573). The close correspondence of the results from these contrasting methods supports the idea that these two methods have provided reliable estimates of the number of nuts at Northton.

The results from Temple Bay and the Braes of Ha'Breck support these propositions. Again, the number of fragments >2mm has produced a higher estimate for the number of nuts (Temple Bay: 34; Braes of Ha'Breck: 11) than Berihuete Azorín and Antonin's (2012) method 1b (Temple Bay: 20; Braes of Ha'Breck: 9). The results of these two methods for the Braes of Ha'Breck assemblage were much closer because the nutshell was less fragmented than the Mesolithic assemblages (see chapter 7). Since the 1mm fragments have not been weighed, the use of Carruthers (2000) method for the >2mm nutshell, produced a much lower estimate for the number of nuts at these sites (Temple Bay: 8; Braes of Ha'Breck:3). However, in these assemblages the number of nut bases and apexes >2mm were counted and this result (Temple Bay: 24; Braes of Ha'Breck:6) is similar to Berihuete Azorín and Antonin's (2012) method 1b result (Temple Bay: 20; Braes of Ha'Breck: 9). This suggests that counting the number of nut bases/apexes is only a reliable method if the >2mm fraction is counted and that it is necessary to weigh the >1mm nutshell to provide a reliable estimate of the number of nuts. Since only the >4mm fraction was examined for Tràigh na Beirigh, reliable estimates of the total number of nuts are not possible for this site. However, the number of nut bases >4mm suggests that at least 10 nuts were present in the samples.

Thus, it seems likely that the Northton assemblage contained approximately 570-585 nuts, whereas the examined samples from the Braes of Ha'Breck, Temple Bay and Tràigh na Beirigh probably contained less than 25 whole nuts.

Table 48: Hazelnut results from Mesolithic sites in the Western Isles. ogs: old ground surface, sm: shell midden, sd: sandy deposit, srd: shell-rich deposit. Asterisks indicate figures that incorporate totals calculated using a subsample. The nut mass used in the calculations was 0.42 (Carruthers 2000; see table 46). The final 6 rows show the results of calculations that use the correction factors as shown in table 47 to estimate of the total number of nuts. The second last row uses Berihuete and Antolin (2012) formula 1b (see table 47) for the number of fragments >2mm, on the basis that a 15mm^2 hazelnut fragment is approximately the same as a fragment caught in a 2mm sieve.

Site	BOH07-9	NT 10	NT 10	NT 10	TNB 11	TNB11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TB 11	TB 11	TB 11	TB 11	TB 11	TB 11
Sample	All examined	21	31	21/ 31	6	8	11	12	6/ 8/ 11 /12	13	15	2	3	5	7	8	2/ 3/ 5/ 7/ 8
Sample volume (litres)	608.6	413	10	423	45	8	2.5	2.5	58	13.5	36	10.5	5	5	7	7	35
Context	All examined	9	9	9	8	9	11	13	8/ 9/ 11/ 13	14	16	5	7	3	4	8	5/ 7/ 3/ 4/ 8
Context type	m	ogs	ogs	ogs	sm	sm	sm	sm	sm	ogs	sd	ogs	srd	ogs	ogs	ogs	ogs/srd
Sieve fractions examined (mm)	4,2	4,2,1	4,2	4,2,1	4	4	4	4	4	4	4	4,2	4,2	4,2	4,2	4,2	4,2
Number of nutshell fragments >4mm	22	264	12	276	12	8	6	1	27	28	3	3	1	1	5	7	17
Number of fragments >2mm	97	8748*	305	9053*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	98	30	32	47	90	297
Number of fragments 1-2mm	78	8484*	293	8777*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	95	29	31	42	83	280

Site	BOH07-9	NT 10	NT 10	NT 10	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TB 11	TB 11	TB 11	TB 11	TB 11	TB 11
Sample	All examined	21	31	21/ 31	6	8	11	12	6/ 8/ 11 /12	13	15	2	3	5	7	8	2/ 3/ 5/ 7/ 8
Sample volume (litres)	608.6	413	10	423	45	8	2.5	2.5	58	13.5	36	10.5	5	5	7	7	35
Context	All examined	9	9	9	8	9	11	13	8/ 9/ 11/ 13	14	16	5	7	3	4	8	5/ 7/ 3/ 4/ 8
Context type	m	ogs	ogs	ogs	sm	sm	sm	sm	sm	ogs	sd	ogs	srd	ogs	ogs	ogs	ogs/srd
Sieve fractions examined (mm)	4,2	4,2,1	4,2	4,2,1	4	4	4	4	4	4	4	4,2	4,2	4,2	4,2	4,2	4,2
Number of fragments >4mm/ per litre	0.04	0.64	1.2	0.65	0.27	1	2.4	0.4	0.47	2.07	0.08	0.29	0.2	0.2	0.71	1	0.49
Number of fragments >2mm/ per litre	0.16	21.2	30.5	21.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	9.33	6	6.4	6.71	12.9	8.61
Mass >4mm (g)	0.74	10.20	0.24	10.4	1.08	0.19	0.11	0.02	1.39	0.59	0.09	0.08	0.03	0.04	0.16	0.26	0.57
Mass >2mm (g)	0.65	75.73	2.28	78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.18	0.26	0.33	0.57	1.19	3.54
Mass >1mm (g)	n/a	235.88*	4.68*	240.56*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Site	BOH07-9	NT 10	NT 10	NT 10	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TB 11	TB 11	TB 11	TB 11	TB 11	TB 11
Sample	All examined	21	31	21/ 31	6	8	11	12	6/ 8/ 11 /12	13	15	2	3	5	7	8	2/ 3/ 5/ 7/ 8
Sample volume (litres)	608.6	413	10	423	45	8	2.5	2.5	58	13.5	36	10.5	5	5	7	7	35
Context	All examined	9	9	9	8	9	11	13	8/ 9/ 11/ 13	14	16	5	7	3	4	8	5/ 7/ 3/ 4/ 8
Context type	m	ogs	ogs	ogs	sm	sm	sm	sm	sm	ogs	sd	ogs	srd	ogs	ogs	ogs	ogs/srd
Sieve fractions examined (mm)	4,2	4,2,1	4,2	4,2,1	4	4	4	4	4	4	4	4,2	4,2	4,2	4,2	4,2	4,2
Mass >4mm (g)/per litre	0.00	0.02	0.02	0.02	0.02	0.02	0.04	0.01	0.02	0.04	0.00	0.01	0.01	0.01	0.02	0.04	0.02
Mass >2mm (g)/per litre	0.00	0.29	0.19	0.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.39	0.26	0.33	0.11	0.17	0.21
Number of >2mm <4mm nutshell fragments with base (cicatrix carpica) end present	6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	13	2	2	2	5	24
Number of >2mm <4mm nutshell fragments with apex end present	3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	9	1	0	1	2	13

Site	BOH07-9	NT 10	NT 10	NT 10	TN B11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TB 11	TB 11	TB 11	TB 11	TB 11	TB 11
Sample	All examined	21	31	21/ 31	6	8	11	12	6/ 8/ 11 /12	13	15	2	3	5	7	8	2/ 3/ 5/ 7/ 8
Sample volume (litres)	608.6	413	10	423	45	8	2.5	2.5	58	13.5	36	10.5	5	5	7	7	35
Context	All examined	9	9	9	8	9	11	13	8/ 9/ 11/ 13	14	16	5	7	3	4	8	5/ 7/ 3/ 4/ 8
Context type	m	ogs	ogs	ogs	sm	sm	sm	sm	sm	ogs	sd	ogs	srd	ogs	ogs	ogs	ogs/srd
Sieve fractions examined (mm)	4,2	4,2,1	4,2	4,2,1	4	4	4	4	4	4	4	4,2	4,2	4,2	4,2	4,2	4,2
Number of >4mm nutshell fragments with base (cicatrix carpica) end present	6	21	1	22	3	2	1	0	6	4	0	0	0	0	0	0	0
Number of >4mm nutshell fragments with apex end present	3	37	0	37	4	1	2	0	7	1	0	1	0	0	2	2	5
Estimated number of nuts using >1mm mass and nut mass from Carruthers 2000	n/a	562	11	573	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Estimated number of nuts using >2mm mass and nut mass from Carruthers 2000	3	180	5	186	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3	1	1	1	3	8

Site	BOH07-9	NT 10	NT 10	NT 10	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TNB 11	TB 11	TB 11	TB 11	TB 11	TB 11	TB11
Sample	All examined	21	31	21/ 31	6	8	11	12	6/ 8/ 11 /12	13	15	2	3	5	7	8	2/ 3/ 5/ 7/ 8
Sample volume (litres)	608.6	413	10	423	45	8	2.5	2.5	58	13.5	36	10.5	5	5	7	7	35
Context	All examined	9	9	9	8	9	11	13	8/ 9/ 11/ 13	14	16	5	7	3	4	8	5/ 7/ 3/ 4/ 8
Context type	m	ogs	ogs	ogs	sm	sm	sm	sm	sm	ogs	sd	ogs	srd	ogs	ogs	ogs	ogs/srd
Sieve fractions examined (mm)	4,2	4,2,1	4,2	4,2,1	4	4	4	4	4	4	4	4,2	4,2	4,2	4,2	4,2	4,2
Estimated number of nuts using >4mm mass and nut mass from Carruthers 2000	2	24	1	25	3	0	0	0	3	1	0	0	0	0	0	1	1
Estimated number of nuts using number of fragments >2mm divided by 8.8	11	994	35	1029	n/a	n/a	n/a	n/a	n/a	n/a	n/a	11	3	4	5	10	34
Estimated number of nuts using Berihuete and Antolin 2012 method 1b for >2mm nutshell	9	563*	20*	583	n/a	n/a	n/a	n/a	n/a	n/a	n/a	6	2	2	3	6	20
Number of nutshell fragments >2mm with bases divided by 2.8	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5	1	1	1	2	9

A2.4 Hazel nutshell preservation

A2.4.1 Introduction

The state of preservation of archaeobotanical remains can reveal important information about the taphonomic history of the material (Hubbard and al Azm 1990). Preservation is affected not only by the conditions of carbonisation, but also by post-depositional processes and through damage incurred during excavation and sample processing (Miksicek 1987; Nicholson 2001:181; Popper 1988:56-7). It is therefore important to record the level of preservation of archaeobotanical remains to enhance understanding of the extent to which these processes have affected the assemblage. Whilst cereal assemblages and individual grains are sometimes classified according to their degree of preservation (e.g. Church 2002a:52), the state of hazelnut shell preservation is rarely recorded. Consequently, most analyses of hazelnut shell reveal nothing about how the material was originally carbonised or the extent to which post-depositional processes have affected the preservation and fragmentation of the assemblage.

A2.4.2 Methods

A preservation scale for hazelnut shell was developed based on the cereal preservation scales created by Hubbard and al Azm (1990). However, classes P3 and P4 were combined into a single category (=P3) and class P6 was excluded, as this category does not apply to hazelnut shell. The preservation of each hazelnut shell fragment was recorded using the scale as indicated in table 49. As with all scales of this nature, there is clearly a degree of subjectivity in deciding which category each fragment falls into, but it is thought that the criteria adopted should provide a reasonable way of broadly classifying the hazelnut shell in an assemblage. Due to the small number of fragments in the assemblage from the Braes of Ha'Breck, the preservation of all of the 2mm and 4mm nutshell fragments was recorded. However, since there were a large number of fragments in the Northton assemblage, this preservation scale was only implemented for the 4mm fraction and a 6.25% riffle sample of the 2F and 12.5% riffle sample of the 2R fractions (a smaller subsample of the 2F was used because there was approximately twice as much hazelnut shell in the 2F than the 2R).

Recently, López-Dóriga (In Press) has proposed a method of identifying whether nutshell was broken before or after charring, based on the level and type of wear on the edges of the nutshell. Since at the time of analysis, this methodology had not been peer reviewed and published, it was decided not to use this methodology at this stage. Additionally, López-Dóriga (In Press) does not explain how post-depositional and modern breakages can be differentiated. However, in order to assess the level of modern hazelnut shell breakage and fragmentation caused by excavation and sampling methods, the number of worn and unworn edges on each of the fragments (examined for preservation scale above) was also recorded. Unworn edges were classified as those that were sharp, shiny, clean, and with no wear visible. All other edges were categorised as worn.

Table 49: Criteria for recording the preservation of charred hazelnut shell used in this research.

Preservation Index	Definition
1	Good preservation: curved morphology and striations on pericarp (if present) clearly visible and longitudinal vesicles visible in cross-section. Surface of nutshell intact (100%) and unworn.
2	Fair preservation: fragments identifiable by curved morphology and striations (if present). Nutshell surface virtually intact (>75%) but surface of nutshell slightly worn. Longitudinal vesicles may be visible in cross-section.
3	Poor preservation: fragments identifiable by curved morphology, but surface of nutshell incomplete (1-74%) and severely worn. If present, striations barely visible on pericarp. Longitudinal vesicles may be visible in cross-section.
4	Barely identifiable: fragments identifiable by curved morphology only. Outer pericarp surface completely abraded (0%) and only inner surface visible.

Appendix 3: Methods for experimental hazelnut preservation studies

A3.1 Appendix outline

This section outlines the detailed methodologies used in two recent trial hazelnut preservation experiments conducted by MSc (Jamie Joyce and Nikki Chiampa) and BSc (Eleanor Kingwell-Banham) students in the Department of Archaeology, Durham University and supervised by the author and Dr Mike Church. The main results are presented in chapter 6, with detailed results from Kingwell-Banham (2008) also presented in figures 44 and 45, to aid interpretation of the hazelnut shell taphonomy from Northton and the Braes of Ha'Breck. Both experiments are unpublished and were small-scale trial experiments that will require further repetition and methodological improvements for full corroboration. However, they provide a useful guide to the potential differences between different charring conditions and will aid future experimental design.

A3.2 Methods

The hearths in all the experiments were constructed on top of paving slabs which were surrounded by bricks on three sides, creating an area approximately $0.25m^2$. In Kingwell-Banham's experiment, native wild Hazel (*Corylus avellana* L.) nuts collected in the UK were used, whereas Joyce and Chiampa used larger commercially grown Hazel (*Corylus avellana* L.) nuts from Turkey.

In the first experiment, Kingwell-Banham (2008) constructed three hearths of mixed local roundwood species and after the fires had been burning for one hour, ten hazelnut shell fragments were added to each hearth. The fires were allowed to burn for five hours and then cool for one hour before being extinguished with cold water. A thermocouple, which was used to measure the temperature after one and half hours and three hours, recorded temperatures which ranged between 420°C - 890°C. Following Boardman and Jones (1990), a further controlled hazelnut charring experiment was conducted using a chamber furnace (E-con 10/8). Ten hazelnut shell fragments were charred at 250,300,350,400,450,500 and 550°C in oxidizing conditions for fixed times between 15 minutes and five hours. After charring the remaining fragments from the hearth and furnace experiments were classified according to Boardman and Jones's (1990) preservation criteria (figures 44 and 45).

Joyce and Chiampa (unpublished data) constructed two hearths of small-medium sized Hazel roundwood and once the fires had been burning for one hour, 20 whole hazelnuts were added to one of the hearths and the cracked shells from 20 hazelnuts were added to the other hearth. The fires were allowed to burn for one and half hours, after which time no further wood was added and the fires were left to go out naturally. After the ash had cooled, it was dry sieved to 4mm and 2mm and the remaining hazelnut shell fragments were classified according to the preservation methodology outlined in appendix 2. Each fragment was also classified according to the percentage of a whole hazelnut it represented (appendix 2).

In addition, an experimental hazelnut roasting pit was constructed, using the conditions that Score and Mithen (2000) discovered to be most effective for roasting hazelnuts. 800 hazelnuts were placed in a 10cm deep pit, which was lined with a 3cm sand layer and capped with a 2cm sand layer. A small fire was constructed on top of the pit using the same methods as the experimental hearths. After one and half hours the fire was allowed to go out naturally and the hazelnuts were removed from the pit. As some of the hazelnuts in the pit were partially charred, it was necessary to classify the nuts according to the degree of charring (0% charred, 1-49% charred, >50-99% charred and 100% charred) prior to recording the degree of preservation. Fifty nuts from each of the charred categories (1-49% charred, >50-99% charred and 100% charred) were then cracked using a large pebble and twenty fragments from each category were randomly selected for analysis. The preservation and whole shell percentage of each fragment was then classified according to the methodology outlined in appendix 2.

Figure 44: Destruction points of experimentally charred hazelnut shell at different temperatures (figure made by the author using data from Kingwell-Banham 2008 table 7).

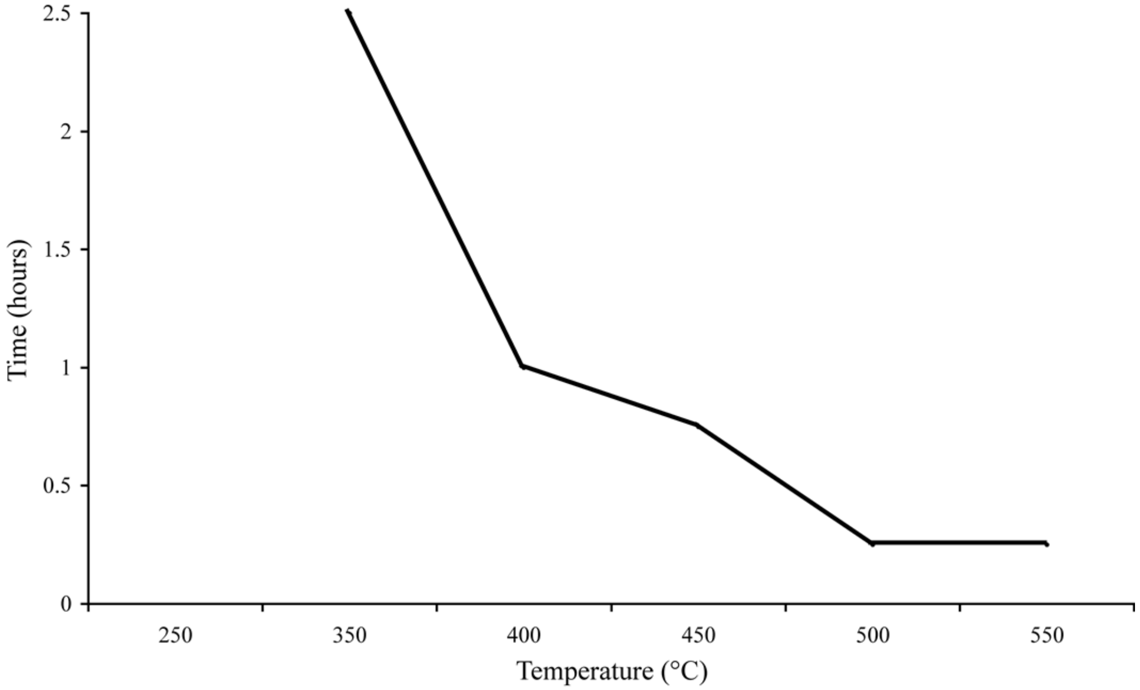
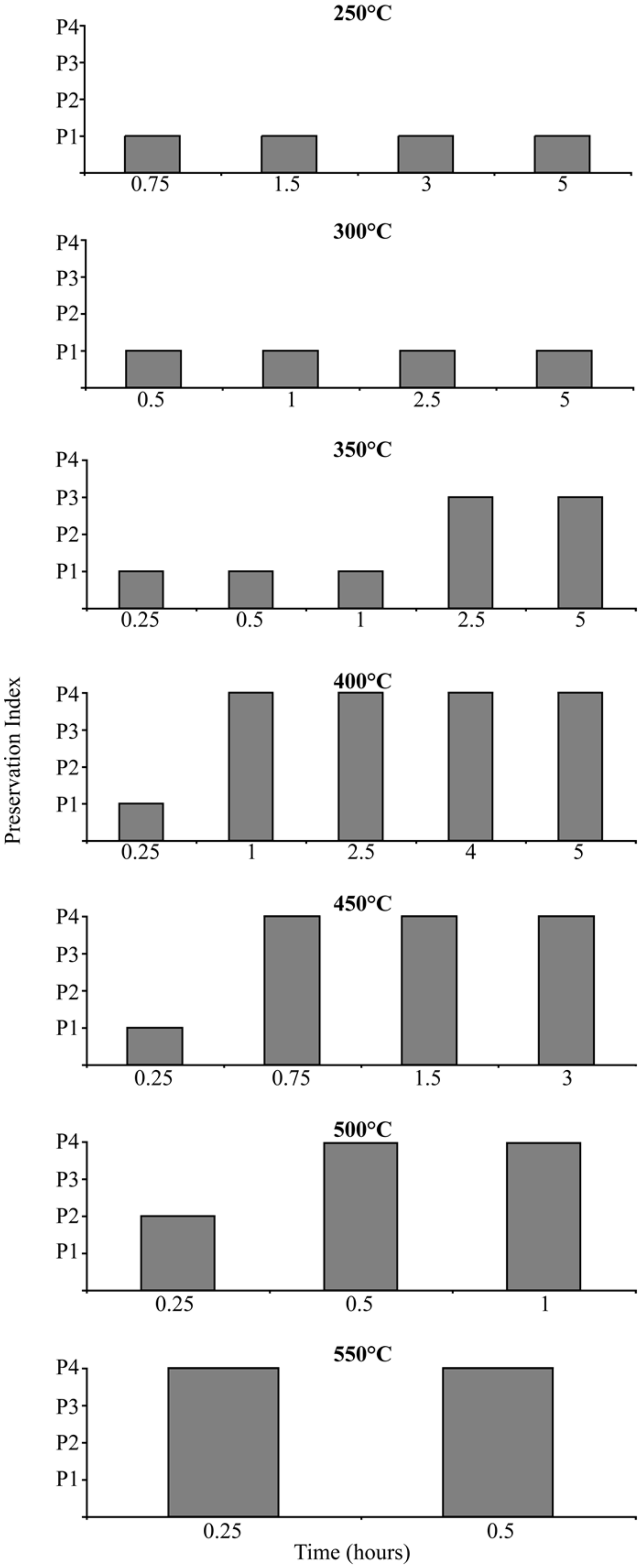


Figure 45: Preservation of experimentally charred hazel nutshell (figure made by the author using data from Kingwell-Banham (2008). To provide comparable results to the preservation criteria conducted in this thesis, Kingwell-Banham's (2008) preservation categories (which followed Boardman and Jones (1990)) were converted into categories with comparable descriptions. Kingwell-Banham's (2008) P3 and P4 were combined as P3 and Kingwell-Banham's (2008) categories P5 and P6 were combined as P4.



Appendix 4: Archaeobotanical results from the Braes of Ha'Breck

Table 50: Cereal results from the Braes of Ha'Breck, Wyre, Orkney. C: caryopsis; CN: culm node; CB: culm base; CF: culm fragment; RI: rachis internode; BC: barley caryopses; WS: potential weed seeds. Asterisks indicate figures calculated using a subsample.

Year	2007	2007	2007	2007	2007	2008	2007	2007	2007
Trench	A	A	A	A	A	A	A	A	A
Phase	Early	Early	Early	Early	Early	Early	Early	Early	Early
Context type	GOL	GOL	GOL	GOL	GOL	GOL	NFF	NFF	NFF
Sample number	3	8	13	27	34	63	4	6	7
Context number	126	129	119	148	103	112	113	127	128
Sample volume (l)	5	10	1	10	10	20	20	2.5	5
Cereal species									
Avena									
cf. *Avena* sp. (C)									
Hordeum (C)									
Hordeum sp. (C)		1				1			1
Hordeum naked (C)	1			2			1		
Hordeum cf. naked (C)									
Hordeum naked symmetric (C)				1	2	5			
Hordeum naked asymmetric (C)									
Hordeum hulled (C)									
Hordeum cf. hulled (C)									
Hordeum cf. hulled symmetric (C)									
Hordeum cf. hulled asymmetric (C)									
Hordeum hulled symmetric (C)									
Triticum									
cf. *Triticum* sp. (C)									
Triticum sp. (C)									
Triticum dicoccum Schübl. (C)									
Cereal indeterminate (C)					2	2	2		
Total grain	1	1	0	3	4	8	3	0	1
Grain per litre	0.2	0.1	0	0.3	0.4	0.4	0.15	0	0.2
Chaff									
Indeterminate (2mm CN)						1			
Indeterminate (1mm CN)						1			
Indeterminate (2mm CB)									
Indeterminate (1mm CB)									
Indeterminate (2/1mm CF)						2			
Hordeum vulgare L. emend. Lam. (RI)									
Hordeum sp. (RI)									
Cereal indet (RI)									
Total chaff	0	0	0	0	0	1	0	0	0
WS:C						0.75			

Year	2007	2007	2008	2009	2009	2007	2007	2007	2007
Trench	A	A	A	A	A	A	A	A	A
Phase	Early	Early	Early	Late	Late	Late	Late	Late	Late
Context type	NFF	NFF	NFF	GOL	GOL	M	M	M	M
Sample number	9	16	57	150	168	2 and 23	19	30	32
Context number	133	104	174	623	634	125	122	120	150
Sample volume (l)	2.5	9	3	20	27	24	17	19	8
Cereal species									
Avena									
cf. *Avena* sp. (C)									
Hordeum (C)									
Hordeum sp. (C)				4	27	1			
Hordeum naked (C)		3			18			1	
Hordeum cf. naked (C)									
Hordeum naked symmetric (C)				7	66	2			
Hordeum naked asymmetric (C)					6				
Hordeum hulled (C)									
Hordeum cf. hulled (C)				1					
Hordeum cf. hulled symmetric (C)									
Hordeum cf. hulled asymmetric (C)									
Hordeum hulled symmetric (C)									
Triticum									
cf. *Triticum* sp. (C)									
Triticum sp. (C)									
Triticum dicoccum Schübl. (C)									
Cereal indeterminate (C)			4	16	75	1		2	
Total grain	0	3	4	28	192	4	0	3	0
Grain per litre	0	0.33	1.33	1.4	7.11	0.17	0	0.16	0
Chaff									
Indeterminate (2mm CN)				1					
Indeterminate (1mm CN)				5					
Indeterminate (2mm CB)		2		2					
Indeterminate (1mm CB)				7					
Indeterminate (2/1mm CF)		1			2				
Hordeum vulgare L. emend. Lam. (RI)									
Hordeum sp. (RI)									
Cereal indet (RI)									
Total chaff	0	2	0	3	0	0	0	0	0
RI:BC				0.00	0.00				
WS:C				0.86	0.05				

Year	2007	2008	2009	2009	2009	2009	2008	2007	2007
Trench	A	A	A	A	A	C	C	C	C
Phase	Late	Late	Late	Late	Late	Early?	Early	Early?	Early?
Context type	M	M	M	M	M	GOL	NFF	NFF	NFF
Sample number	37	67	136	138	195	234	97	21	26
Context number	139	143	193	192	672	1020	434	404	422
Sample volume (l)	40	20	20	15	6.5	0.4	2	10	10
Cereal species									
Avena									
cf. *Avena* sp. (C)	1								
Hordeum (C)									
Hordeum sp. (C)	5	4		2		15	7	13	11
Hordeum naked (C)	2	1				6	1	5	
Hordeum cf. naked (C)								1	
Hordeum naked symmetric (C)		2		2		12	3	3	2
Hordeum naked asymmetric (C)		2			1	3			1
Hordeum hulled (C)									
Hordeum cf. hulled (C)								1	
Hordeum cf. hulled symmetric (C)									
Hordeum cf. hulled asymmetric (C)									
Hordeum hulled symmetric (C)		1							
Triticum									
cf. *Triticum* sp. (C)									
Triticum sp. (C)									
Triticum dicoccum Schübl. (C)									
Cereal indeterminate (C)	9	7	5	5	2	30	16	29	15
Total grain	17	17	5	9	3	66	27	52	29
Grain per litre	0.43	0.85	0.25	0.6	0.46	165	13.5	5.2	2.9
Chaff									
Indeterminate (2mm CN)		1			1				
Indeterminate (1mm CN)		8	1	2					
Indeterminate (2mm CB)		4	4				2		
Indeterminate (1mm CB)		24	9	2	1				
Indeterminate (2/1mm CF)							1		
Hordeum vulgare L. emend. Lam. (RI)						2			
Hordeum sp. (RI)									
Cereal indet (RI)									
Total chaff	0	5	4	0	1	2	2	0	0
RI:BC		0.00				0.06	0.00	0.00	0.00
WS:C	2.00	1.53		0.89		0.05	0.26	0.04	0.00

Year	2007	2008	2008	2009	2009	2009	2009	2009	2009
Trench	C	C	C	C	C	C	C	C	C
Phase	Early?	Early?	Early?	Early?	Early?	Early?	Early?	Early?	Early?
Context type	NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF
Sample number	33	42	61	129	135	140	142	206	216
Context number	429	441	477	555	562	447	574	449	564
Sample volume (l)	5	3	20	7	1.5	3	10	2.2	6.2
Cereal species									
Avena									
cf. *Avena* sp. (C)									
Hordeum (C)									
Hordeum sp. (C)	11		7				4		7
Hordeum naked (C)	3						1		2
Hordeum cf. naked (C)	2						1		
Hordeum naked symmetric (C)	2		8				6		4
Hordeum naked asymmetric (C)							1		2
Hordeum hulled (C)									
Hordeum cf. hulled (C)									
Hordeum cf. hulled symmetric (C)							1		
Hordeum cf. hulled asymmetric (C)									
Hordeum hulled symmetric (C)							1		
Triticum									
cf. *Triticum* sp. (C)	1								
Triticum sp. (C)									
Triticum dicoccum Schübl. (C)									
Cereal indeterminate (C)	23		13				23		7
Total grain	42	0	28	0	0	0	38	0	22
Grain per litre	8.4	0	1.4	0	0	0	3.8	0	3.55
Chaff									
Indeterminate (2mm CN)			2						
Indeterminate (1mm CN)			6				3		
Indeterminate (2mm CB)			1						
Indeterminate (1mm CB)			7				2		
Indeterminate (2/1mm CF)			3						
Hordeum vulgare L. emend. Lam. (RI)							5		
Hordeum sp. (RI)									
Cereal indet (RI)							1		
Total chaff	0	0	3	0	0	0	6	0	0
RI:BC	0.00		0.00				0.33		0.00
WS:C	0.05		0.25				0.24		0.32

Year	2009	2009	2008	2007	2007	2007	2007	2007	2008
Trench	C	C	C	C	C	C	C	C	C
Phase	Early?	Early?	Late	Late	Late	Late	Late	Late	Late
Context type	NFF	NFF	GOL	HD	HD	HD	HD	HD	HD
Sample number	222	228	83	15	20	24	28	35	70
Context number	1004	1012	501	417	421	414	424	433	419
Sample volume (l)	0.3	2	1	5	2.5	20	12.5	1	3
Cereal species									
Avena									
cf. *Avena* sp. (C)									
Hordeum (C)									
Hordeum sp. (C)		1	5	2		94.9*	14		15
Hordeum naked (C)			9	1		69.4*	6		8
Hordeum cf. naked (C)									1
Hordeum naked symmetric (C)			5			61*	12		7
Hordeum naked asymmetric (C)						10.2*			1
Hordeum hulled (C)									
Hordeum cf. hulled (C)									
Hordeum cf. hulled symmetric (C)									
Hordeum cf. hulled asymmetric (C)						1.7*			
Hordeum hulled symmetric (C)									
Triticum									
cf. *Triticum* sp. (C)									
Triticum sp. (C)						3.4*			
Triticum dicoccum Schübl. (C)						3.4*			
Cereal indeterminate (C)			43		1	88.1*	13	0	80
Total grain	0	1	62	3	1	332.1*	45	0	112
Grain per litre	0	0.5	62	0.6	0.4	16.61*	3.6	0	37.3
Chaff									
Indeterminate (2mm CN)		1							
Indeterminate (1mm CN)									2
Indeterminate (2mm CB)		2							
Indeterminate (1mm CB)		1							5
Indeterminate (2/1mm CF)									
Hordeum vulgare L. emend. Lam. (RI)									
Hordeum sp. (RI)									
Cereal indet (RI)									
Total chaff	0	3	0	0	0	0	0	0	0
RI:BC			0.00			0.00	0.00		0.00
WS:C			0.24			0.00	0.07		0.13

Year	2008	2008	2008	2008	2008	2008	2008	2008	2008
Trench	C	C	C	C	C	C	C	C	C
Phase	Late	Late	Late	Late	Late	Late	Late	Late	Late
Context type	HD	HD	HD	HD	HD	HD	HD	NFF	NFF
Sample number	71	76	78	79	82	91	124	88	89
Context number	495	497	496	141	503	494	418	436	506
Sample volume (l)	3	1	10	3	1	2	10	2	2
Cereal species									
Avena									
cf. *Avena* sp. (C)									
Hordeum (C)									
Hordeum sp. (C)	5	7	20	3	3	25	261.41*	86.25*	3
Hordeum naked (C)	4	5	7	3	1	7	125.48*	76.96*	
Hordeum cf. naked (C)							6.27*	1.33*	
Hordeum naked symmetric (C)	2	1	5	2		3	60.65*	39.81*	
Hordeum naked asymmetric (C)							12.55*	1.33*	
Hordeum hulled (C)								1.33*	
Hordeum cf. hulled (C)							2.09*		
Hordeum cf. hulled symmetric (C)									
Hordeum cf. hulled asymmetric (C)									
Hordeum hulled symmetric (C)									
Triticum									
cf. *Triticum* sp. (C)		1					2.091*		
Triticum sp. (C)									
Triticum dicoccum Schübl. (C)									
Cereal indeterminate (C)	49	14	31	23	23	35	1064.46*	203.01*	5
Total grain	60	28	63	31	27	70	1535.001*	410.02*	8
Grain per litre	20	28	6.3	10.3	27	35	153.5*	205.01*	4
Chaff									
Indeterminate (2mm CN)									
Indeterminate (1mm CN)	3					2	4		
Indeterminate (2mm CB)	2			1				1	
Indeterminate (1mm CB)	6				1		4	5	
Indeterminate (2/1mm CF)	19				2	9			
Hordeum vulgare L. emend. Lam. (RI)							7	2	
Hordeum sp. (RI)									
Cereal indet (RI)							2		
Total chaff	2	0	0	1	0	0	9	3	0
RI:BC	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	
WS:C	0.52	0.25	0.06	0.00	0.48	0.16	0.08	0.11	0.38

Year	2008	2008	2008	2008	2007	2008	2008	2008	2009
Trench	C	C	C	C	C	C	C	C	C
Phase	Late	Late	Late	Late	Late?	Late?	Late?	Late?	Late?
Context type	NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF
Sample number	96	108	110	114	41	47	49	107	131
Context number	517	522	523	526	427	468	469	499	556
Sample volume (l)	20	3	3	10	10	20	20	4	20
Cereal species									
Avena									
cf. *Avena* sp. (C)									
Hordeum (C)									
Hordeum sp. (C)		100	8		198.6*	1		1	
Hordeum naked (C)		30	4	1	118.3*		2	1	
Hordeum cf. naked (C)		1				1			
Hordeum naked symmetric (C)		32	5		80.3*	8		1	
Hordeum naked asymmetric (C)		2			10.6*		1		
Hordeum hulled (C)			1						
Hordeum cf. hulled (C)			1		2.1*				
Hordeum cf. hulled symmetric (C)									
Hordeum cf. hulled asymmetric (C)									
Hordeum hulled symmetric (C)									
Triticum									
cf. *Triticum* sp. (C)									
Triticum sp. (C)		1							
Triticum dicoccum Schübl. (C)									
Cereal indeterminate (C)	3	232	15	1	281*	15	6	20	2
Total grain	3	398	34	2	690.9*	25	9	23	2
Grain per litre	0.15	133	11.3	0.2	69.09*	1.25	0.45	5.75	0.1
Chaff									
Indeterminate (2mm CN)									
Indeterminate (1mm CN)		2				1			
Indeterminate (2mm CB)		1				7			
Indeterminate (1mm CB)		3				8	2	1	1
Indeterminate (2/1mm CF)						1			
Hordeum vulgare L. emend. Lam. (RI)									
Hordeum sp. (RI)		2							
Cereal indet (RI)									
Total chaff	0	3	0	0	0	7	0	0	0
RI:BC		0.01	0.00		0.00	0.00		0.00	
WS:C		0.10	0.21		0.00	0.60	0.11	0.13	

Year	2007	2007	2007	
Trench	C	C	C	
Phase	Unknown	Unknown	Unknown	
Context type	NFF	NFF	NFF	
Sample number	36	38	39	
Context number	405	406	432	Total
Sample volume (l)	2.5	10	10	608.6g
Cereal species				
Avena				
cf. *Avena* sp. (C)				1
Hordeum (C)				
Hordeum sp. (C)	11	133.1*	13	1132
Hordeum naked (C)	2	43.9*	9	581
Hordeum cf. naked (C)		13.7*		28
Hordeum naked symmetric (C)	5	41.2*	7	505
Hordeum naked asymmetric (C)		4.1*	3	62
Hordeum hulled (C)				2
Hordeum cf. hulled (C)			1	8
Hordeum cf. hulled symmetric (C)				1
Hordeum cf. hulled asymmetric (C)				2
Hordeum hulled symmetric (C)				2
Triticum				
cf. *Triticum* sp. (C)				4
Triticum sp. (C)				4
Triticum dicoccum Schübl. (C)				3
Cereal indeterminate (C)	3	172.9*	10	2721
Total grain	21	408.9*	43	5058
Grain per litre	8.4	40.89*	4.3	
Chaff				
Indeterminate (2mm CN)				7
Indeterminate (1mm CN)				40
Indeterminate (2mm CB)				29
Indeterminate (1mm CB)				89
Indeterminate (2/1mm CF)				40
Hordeum vulgare L. emend. Lam. (RI)				16
Hordeum sp. (RI)				2
Cereal indet (RI)				3
Total chaff	0	0	0	57
RI:BC	0.00	0.00	0.00	
WS:C	0.00	0.00	0.05	

Table 51: Fruits and seed results from the Braes of Ha'Breck, Wyre, Orkney; NF: nutshell fragment; FST: fruit stone fragment; S: seed; FR: fruit; N: nut/nutlet; A: achene; C: caryopsis; F: fragment; g: grams.

Year	2007	2007	2007	2007	2007	2008	2007
Trench	A	A	A	A	A	A	A
Phase	Early	Early	Early	Early	Early	Early	Early
Context type	GOL	GOL	GOL	GOL	GOL	GOL	NFF
Sample number	3	8	13	27	34	63	4
Context number	126	129	119	148	103	112	113
Sample volume (l)	5	10	1	10	10	20	20
Edible fruits and nuts							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (2mm NF)						1F	
Corylus avellana L. (2mm NF)						0.006g	
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)				2		2	
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							
Brassicaceae (S)							1
Carex sp. (trigonous) (N)				2			
cf. *Carex* sp. (trigonous) (N)						1	
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)							
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)							
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)							
Poaceae (large) (C)							
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)							
Rumex crispus L. (A)							
Rumex cf. *crispus* L. (A)							
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)							
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)				1		2	1
Sinapis arvensis L. (FR)							
cf. *Sinapis arvensis* L. (S)							
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)			1	2		3	2
cf. fungal sclerotia							

Year	2007	2007	2007	2007	2008	2009	2009
Trench	A	A	A	A	A	A	A
Phase	Early	Early	Early	Early	Early	Late	Late
Context type	NFF	NFF	NFF	NFF	NFF	GOL	GOL
Sample number	6	7	9	16	57	150	168
Context number	127	128	133	104	174	623	634
Sample volume (l)	2.5	5	2.5	9	3	20	27
Edible fruits and nuts							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (2mm NF)						1F	
Corylus avellana L. (2mm NF)						0.022g	
Crataegus monogyna Jacq. (FTF)						1F	
Empetrum nigrum L. (S)				3			
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							1
Brassicaceae (S)							
Carex sp. (trigonous) (N)				1			
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)				1			
Chenopodium sp. (S)							
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)							1
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)						1	1
Poaceae (large) (C)							
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)						1	
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)							
Rumex crispus L. (A)						2	
Rumex cf. *crispus* L. (A)				1			
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)						1	
Rumex cf. *acetosella* L. (A)						1	
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)							
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)				1			2
Sinapis arvensis L. (FR)							
cf. *Sinapis arvensis* L. (S)							
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)				2	4	18	4
cf. fungal sclerotia							

Year	2007	2007	2007	2007	2007	2008	2009
Trench	A	A	A	A	A	A	A
Phase	Late	Late	Late	Late	Late	Late	Late
Context type	M	M	M	M	M	M	M
Sample number	2 & 23	19	30	32	37	67	136
Context number	125	122	120	150	139	143	193
Sample volume (l)	24	17	19	8	40	20	20
Edible fruits and nuts							
Corylus avellana L. (4mm NF)	2F					3F	9F
Corylus avellana L. (4mm NF)	0.118g					0.092g	0.263g
Corylus avellana L. (2mm NF)						7F	37F
Corylus avellana L. (2mm NF)						0.051g	0.266g
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)							
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)						1	
Brassicaceae (S)							1
Carex sp. (trigonous) (N)				1		1	
cf. *Carex* sp. (trigonous) (N)							1
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)							
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)					1		
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)				1			1
Poaceae (large) (C)							
Polygonaceae (A)							
Polygonum aviculare L. (A)					1		
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)					3		
cf. *Rosa* sp. (A)	1		1				
Rumex sp. (A)						1	
Rumex crispus L. (A)					1		
Rumex cf. *crispus* L. (A)							
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)							
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)					7	6	
Sinapis arvensis L. (FR)						1F	
cf. *Sinapis arvensis* L. (S)			2			1	
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)	1	1	3	1	21	16	1
cf. fungal sclerotia							

Year	2009	2009	2009	2008	2007	2007	2007
Trench	A	A	C	C	C	C	C
Phase	Late	Late	Early?	Early	Early?	Early?	Early?
Context type	M	M	GOL	NFF	NFF	NFF	NFF
Sample number	138	195	234	97	21	26	33
Context number	192	672	1020	434	404	422	429
Sample volume (l)	15	6.5	0.4	2	10	10	5
Edible fruits and nuts							
Corylus avellana L. (4mm NF)		1F					
Corylus avellana L. (4mm NF)		0.014g					
Corylus avellana L. (2mm NF)	15F	2F		1F			
Corylus avellana L. (2mm NF)	0.105g	0.013g		0.004g			
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)							1
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							
Brassicaceae (S)	1						
Carex sp. (trigonous) (N)	1			1	1		
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)							
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)							
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)				1			
Poaceae (large) (C)							
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)							
Rumex crispus L. (A)							
Rumex cf. *crispus* L. (A)							
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)							
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)	5						2
Sinapis arvensis L. (FR)							
cf. *Sinapis arvensis* L. (S)				1			
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)	1	2	3	4	1		
cf. fungal sclerotia	5						

Year	2008	2008	2009	2009	2009	2009	2009
Trench	C	C	C	C	C	C	C
Phase	Early?	Early?	Early?	Early?	Early?	Early?	Early?
Context type	NFF	NFF	NFF	NFF	NFF	NFF	NFF
Sample number	42	61	129	135	140	142	206
Context number	441	477	555	562	447	574	449
Sample volume (l)	3	20	7	1.5	3	10	2.2
Edible fruits and nuts							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (2mm NF)							
Corylus avellana L. (2mm NF)							
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)		1					
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							
Brassicaceae (S)							
Carex sp. (trigonous) (N)		1					
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)	1						
cf. Chenopodiaceae (S)						1	
Fabaceae (S)							
Galium aparine L. (N)							
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)		1					
Poaceae (small) (C)							
Poaceae (large) (C)							
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)							
Rumex crispus L. (A)							
Rumex cf. *crispus* L. (A)							
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)							
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)		1				5	
Sinapis arvensis L. (FR)		1F					
cf. *Sinapis arvensis* L. (S)						1	
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)		4				2	1
cf. fungal sclerotia							

Year	2009	2009	2009	2008	2007	2007	2007
Trench	C	C	C	C	C	C	C
Phase	Early?	Early?	Early?	Late	Late	Late	Late
Context type	NFF	NFF	NFF	GOL	HD	HD	HD
Sample number	216	222	228	83	15	20	24
Context number	564	1004	1012	501	417	421	414
Sample volume (l)	6.2	0.3	2	1	5	2.5	20
Edible fruits and nuts							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (2mm NF)	1F						
Corylus avellana L. (2mm NF)	0.005g						
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)				1			1
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							
Brassicaceae (S)							
Carex sp. (trigonous) (N)			1	1	1		
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)				1			
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)							
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)							
Poaceae (large) (C)							
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)				2			
Rumex crispus L. (A)				2			
Rumex cf. *crispus* L. (A)							
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)				1			
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)				5			
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)	2		2	1			
Sinapis arvensis L. (FR)							
cf. *Sinapis arvensis* L. (S)							
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)	5			2			1
cf. fungal sclerotia							

Year	2007	2007	2008	2008	2008	2008	2008
Trench	C	C	C	C	C	C	C
Phase	Late	Late	Late	Late	Late	Late	Late
Context type	HD	HD	HD	HD	HD	HD	HD
Sample number	28	35	70	71	76	78	79
Context number	424	433	419	495	497	496	141
Sample volume (l)	12.5	1	3	3	1	10	3
Edible fruits and nuts							
Corylus avellana L. (4mm NF)				4F			
Corylus avellana L. (4mm NF)				0.168g			
Corylus avellana L. (2mm NF)			2F	1F	2F		
Corylus avellana L. (2mm NF)			0.12g	0.004g	0.015g		
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)			1	1		2	1
cf. *Empetrum nigrum* L. (S)				1			
Seeds							
Brassica sp. (S)			1				
Brassicaceae (S)							
Carex sp. (trigonous) (N)				1	1		
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)	1						
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)							
Montia fontana L. (S)			1				
Montia fontana L. ssp. *fontana* (S)			1				
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)				2			
Poaceae (large) (C)				1			
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)			1	1			
Rumex crispus L. (A)							
Rumex cf. *crispus* L. (A)	1						
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)				1			
Rumex cf. *obtusifolius* L. (A)			1	2			
Sinapis arvensis L. (S)			1				
Sinapis arvensis L. (FR)							
cf. *Sinapis arvensis* L. (S)							
Spergula arvensis L. (S)				1			
Indeterminate (S/FR/N/C)					1		
Indeterminate (S)	1		9	22	6	4	
cf. fungal sclerotia							

Year	2008	2008	2008	2008	2008	2008	2008
Trench	C	C	C	C	C	C	C
Phase	Late	Late	Late	Late	Late	Late	Late
Context type	HD	HD	HD	NFF	NFF	NFF	NFF
Sample number	82	91	124	88	89	96	108
Context number	503	494	418	436	506	517	522
Sample volume (l)	1	2	10	2	2	20	3
Edible fruits and nuts							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (4mm NF)							
Corylus avellana L. (2mm NF)	1F				4F		
Corylus avellana L. (2mm NF)	0.004g				0.021g		
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)		1	1	2			1
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							
Brassicaceae (S)							
Carex sp. (trigonous) (N)			1				1
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)			1	1			
cf. Chenopodiaceae (S)							
Fabaceae (S)							
Galium aparine L. (N)							
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)		1					
Plantago lanceolata L. (S)		1					
Poaceae (small) (C)	1			1			
Poaceae (large) (C)							
Polygonaceae (A)				1			
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)			4	2		2	2
Rumex crispus L. (A)							
Rumex cf. *crispus* L. (A)							1
Rumex crispus L./*obtusifolius* L. (A)	1		4				
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)			2				
Rumex cf. *obtusifolius* L. (A)			4				
Sinapis arvensis L. (S)	2						2
Sinapis arvensis L. (FR)							1F
cf. *Sinapis arvensis* L. (S)							
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)	4		84	23			16
Indeterminate (S)	9	9	113	42	3	1	34
cf. fungal sclerotia							

Year	2008	2008	2007	2008	2008	2008	2009
Trench	C	C	C	C	C	C	C
Phase	Late	Late	Late?	Late?	Late?	Late?	Late?
Context type	NFF	NFF	NFF	NFF	NFF	NFF	NFF
Sample number	110	114	41	47	49	107	131
Context number	523	526	427	468	469	499	556
Sample volume (l)	3	10	10	20	20	4	20
Edible fruits and nuts							
Corylus avellana L. (4mm NF)				1F	1F		
Corylus avellana L. (4mm NF)				0.047g	0.037g		
Corylus avellana L. (2mm NF)				1F			
Corylus avellana L. (2mm NF)				0.01g			
Crataegus monogyna Jacq. (FTF)							
Empetrum nigrum L. (S)	1				1		
cf. *Empetrum nigrum* L. (S)							
Seeds							
Brassica sp. (S)							
Brassicaceae (S)							
Carex sp. (trigonous) (N)				1			
cf. *Carex* sp. (trigonous) (N)							
cf. *Carex* sp. (biconvex) (N)							
Chenopodium sp. (S)							
cf. Chenopodiaceae (S)							
Fabaceae (S)	1						
Galium aparine L. (N)							
Montia fontana L. (S)							
Montia fontana L. ssp. *fontana* (S)							
Montia cf. *fontana* L. (S)							
Plantago lanceolata L. (S)							
Poaceae (small) (C)	2		1				
Poaceae (large) (C)				1			
Polygonaceae (A)							
Polygonum aviculare L. (A)							
Ranunculus sp. (A)							
Ranunculus cf. *bulbosus* L. (A)							
cf. *Rosa* sp. (A)							
Rumex sp. (A)				3			
Rumex crispus L. (A)							
Rumex cf. *crispus* L. (A)							
Rumex crispus L./*obtusifolius* L. (A)							
Rumex cf. *crispus* L./*obtusifolius* L. (A)							
Rumex acetosella L. (A)							
Rumex cf. *acetosella* L. (A)							
Rumex cf. *acetosa* L. (A)							
Rumex obtusifolius L. (A)							
Rumex cf. *obtusifolius* L. (A)							
Sinapis arvensis L. (S)				1			
Sinapis arvensis L. (FR)							
cf. *Sinapis arvensis* L. (S)							
Spergula arvensis L. (S)							
Indeterminate (S/FR/N/C)							
Indeterminate (S)	4		2	9	1	3	1
cf. fungal sclerotia				2			

Year	2007	2007	2007	
Trench	C	C	C	
Phase	Unknown	Unknown	Unknown	
Context type	NFF	NFF	NFF	
Sample number	36	38	39	
Context number	405	406	432	Total
Sample volume (l)	2.5	10	10	608.6g
Edible fruits and nuts				
Corylus avellana L. (4mm NF)				21F
Corylus avellana L. (4mm NF)				0.739g
Corylus avellana L. (2mm NF)				76F
Corylus avellana L. (2mm NF)				0.646g
Crataegus monogyna Jacq. (FTF)				1F
Empetrum nigrum L. (S)				23
cf. *Empetrum nigrum* L. (S)				1
Seeds				
Brassica sp. (S)				3
Brassicaceae (S)				3
Carex sp. (trigonous) (N)				17
cf. *Carex* sp. (trigonous) (N)				2
cf. *Carex* sp. (biconvex) (N)				1
Chenopodium sp. (S)				5
cf. Chenopodiaceae (S)				1
Fabaceae (S)				1
Galium aparine L. (N)				2
Montia fontana L. (S)				1
Montia fontana L. ssp. *fontana* (S)				1
Montia cf. *fontana* L. (S)				1
Plantago lanceolata L. (S)				2
Poaceae (small) (C)				12
Poaceae (large) (C)				2
Polygonaceae (A)				1
Polygonum aviculare L. (A)				1
Ranunculus sp. (A)				1
Ranunculus cf. *bulbosus* L. (A)				3
cf. *Rosa* sp. (A)				2
Rumex sp. (A)		1		19
Rumex crispus L. (A)				5
Rumex cf. *crispus* L. (A)				3
Rumex crispus L./*obtusifolius* L. (A)				5
Rumex cf. *crispus* L./*obtusifolius* L. (A)				1
Rumex acetosella L. (A)				1
Rumex cf. *acetosella* L. (A)				1
Rumex cf. *acetosa* L. (A)		1		1
Rumex obtusifolius L. (A)				8
Rumex cf. *obtusifolius* L. (A)				7
Sinapis arvensis L. (S)				44
Sinapis arvensis L. (FR)				4F
cf. *Sinapis arvensis* L. (S)			1	6
Spergula arvensis L. (S)				1
Indeterminate (S/FR/N/C)				128
Indeterminate (S)			1	380
cf. fungal sclerotia				7

Table 52: Tuber/root results from the Braes of Ha'Breck, Wyre, Orkney. F: fragment; RT: root tuber; B: bulbil; R: root; T: tuber; RH: rhizome; ST: stolon.

Year		2007	2007	2007	2007	2007	2008	2007	2007	2007	2007	2007
Trench		A	A	A	A	A	A	A	A	A	A	A
Phase		Early	Early	Early	Early	Early	Early	Early	Early	Early	Early	Early
Context type		GOL	GOL	GOL	GOL	GOL	GOL	NFF	NFF	NFF	NFF	NFF
Sample number		3	8	13	27	34	63	4	6	7	9	16
Context number		126	129	119	148	103	112	113	127	128	133	104
Sample volume (litres)		5	10	1	10	10	20	20	2.5	5	2.5	9
Species	Plant part											
cf. *Ranunculus ficaria* L.	RT/B											
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH											
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH											
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH											
Indeterminate (glassy/vesicular)	2mm T/R/RH											
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH											
Indeterminate (cf. secondary root/tuber)	2mm T/R											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH						2					
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH											
Indeterminate (glassy/vesicular)	1mm T/R/RH						2F					
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH						1F					
Indeterminate (cf. secondary root/tuber)	1mm T/R											
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH											

Year		2008	2009	2009	2007	2007	2007	2007	2007	2008	2009	2009
Trench		A	A	A	A	A	A	A	A	A	A	A
Phase		Early	Late	Late	Late	Late	Late	Late	Late	Late	Late	Late
Context type		NFF	GOL	GOL	M	M	M	M	M	M	M	M
Sample number		57	150	168	2 & 23	19	30	32	37	67	136	138
Context number		174	623	634	125	122	120	150	139	143	193	192
Sample volume (litres)		3	20	27	24	17	19	8	40	20	20	15
Species	Plant part											
cf. *Ranunculus ficaria* L.	RT/B											
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH											
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH			2F								3F
Indeterminate (cf. secondary root/tuber)	4mm T/R											1F
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH				2F							
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH											
Indeterminate (glassy/vesicular)	2mm T/R/RH					2F			7F			
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH		1F	11F		3F			112F		7F	19F
Indeterminate (cf. secondary root/tuber)	2mm T/R											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH		1					1				
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH								2			
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH											
Indeterminate (glassy/vesicular)	1mm T/R/RH			11F				3F	18F	8F		3F
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH		2F	1F					349F		9F	42F
Indeterminate (cf. secondary root/tuber)	1mm T/R									2F		
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH											

Year		2009	2009	2008	2007	2007	2007	2008	2008	2009	2009	2009
Trench		A	C	C	C	C	C	C	C	C	C	C
Phase		Late	Early?	Early	Early?	Early?	Early?	Early?	Early?	Early?	Early?	Early?
Context type		M	GOL	NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF
Sample number		195	234	97	21	26	33	42	61	129	135	140
Context number		672	1020	434	404	422	429	441	477	555	562	447
Sample volume (litres)		6.5	0.4	2	10	10	5	3	20	7	1.5	3
Species	Plant part											
cf. *Ranunculus ficaria* L.	RT/B											
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH											
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH	5F										
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH											
Indeterminate (glassy/vesicular)	2mm T/R/RH	1F			9F		1F		2F			
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH	19F		2F					1F			
Indeterminate (cf. secondary root/tuber)	2mm T/R											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH						1					
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH											
Indeterminate (glassy/vesicular)	1mm T/R/RH	1F		4F	2F				2F			
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH	8F		7F								
Indeterminate (cf. secondary root/tuber)	1mm T/R											
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH											

Year		2009	2009	2009	2009	2009	2008	2007	2007	2007	2007	2007
Trench		C	C	C	C	C	C	C	C	C	C	C
Phase		Early?	Early?	Early?	Early?	Early?	Late	Late	Late	Late	Late	Late
Context type		NFF	NFF	NFF	NFF	NFF	GOL	HD	HD	HD	HD	HD
Sample number		142	206	216	222	228	83	15	20	24	28	35
Context number		574	449	564	1004	1012	501	417	421	414	424	433
Sample volume (litres)		10	2.2	6.2	0.3	2	1	5	2.5	20	12.5	1
Species	Plant part											
cf. *Ranunculus ficaria* L.	RT/B											
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH											
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH											
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (cf. secondary root/tuber)	4mm T/R											
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH			1F								
Indeterminate (glassy/vesicular)	2mm T/R/RH									1F		
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH	3F										
Indeterminate (cf. secondary root/tuber)	2mm T/R											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH						1F					
Indeterminate (glassy/vesicular)	1mm T/R/RH					1F				1F		
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH	2F		1F								
Indeterminate (cf. secondary root/tuber)	1mm T/R											
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH											

Year		2008	2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
Trench		C	C	C	C	C	C	C	C	C	C	C
Phase		Late	Late	Late	Late	Late	Late	Late	Late	Late	Late	Late
Context type		HD	HD	HD	HD	HD	HD	HD	HD	NFF	NFF	NFF
Sample number		70	71	76	78	79	82	91	124	88	89	96
Context number		419	495	497	496	141	503	494	418	436	506	517
Sample volume (litres)		3	3	1	10	3	1	2	10	2	2	20
Species	Plant part											
cf. *Ranunculus ficaria* L.	RT/B	1										
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH											
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH								4F			
Indeterminate (cf. secondary root/tuber)	4mm T/R								1F			
Indeterminate (cf. secondary root/tuber)	4mm T/R							1				
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH								1F			
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH											
Indeterminate (glassy/vesicular)	2mm T/R/RH	4F			1F		2F	1F				
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH	6F	1F				1F	1F		2F		
Indeterminate (cf. secondary root/tuber)	2mm T/R											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH							1				
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH											
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH								3F			
Indeterminate (glassy/vesicular)	1mm T/R/RH	4F							1F			
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH	36F	2F				4F			6F		
Indeterminate (cf. secondary root/tuber)	1mm T/R	1F										
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH						1F					

Year		2008	2008	2008	2007	2008	2008	2008	2009
Trench		C	C	C	C	C	C	C	C
Phase		Late	Late	Late	Late?	Late?	Late?	Late?	Late?
Context type		NFF	NFF	NFF	NFF	NFF	NFF	NFF	NFF
Sample number		108	110	114	41	47	49	107	131
Context number		522	523	526	427	468	469	499	556
Sample volume (litres)		3	3	10	10	20	20	4	20
Species	Plant part								
cf. *Ranunculus ficaria* L.	RT/B								
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH					1			
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH					1F			
Indeterminate (cf. secondary root/tuber)	4mm T/R								
Indeterminate (cf. secondary root/tuber)	4mm T/R								
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH								
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH								
Indeterminate (glassy/vesicular)	2mm T/R/RH	2F		2F				1F	
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH	1F		2F	1F	5F	1F	14F	
Indeterminate (cf. secondary root/tuber)	2mm T/R					2F		1F	
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH					1			
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH								
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH								
Indeterminate (glassy/vesicular)	1mm T/R/RH	1F				3F			1F
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH			8F		4F		73F	1F
Indeterminate (cf. secondary root/tuber)	1mm T/R								
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH								

Year		2007	2007	2007	
Trench		C	C	C	
Phase		Unknown	Unknown	Unknown	
Context type		NFF	NFF	NFF	
Sample number		36	38	39	
Context number		405	406	432	Total
Sample volume (litres)		2.5	10	10	608.6
Species	Plant part				
cf. *Ranunculus ficaria* L.	RT/B				1
Indeterminate (possibly further identifiable under SEM)	4mm T/R/RH				1
Indeterminate (glassy/vesicular)	cf. 4mm T/R/RH				15F
Indeterminate (cf. secondary root/tuber)	4mm T/R				2F
Indeterminate (cf. secondary root/tuber)	4mm T/R				1
Indeterminate (possibly further identifiable under SEM)	2mm T/R/RH				3F
Indeterminate (possibly further identifiable under SEM)	cf. 2mm T/R/RH				1F
Indeterminate (glassy/vesicular)	2mm T/R/RH			6F	42F
Indeterminate (glassy/vesicular)	cf. 2mm T/R/RH		4F	1F	218F
Indeterminate (cf. secondary root/tuber)	2mm T/R				3F
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH				7
Indeterminate (possibly further identifiable under SEM)	cf. 1mm T/R/RH				2
Indeterminate (possibly further identifiable under SEM)	1mm T/R/RH				4F
Indeterminate (glassy/vesicular)	1mm T/R/RH		2F	8F	76F
Indeterminate (glassy/vesicular)	cf. 1mm T/R/RH			1F	557F
Indeterminate (cf. secondary root/tuber)	1mm T/R				3F
Indeterminate (small, poorly preserved, irregular, too small for further identification)	cf. 1mm T/R/RH				1F

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