Palaeoenvironmental Investigations of Holocene Landscapes in the North Tyne Basin, Northern England

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by

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Abstract

The vegetation history of the North Tyne basin, northern England, is presented for an extended Holocene period, dating back to *ca.* 8000 cal. BC. This study focuses upon vegetation histories from two types of site, which record changes at differing spatial scales. The regional vegetation of the area is recorded within three radiocarbon-dated pollen diagrams from upland sites at Drowning Flow, Bloody Moss and Sells Burn. These sites provide a different perspective of regional vegetation history in comparison to existing published accounts from the region. This work also fills a spatial gap in current knowledge, by providing records from the area between Hadrian's Wall in the south and the Cheviots to the north for which only one previous site exists (Steng Moss: Davies and Turner, 1979). These regional records are complemented by the reconstruction of local, valley floor vegetation derived from organic-rich palaeochannel fills at Brownchesters Farm, Redesdale and Snabdaugh Farm, North Tynedale. These sites demonstrate how patterns of vegetation at local scales can provide valuable additional insights into former landscapes, valley floor land-use and human activity. Perceived problems of the usage of alluvial sediments for palynological investigation are discussed, while methodologies to overcome these difficulties are developed and the potential benefits of these contexts for vegetation reconstruction outlined. The unusually long and readily dateable alluvial record has also facilitated a new perspective on the timing and controls of Holocene fluvial activity in the North Tyne basin. The close integration of archaeological evidence with the results from this study has contributed to a number of debates concerning former human activity in the area. Palynological results suggest that the impact of Mesolithic and Neolithic societies upon the landscape has been underestimated; that postulated alterations in upland / lowland settlement patterns during the Bronze Age are a consequence of a fragmentary archaeological record rather than a response to changing environmental conditions; that Iron Age (and earlier) agricultural activity has been underestimated and that forest clearance was a gradual phenomenon with its origins in the Late Mesolithic and not primarily a result of activity associated with invading Roman forces.

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Cheers!

Sorry if I missed anyone!

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Chapter 1

Introduction and review of literature

1.1 Introduction

The reconstruction of former Holocene landscapes and the modelling of past human activity is a difficult, complex and multi-faceted task. Individual analytical techniques, whilst providing important insights into past environments, are frequently spatially and temporally fragmented, particularly in upland environments subject to long-term erosion. Multi-disciplinary approaches have significant benefits in this respect, by providing different perspectives to what are often very similar problems, questions and debates (Edwards, 1993). For example, the application and integration of palaeoecological techniques with elements of archaeological evidence has provided numerous opportunities for the detailed study of past environments inaccessible by individual methodologies (*e.g.* Edwards, 1989; Edwards *et al.*, 1983; Davies, 1997; Simmons, 1975a, 1975b , 1996; Turner, 1979).

The archaeological record of northern England extends back to the Palaeolithic (Cousins and Tolan-Smith, 1995), yet, with the exception of Hadrian's Wall, (designated a World Heritage site, Breeze and Dobson, 1987), the region's prehistoric archaeological record has received little attention. However, recent work in the Milfield basin, north Northumberland is challenging perceptions of prehistoric human activity and prompting a re-evaluation of the region's multi-period archaeological record (Waddington, 1998a).

A palaeoecological research program designed to address specific archaeological issues is therefore desirable, in order that more accurate reconstruction of Holocene landscapes can be achieved.

Whilst the North Tyne basin contains archaeological evidence of all periods from the Mesolithic onwards, records to date have been insufficiently complemented by radiocarbon-dated palaeoecological studies. Although work by Jobey (1965, 1977, 1978; Jobey and Jobey, 1988), Charlton and Day (1978, 1979, 1981, 1982), Harbottle and Newman (1973, 1977), Gates (1983) and Topping (1989) have provided detailed archaeological information concerning individual sites and specific periods of prehistory, longer-term studies at landscape scale are lacking. A number of questions and debates raised by the archaeological evidence are pertinent to the palynologist and some, particularly those concerned with the Roman period, have been addressed by several studies (Davies and Turner, 1979; Dumayne, 1993a, 1993b; Dumayne and Barber, 1994). Whilst these have provided a temporal and spatial focus for existing palynological investigations, it has in some instances been to the detriment of analyses concerning longer-term Holocene vegetation dynamics and the influence of earlier, and later, human communities upon the landscape of the area. Palynological studies that address the following key areas are consequently critical in terms of understanding regional vegetation histories and the impact of past societies upon Holocene landscapes in northern Britain.

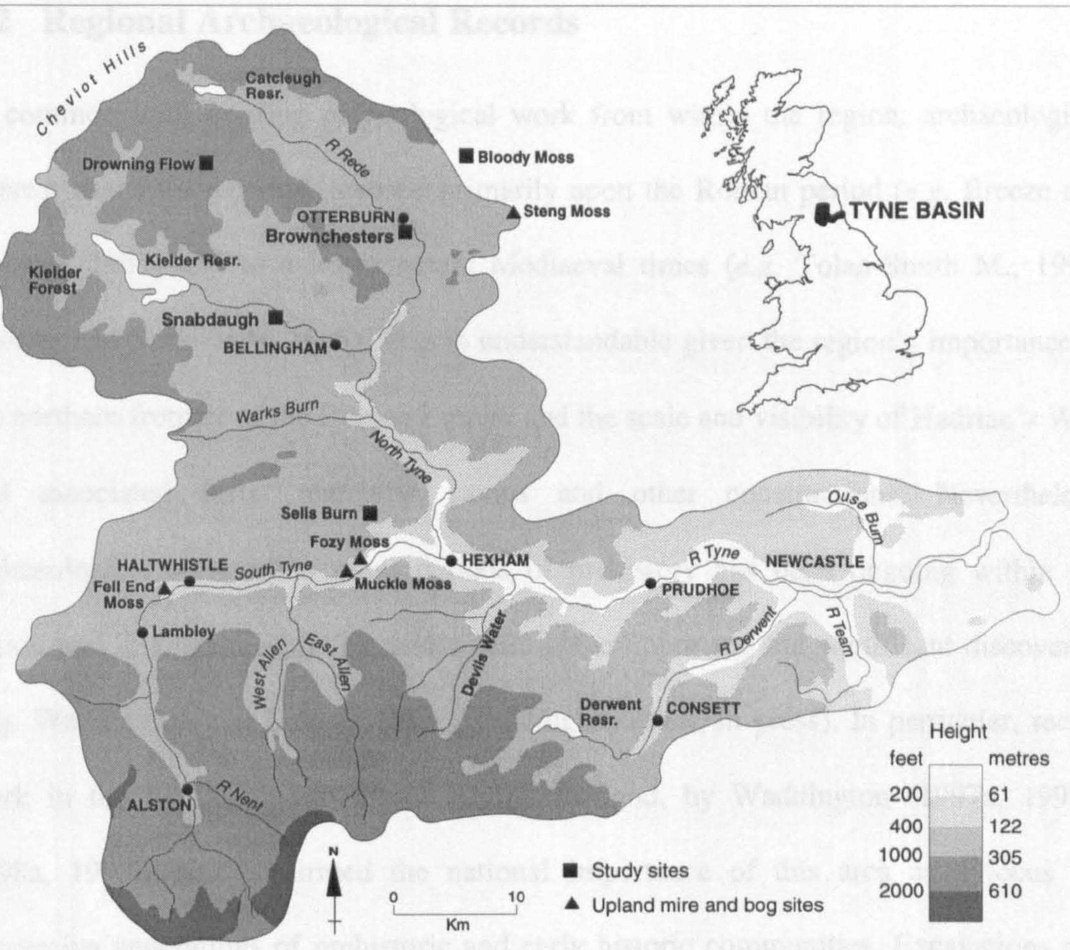
The earliest impact of Stone-Age human societies upon vegetation of northern England has been poorly documented, due in part to a focus upon regional-scale vegetation histories that may not register the impact of small-scale and possibly temporary forest clearance (*e.g.* Davies and Turner, 1979, Dumayne, 1992). Published archaeology and limited field survey suggests that there is a virtual absence of Mesolithic communities in North Tynedale and Redesdale, despite evidence that is emerging from the lower part of the Tyne system (Tolan-Smith, 1996, 1997) and an otherwise strongly riverine distribution of Mesolithic sites in the wider region (Davies, 1983). Palynological techniques, particularly those focused upon local scale vegetation records, may offer the opportunity to analyse any impacts Mesolithic societies may have had on the environment of the North Tyne basin. The evidence of cereal production and the development of Neolithic-type societies has also been documented as occurring relatively late in northern Britain (Pratt, 1996), although recent archaeological evidence from Milfield is altering these perceptions (Waddington, 1997a). The north-east and south-east parts of the region have apparently formed the focus for cereal cultivation (Pratt, 1996; Huntley, 1997), with existing palynological studies suggesting that the area of the North Tyne did not support arable agriculture until much later in prehistory (Davies and Turner, 1979). This conclusion requires careful testing to analyse if this is simply a function of the scale and focus of existing palynological investigations.

Later prehistoric periods also contain a number of questions derived from regional archaeological issues. For example, climate conditions during the Early and Late Bronze Ages have been cited as responsible for alterations in the pattern of upland-lowland human settlement and subsistence activity during this period (Burgess, 1984, 1985). As population shifts are likely to have repercussions within the vegetation record, these theories are testable by palynological studies at appropriate scales. Indeed, debates surrounding the relative impacts of human activity within upland and lowland environments are a critical issue for palynologists throughout much of prehistory (Janssen, 1986). Questions surrounding the onset of major deforestation of the region and associated large-scale cereal cultivation have been the focus of much existing palynological work. The Roman forces which invaded in AD 79 have been cited as causing widespread vegetation changes, although archaeological evidence suggests that levels of native Iron Age tillage in upland areas may have previously been underestimated (Topping, 1989). Post-Roman vegetation change has also received little attention within existing palynological literature (*e.g.* Davies and Turner, 1979).

This study analyses these multi-period archaeological issues within the context of the North Tyne basin (Figure 1.1), facilitating debates concerning periods of prehistory to be engaged with landscape-scale vegetation reconstructions. This is particularly important given recent archaeological evidence emerging from the region that suggests this area of northern Britain was an important social, cultural and political centre throughout many periods other than the Roman occupation (Waddington, 1998a). This study also encompasses analysis of vegetation changes at a smaller, local spatial scales and within the potentially critical context of valley floor environments that are the most likely to have been proximal to areas of former human settlement and cultivation. The usage of radiocarbon-dated palaeochannel fills provides a unique opportunity to examine temporary and localised vegetation fluctuations possibly induced by anthropogenic involvement that may not be visible within upland regional pollen records. These valley floor studies may be particularly beneficial to studies concerned with the early impacts of human activity and the onset of agricultural practices in the region.

There follows a brief review of some of the pertinent elements of regional archaeology, including an outline of ongoing efforts to integrate these multi-proxy approaches into regional landscape-scale syntheses of Holocene environments. Existing palynological records from the area of the North Tyne basin are also examined in the context of regional archaeology and issues of scale are discussed with reference to approaches already adopted elsewhere. An outline of valley floor geoarchaeological methods and current Holocene alluvial histories in Britain is also addressed. It should be noted that unless otherwise stated all dates mentioned in the text are calibrated calendar dates (BC / AD) and all dates quoted as BP are uncalibrated radiocarbon dates.

Figure 1.1: Location of study sites and upland mire and bog sites



1.2 Regional Archaeological Records

In common with existing palynological work from within the region, archaeological interest has, until recently, focused primarily upon the Roman period (*e.g.* Breeze and Dobson, 1987) and to a lesser extent Mediaeval times (*e.g.* Tolan-Smith M., 1997) (Young and Simmonds, 1995). This is understandable given the region's importance as the northern frontier of the Roman Empire and the scale and visibility of Hadrian's Wall and associated forts, marching camps and other constructions. Nevertheless, archaeological work upon other periods of prehistory has been ongoing within the region and this has recently expanded with some important and significant discoveries (*e.g.* Waddington and Davies, 1998; Waddington *et al.*, in press). In particular, recent work in the Milfield basin, north Northumberland, by Waddington (1997a, 1997b, 1998a, 1998b) has confirmed the national importance of this area as a focus for successive generations of prehistoric and early historic communities. Excavations and radiocarbon dating of features associated with the Coupland enclosure, near Milfield village, have revealed this hengiform monument to be the oldest in the country, dating to *ca.* 3800 BC. In addition, one of the principal functions of this feature appears to be related directly to early agricultural practices, and yet existing palynological records indicate such activity occurred much later within northern England during the Bronze Age or even later (Rowell and Turner, 1985; Davies and Turner, 1979; Fenton-Thomas, 1992).

Further debate surrounds the apparent shift of prehistoric people from the low-lying river valleys to the Cheviot uplands in the Early Bronze Age. Archaeological evidence suggests that an increase in small hut circles in the uplands during this period reflect a corresponding abandonment of the lowlands (Burgess, 1984, 1985). It is postulated that this shift in population was a response to the well-documented climatic amelioration that occurred during this period (Lamb, 1981). This trend is reversed in the Late Bronze Age, associated with a worsening of climatic conditions. Contradictory evidence is, however, beginning to emerge with the radiocarbon dating of what were originally believed to be later valley-floor and valley-side settlement sites (*e.g.* Lookout Plantation, Milfield Plain, Monaghan, 1994; Hallshill, Redesdale, Gates, 1983). In this case, the comparison of local pollen records from lowland sites with those from the uplands may contribute to debates concerning patterns of upland and lowland human settlement.

Within the Tyne basin, recent and ongoing archaeological research has been carried out under the auspices of the Tyne-Solway Ancient and Historic Landscapes Programme based in the Department of Archaeology, Newcastle University. Associated field-walking of the Lower Tyne corridor is discovering evidence of the presence of Mesolithic and Neolithic communities on the valley floor and valley sides (Tolan-Smith, 1996, 1997b). Work in the North Tyne basin, with the exception of excavations at High Rochester Roman Fort in Upper Redesdale (Crow, 1997), has been less intensive, despite early surveys (Charlton and Day, 1976) which have indicated the presence of human communities in the area since the Mesolithic. Palaeoenvironmental and geoarchaeological work may be critical in establishing the nature and extent of former human activity within the area and allow archaeological research to be directly targetted into the areas most likely to yield finds which will enhance the current understanding of past communities and their associated environment.

1.3 Palynological Records from the North Tyne basin

Whilst many areas of northern England have been the subject of palynological study (*e.g.* the North York Moors, the North Pennines and the Cheviot Hills), a recent review and spatial analysis of published and unpublished pollen records from sites in Northumberland and County Durham has highlighted the absence of pollen sites in central Northumberland (Pratt, 1996; Figure 1.2). Despite containing many potential sites for palaeoecological study, the North Tyne basin is particularly poorly documented, with existing pollen records restricted to peripheral upland mire sites at Steng Moss (NY 965913: Davies and Turner, 1979) and Fozy Moss (NY 830714: Dumayne, 1992, 1993a, 1993b; Dumayne and Barber, 1994). These sites, along with an undated diagram from the lower South Tyne basin at Muckle Moss (NY 800670: Pearson, 1954, 1960) (Figure 1.1) provide the only temporally extensive pollen records from the area. Other studies from archaeological sites, such as ditch fills at Vindolanda in the South Tyne valley (Manning *et al.*, 1997), unpublished work from excavations at Kennell Hall Knowe (see Jobey, 1978 for archaeology) and palaeochannel fills at Snabdaugh (Passmore, 1994; Passmore and Macklin, 1997) in the upper reaches of the North Tyne, represent the only other palynological work in the area.

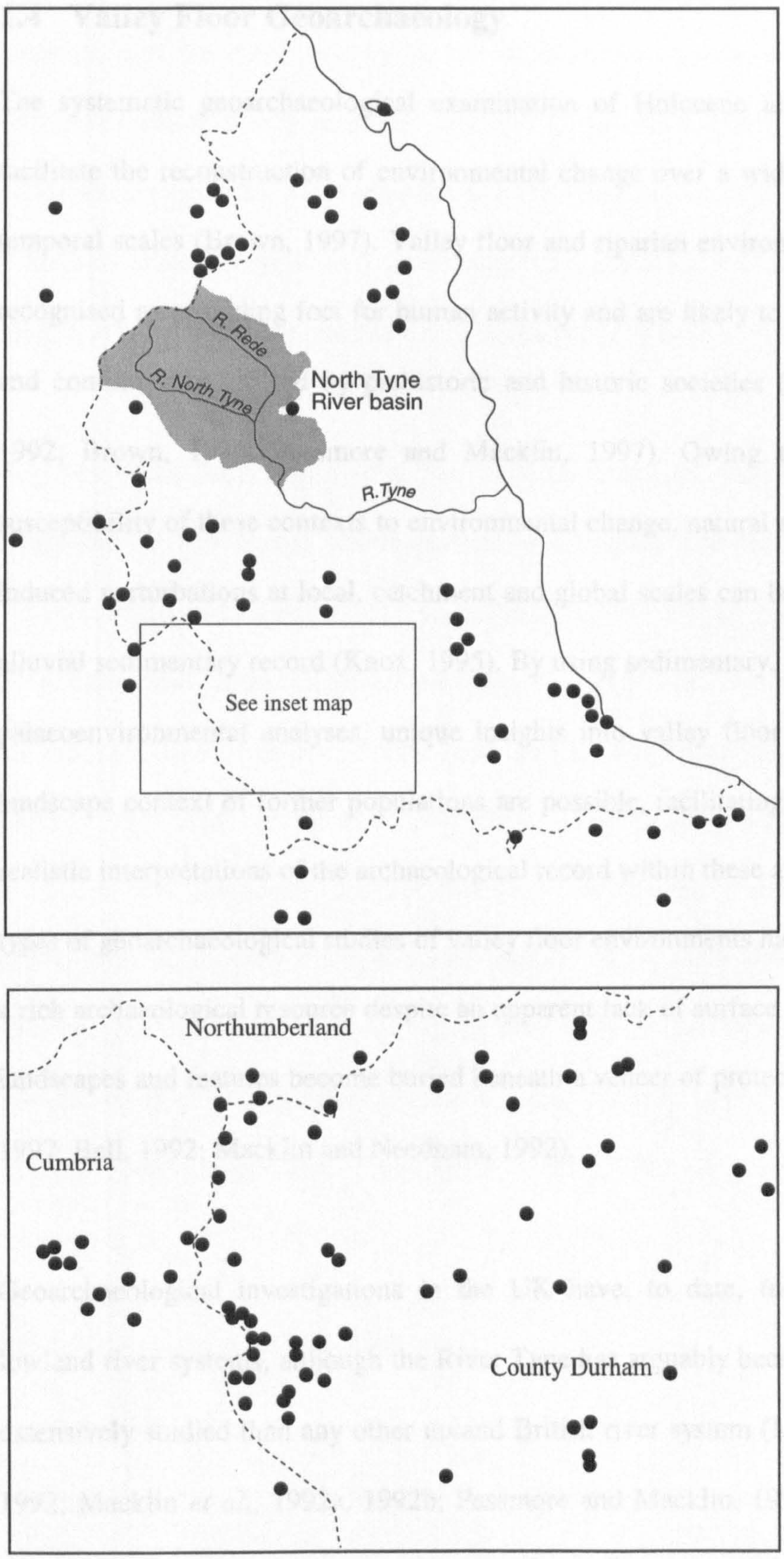
The principal reasons for this spatial gap in existing palynological studies are twofold. Firstly, over recent years there has been increasing attention within the palaeoecological literature concerning the vegetation history of the corridor associated with Hadrian's Wall to answer questions concerning Roman impact (Dumayne, 1992, 1993a, 1993b; Dumayne and Barber, 1994; Manning *et al.*, 1997). Secondly, studies have examined the upland areas of the North Pennines and Cheviot Massif, where deep peat profiles are known to be present and archaeological records are frequently more extensive (Turner and Hodgson, 1979, 1981, 1983; Roberts *et al.*, 1973; Chambers, 1978; Tipping 1992, 1996).

In addition to the peripheral nature of the sites outlined above, each of these records is also focused principally upon the vegetation around the period of Roman occupation of the region in the early centuries AD (*cf.* Turner, 1979; Davies and Turner, 1979; Dumayne, 1993a; 1993b; Dumayne and Barber 1994; Dumayne-Peaty and Barber, 1997; McCarthy, 1995, 1997; Manning *et al.*, 1997). The key questions these studies have attempted to address concern the timing of landscape-scale forest removal in the region and the degree to which it may be regarded as reflecting the increased need for agriculture and / or timber associated with the Roman incursion and the construction of frontier defences, including Hadrian's Wall. These debates over the relative impact of the Romans hinge upon problems inherent with the chronological control and resolution provided by radiocarbon dating frameworks (Dumayne *et al.*, 1995). This is partially due to problems with funding the large numbers of dates required to adequately resolve these questions, but is also a consequence of the magnification of error margins in the dendrochronological radiocarbon calibration curve during the years in question (Stuiver *et al.*, 1986, 1993). Various methods have been put forward to attempt to address these problems, notably by wiggle-matching the calibration curves and 'dragging' dates to known events (Dumayne *et al.*, 1995; Baillie, 1991, Clymo *et al.*, 1990), or by using precisely-dated archaeological sedimentary sequences as a window for pollen analysis (Manning *et al.*, 1997). Nevertheless, questions concerning the relative impact of the Romans remain, with existing evidence suggesting that the timing and scale of forest removal has been spatially variable. Elucidation of patterns of clearance within the North Tyne basin, which lies in the frontier zone beyond the wall, will contribute significantly to this debate.

A further element of concern is the spatial resolution of existing pollen diagrams from the region. The current principal diagrams from the region, Fozy Moss and Steng Moss (*op cit.*), are both large upland mires and reflect a predominantly regional vegetation signal (Jacobsen and Bradshaw, 1981; Figure 2.1). These types of off-site (*sensu* Edwards, 1991b) palaeoecological studies, provide valuable information concerning broad-scale vegetation change and allow both archaeological sites and landscapes to be seen within an environmental context. However, small-scale, local fluctuations in species composition are a relatively diluted constituent in diagrams from these sites (Jannsen, 1973, 1986). As a consequence, small, temporary and early anthropogenic involvement with the vegetation can be extremely difficult to discern (Buckland and Edwards, 1984). For example, the early cultivation of cereals and the onset of agricultural practices are notoriously difficult to identify confidently in pollen records of a regional nature (Edwards and Hirons, 1984; Edwards, 1989; Boyd, 1988; Hall *et al.*, 1993). Coupled to this is the likelihood that cultivation and settlement occurred within valley floor and valley side environments in preference to remote upland areas where conditions were harsher. Organic-rich palaeochannel sediments within floodplain contexts provide a unique opportunity for these local-scale palynological investigations (Passmore and Macklin, 1997).

Due to the relative insensitivity of the palynological record from upland mire sites, many authors (*e.g.* Bradshaw 1988; Edwards 1991a; Huntley 1997) have highlighted the importance of local vegetation records in providing the 'fine-print' with which to complement the more general regional picture. Indeed, Janssen (1986) and Brown (1996) both outline how the use of contrasting pollen diagrams from floodplain and upland localities can allow greater insight into a range of environmental settings. This is a particularly important means of linking archaeological features directly to vegetation records, as regional pollen analysis often presents too general a picture for optimum integration with archaeology (Smith, 1975). Janssen (1981), for example, has used regional pollen diagrams for chronological correlation of major events and local records as evidence for activity at and around specific sites. Huntley (1997), in a recent consideration of the direction of future palaeoenvironmental research in northern England, has also made a plea for the reconstruction of more local vegetation histories with which to correlate the rich archaeological information that is beginning to emerge from the region. When such studies are undertaken, whereby numerous pollen cores are taken from within a relatively limited area, specific loci of activity may be discerned (Tipping, 1992) which in turn may provide further clues to the lifestyles of past human communities.

Figure 1.2: Existing Pollen Sites in Northern England (from Pratt, 1996).



1.4 Valley Floor Geoarchaeology

The systematic geoarchaeological examination of Holocene alluvial sequences may facilitate the reconstruction of environmental change over a wide range of spatial and temporal scales (Brown, 1997). Valley floor and riparian environments have long been recognised as providing foci for human activity and are likely to have been intensively and continuously utilised by prehistoric and historic societies (Waters, 1992; Evans, 1992; Brown, 1996; Passmore and Macklin, 1997). Owing to the sensitivity and susceptibility of these contexts to environmental change, natural and anthropogenically-induced perturbations at local, catchment and global scales can be registered within the alluvial sedimentary record (Knox, 1995). By using sedimentary, geomorphological and palaeoenvironmental analyses, unique insights into valley floor development and the landscape context of former populations are possible, facilitating more meaningful and realistic interpretations of the archaeological record within these areas. In addition, these types of geoarchaeological studies of valley floor environments have frequently revealed a rich archaeological resource despite an apparent lack of surface archaeology as former landscapes and features become buried beneath a veneer of protective alluvium (Brown, 1997; Bell, 1992; Macklin and Needham, 1992).

Geoarchaeological investigations in the UK have, to date, focused primarily upon lowland river systems, although the River Tyne has arguably been more intensively and extensively studied than any other upland British river system (Macklin and Needham, 1992; Macklin *et al.*, 1992a, 1992b; Passmore and Macklin, 1997). Work on selected reaches located predominantly within the South Tyne system has shown that upland rivers are characterised by incised and terraced valley floors, which have been subject to reworking and erosion during later prehistoric and historic times. The alluvial records in these systems are dominated by gravel, deposited as channel bed and bar sediments, with relatively thin fine members and few documented examples of well-developed valley floor peat. This has both inhibited the construction of detailed chronologies to elucidate the phases of valley floor development, and largely precluded palaeoecological study that would provide insights into environmental change.

Recent studies have highlighted the local incidence of valley floor configurations conducive to low-energy sedimentation and organic accumulation, notably in the Southern Uplands of Scotland (Tipping, 1995a, 1995b, 1995c), piedmont rivers draining the Cheviot Hills in Northumberland (Tipping, 1992, 1998; Passmore *et al.*, 1998) and the middle reaches of the North Tyne and Rede (Passmore, 1994; Passmore and Macklin, 1997; Moores *et al.*, 1998). Preliminary investigations in these areas have revealed a well-developed record of Holocene fluvial activity, with the potential to yield information concerning environmental change, valley floor development and human activity. These environments go some way towards satisfying the need for a full integration of palynological records with other disciplines (*e.g.* Macklin *et al.*, 1991; Shotton, 1978; Macklin and Lewin, 1986; Tipping, 1992; Tipping and Halliday, 1994).

1.5 Holocene Alluvial Histories

Elucidating the timing, character and controls upon the development of valley floor environments has been the focus of numerous studies across the U.K. (*e.g.* Harvey, 1985; Macklin and Lewin, 1986; Burrin and Scaife, 1984). These investigations have focused upon episodes of valley floor alluviation and channel abandonment and frequently attempt to link periods of geomorphic change to alterations in climate and / or anthropogenic regimes. Macklin and Lewin (1993) highlight an apparent widespread synchrony of fluvial patterns across a number of U.K. river catchments, which they attribute principally to changes in large-scale (hemispheric) atmospheric circulation patterns. They also draw parallels, in terms of chronology, with documented alluvial histories from both Europe (*e.g.* Becker and Schirmer, 1977, Starkel *et al.*, 1996) and the USA (*e.g.* Knox, 1983). It is concluded that the British Holocene fluvial record is "climatically driven but culturally blurred" (Macklin and Lewin, 1993; Page 119).

Conversely, the effect of anthropogenic disturbance upon fluvial systems has been cited by some authors (*e.g.* Bell, 1982; Burrin and Scaife, 1988) as the principal causal agent controlling Holocene river activity. This would appear to explain the apparent increase in fluvial activity at around 4000 BC in rivers from lowland, southern England, as the timing is concomitant with the technological and agricultural advances associated with the onset of the Neolithic period. Macklin and Lewin (1993) have argued that as upland rivers also appear to exhibit evidence of increased fluvial activity at around this time, despite the relative absence of extensive archaeology, climatic mechanisms must be responsible. However, recent archaeological discoveries are pointing towards a far more intensively utilised landscape during the Neolithic in northern Britain and as a consequence purely climatic controls over fluvial activity during this period may need re-evaluation (Passmore and Macklin, 1997).

To test these competing, although not necessarily mutually exclusive (Macklin *et al.*, in press; Tipping, 1998), hypotheses concerning the controls of alluvial valley floor development, it is important to attempt to design studies that combine proxy records within an individual basin (Tipping 1995a). River basins form discrete, bounded study units within which processes may be analysed at a variety of scales. The establishment of causality is difficult and much current work is equivocal in identifying causal relationships between climate, vegetation, anthropogenic influence and fluvial activity (Bell, 1982; Burrin and Scaife, 1988; Ballyntyne 1991). Recent, basin wide investigations of Holocene alluvial records within the Cheviots and Milfield basin area of Northumberland are beginning to link periods of soil disturbance induced by anthropogenic activity and response within downstream alluvial records (Tipping, 1992, 1998). Likewise, Passmore and Macklin (1994) have linked discrete sedimentary units to upstream anthropogenic activity on a more recent time-scale associated with heavy metal mining in the North Pennines. Further work, using this multi-proxy approach, upon upland British rivers is necessary in order to address the question of causality within the alluvial record.

One of the principal questions pertaining to British Holocene alluvial sequences is whether the absence of dated alluvial units between *ca.* 8000-5200 uncal. BP (*ca.* 7000-4000 BC) (Macklin and Lewin, 1993) and lack of recorded channel abandonment *ca.* 9000-5000 uncal. BP (*ca.* 8000-4000 BC) (Brown, 1996) is genuine. This period may have been extremely stable in terms of British fluvial records, or it may be the case that sites with dateable units of this antiquity have not yet been found. If the climatically driven hypothesis is correct, the U.K. alluvial record should contain similar evidence to both mainland Europe and also the USA, where fluvial discontinuities dating to this period do exist (Starkel, 1985; Knox, 1983). Therefore, attempts to find sites which are likely to contain evidence for early Holocene fluvial activity are potentially very valuable for enhancing not only local alluvial histories but also the enhancement of our understanding of country-wide valley-floor development.

1.6 Thesis Aims

The aims of this thesis are:

1) To provide regional-scale radiocarbon-dated pollen diagrams from the North Tyne basin in order to extend both the spatial and temporal coverage offered by studies of Holocene vegetation histories.
2) To address ongoing debates concerning the nature of former human occupation in the region at an appropriate scale, specifically;
    - to examine palynological evidence of Mesolithic occupation of the North Tyne basin, for which little archaeological evidence exists.
    - to examine the timing and scale of the onset of arable and pastoral agriculture within the North Tyne basin.
    - to analyse the palynological evidence with respect to hypothesised population shifts during the Bronze Age.
    - to examine the palynological evidence for pre-Roman and Romano-British agricultural activity in the area.
    - to analyse post-Roman vegetation dynamics and later human activity.
3) To attempt to analyse the potential of palaeochannel sediments for the reconstruction of floodplain environments via pollen analysis and to provide a geoarchaeological assessment of the value of these contexts.

1.7 Study Area

The North Tyne basin, consisting of the river North Tyne and its principal tributary the River Rede, covers an area of *ca.* 1118km^2, draining the south-western portion of the Cheviot Hills to the north and the Bewcastle Fells to the south and west (Figure 1.1). The North Tyne joins the South Tyne at Warden to form the River Tyne, the ninth largest river catchment in Britain, measured in terms of both drainage area and discharge. The modern area of the North Tyne basin is dominated in the upper part of its catchment by Kielder Forest, an area of commercial forestry planted from 1926 onwards. Remaining land-use consists predominantly of rough pastoral agriculture, which is grazed by sheep, with limited higher-quality grazing and arable agriculture in low-lying valley floor and valley-side locations. Lower Carboniferous group rocks, including coal measures, limestone and Fell sandstone dominate the geology of the catchment. The entire basin lies within the limits of the former Late Devensian ice sheet and as a consequence is mantled by glacial, periglacial and glaciofluvial sediments deposited subsequent to glacial retreat (*ca.* 14,000-10,000 uncal. BP).

1.8 Thesis Structure

The thesis is divided into 8 chapters; Chapter 2 examines the utility of palaeochannels for the purposes of palaeoenvironmental reconstruction, as this forms a key element in the methodology for this thesis. A brief review of the common contexts for palynological analysis is followed by an examination of how a variety of palaeoecological techniques have been applied to valley floor and valley side environments. The application of palynological techniques to alluvial environments is discussed with particular reference to the taphonomy of alluvial pollen. A summary of the sedimentary environments characteristic of floodplains is followed by an outline of palaeochannel formation and subsequent sedimentation. The benefits of palaeochannel sediments for palynological investigation and also their potential for recording flood histories are highlighted.

Chapter 3 details the sites selected for this study and outlines some of the background information for each. The methods employed for the study are also outlined, with particular reference made to how pollen counts were undertaken in the light of the review of palaeochannel sediments in Chapter 2. Previous work upon the concept of pollen deterioration is reviewed and its potential importance acknowledged. Accordingly, the methodologies adopted to attempt to address the concerns are detailed.

Chapter 4 presents the results of analyses from the upland sites examined in this study. For each site the stratigraphy, radiocarbon dating and palynological analyses are detailed. Likewise, Chapter 5 presents the results from each of the valley floor sites. Here, analyses are presented on a terrace by terrace basis in the light of geomorphological mapping. For each terrace the morphology, stratigraphy, dating control and palynology of the associated palaeochannels is described. In addition to this, Chapter 5 presents the results of analyses of pollen deterioration and a discussion of these results and their implications for alluvial pollen taphonomy.

Chapter 6 focuses on Holocene valley floor development and the alluvial geoarchaeology of the North Tyne basin. Discussion includes a consideration of the timing of alluvial episodes in the light of other British and world-wide studies, some preliminary findings in terms of alluvial records of flood histories and also examines the issue of external controls of the fluvial system

Chapter 7 synthesises the palynological and geomorphological findings of this investigation in the light of previous work in the region and further afield. In order to examine specific questions that have arisen from archaeological debates, the discussion is structured on a period by period basis. Particular attention is paid to the variation between palynological records at different spatial scales and the connectivity between archaeological, palynological and geomorphological records. A record of Holocene vegetation change within the North Tyne basin is produced, which encompasses fluctuations at a variety of spatial scales and attempts to include the possible impact of former human communities.

Chapter 8 summarises the principle conclusions and findings of this study and recommends potential directions for future research.

Chapter 2

The Utility of Palaeochannels for Palaeoenvironmental Reconstruction

2.1 Introduction

Holocene palaeochannels within the UK are relatively under-utilised sources of palaeoenvironmental information (Passmore and Macklin, 1997). However, multi-proxy approaches to landscape reconstruction based upon data from palaeochannel sediments can allow insights into the nature of Holocene valley floor vegetation and fluvial activity not attainable from upland peat and lake sediments. This chapter briefly reviews the most commonly employed sedimentary sources of palaeoenvironmental information and outlines the application of palynological techniques to geomorphic contexts. The application of palaeoecological methods within alluvial environments is also reviewed and particular attention paid to the utility of palaeochannels for studies at high spatial and temporal resolutions. In addition, the problems and advantages associated with the taphonomy and provenance of pollen within fluvial sedimentary sequences is discussed and methods outlined which attempt to address these concerns.

2.2 Palynological studies from lakes, bogs and soils

Since pollen analysis was first pioneered by von Post (1916), the sediments utilised for analysis have been largely restricted to peat (*e.g.* Aaby, 1986; Davies and Turner, 1979; Dumayne and Barber, 1994), lake sediments (*e.g.* Davis, 1967; Bonny, 1976;

Pennington, 1979; Peglar, 1993b) and, to a lesser extent, soils (*e.g.* Dimbleby, 1957; 1961a, 1961b; Tipping *et al.*, 1994). This is primarily due to these types of sediment providing the conditions necessary for the preservation of pollen and spores, namely anaerobic, non-oxidising (usually waterlogged) sediment, with a low pH to minimise micro-organism activity. Peat and lake sediments typically provide sediments that have accumulated both rapidly and continuously over millennia, providing the longest chronologies and offering the best temporal resolution.

Numerous studies have examined the relationship between pollen records found within lake and bog sediments and the extent to which they are representative of past vegetation. These taphonomic processes are too extensive to review thoroughly here, but some of the key texts are outlined below. Differences exist in pollen production (Faegri and Iversen, 1989; Davis, 1963; Anderson, 1970), pollen dispersal (Caseldine, 1981; Tinsley and Smith, 1974), pollen deposition (Tauber, 1965, 1967; Jacobsen and Bradshaw, 1981), pollen preservation in sediments (Havinga, 1967; Cushing, 1967; Hall, 1981; Sangster and Dale, 1961, 1964) and pollen survival during laboratory processes (Charman, 1992). It is vital to have an appreciation of all taphonomic processes to correctly interpret pollen diagrams (Lawrence, 1968).

Notwithstanding these taphonomic considerations, reliable reconstructions of former vegetation assemblages can be made through the analysis of fossil pollen from these sedimentary contexts. Indeed, vegetation records spanning the entire Holocene period (and earlier) have been constructed for many areas of the British Isles (see Bell and Walker, 1992), Europe (*e.g.* Woillard, 1978) and the rest of the world. Palynological analyses have assisted not only in the reconstruction of former climatic conditions, but have also aided archaeologists in discerning the extent and character of land-use activities, even where archaeological material is absent or poorly preserved. However, in some cases palynological analyses of the traditionally utilised sediment mediums are inadequate for answering important questions pertaining to local vegetation history and the earliest impact of human societies upon the landscape. For instance, the impact of the first agricultural communities is frequently a difficult feature to discern within off-site pollen diagrams and various methods have been employed to increase the detection rate of palynological indicator species (*e.g.* Edwards and McIntosh, 1988; Turner, 1975; Maguire, 1983).

2.3 Palaeoecological studies from Holocene valley side and valley floor environments

In comparison with vegetation records from lake and peat sediments, relatively little work has been undertaken to elucidate vegetation histories associated with alternative depositional sedimentary sequences, or with linking vegetation records directly to important elements of geomorphic landscape development. Whilst a number of authors have advocated the need for a multi-disciplinary approach to problems concerning past environments (Tipping, 1995a; Macklin and Needham, 1992), this has not been widely forthcoming. This trend is being reversed and a number of examples of successful collaborations between workers in the fields of geomorphology, archaeology and palaeoecology occur (*e.g.* Mercer and Tipping, 1994; Macklin *et al.*, 1991; Burrin and Scaife, 1988; Passmore *et al.*, 1992; Moores *et al.*, 1998).

Palaeoecological methods have provided valuable insights whenever they have been applied to geomorphic contexts, in terms of both highlighting background ecological information and providing clues to the possible controls or mechanisms of landforming processes. A range of palaeoecological methods has been used to elucidate environments associated with geomorphic features, including analysis of molluscs (Robinson, 1978; Shotton, 1978), diatoms (Battarbee, 1986), plant macrofossils (Robinson, 1978; Becker and Schirmer, 1977; Cotton *et al.*, in press), pollen (Harvey *et al.*, 1981) and Coleoptera (Bishop and Coope, 1977).

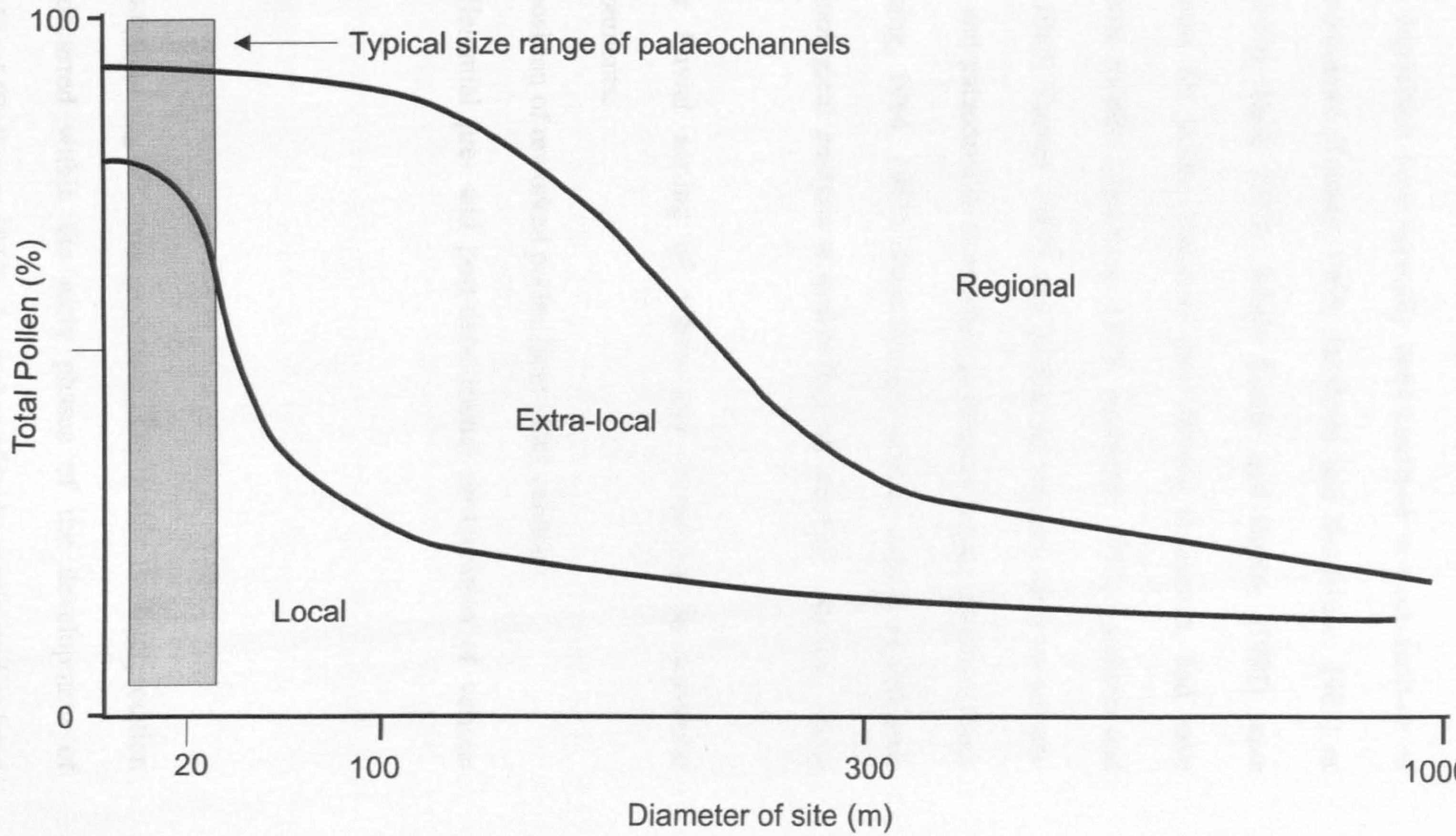
These various palaeoecological techniques have been applied to a diverse spectrum of valley-side and valley-floor landforms. For example, palynological analyses have been instrumental in determining the chronology and controls of Holocene debris cones (Brazier *et al.*, 1988;Brazier and Ballantyne, 1989; Harvey *et al.*, 1981), alluvial fans (Tipping and Halliday, 1994), solifluction terraces (Mottershead, 1977) and landslides (Tallis and Johnson, 1980; Redda and Hansom, 1989) in upland British river valleys. Pollen analysis has also been used by Ballantyne and Whittington (1987) to examine the accumulation and early vegetation history of niveo-aeolian sand deposits. Tipping (1995d) has investigated the development of valley floor peat using pollen and charcoal analyses, sediment stratigraphy and magnetic susceptibility. He identifies three forms of discrete minerogenic banding attributed to different geomorphic processes, thereby allowing a more detailed reconstruction of local environmental history. Similar methods were employed in the analysis of soil (Edwards *et al.*, 1991) and peat erosion (Stevenson *et al.*, 1989) where pollen and other evidence, including minerogenic inwash bands, has indicated the possible impact of human vegetation disturbance upon lakes and peat bog sediments. Dimbleby (1957, 1961a, 1961b) has also employed palynological techniques to assist in the understanding of soil development processes and post-depositional influences on pollen grains. Thus, palaeoecological methods have facilitated a greater understanding of landscape development within a diverse range of geomorphic contexts. Edwards (1979), however, has warned against the over-use of palynological techniques as a chronological tool, advising caution due to differing taphonomic processes, for example, when correlating lake and peat deposits.

2.4 Holocene alluvial contexts

The application of palynological techniques to alluvial contexts is not widely practised in the UK despite the potential shown by some geoarchaeological investigations in the lowlands (Scaife and Burrin, 1992; Burrin and Scaife, 1984; Brown and Keough, 1992) and uplands (Tipping, 1995a, 1995b, 1995c, 1998; Passmore *et al.*, 1992, Macklin *et al.*, 1991; Passmore, 1994; Passmore and Macklin, 1997). This is due partly to the relative abundance of lake and peat bog sites where pollen preservation is known to be good and taphonomic processes are reasonably well understood (Campbell and Chmura, 1994), and also concern over the influence of water currents upon pollen assemblages from alluvial environments (Brown, 1996). Elsewhere in the world, and particularly in arid and semi-arid regions, there is a paucity of 'wetland' sites and palynological methods have been applied more extensively to river terrace deposits and other alluvial features (*e.g.* America: Delcourt and Delcourt 1980; Delcourt *et al.*, 1980; Fall 1987; Martin 1963; Solomon *et al.*, 1982; Freeman, 1972; China: Qinghai *et al.*, 1996). However, while palynological analyses have proved the existence of preserved pollen in these contexts, debate still exists as to how representative these are in terms of vegetation history.

The origins of pollen assemblages found within alluvial sediments are relatively poorly understood, and it is recognised that fluvial processes have a potentially great effect upon the composition of spectra derived from these contexts (Brown, 1996). Limited taphonomic work has focused upon the processes by which pollen is incorporated into alluvial sediments and as a consequence our understanding of the mechanisms is incomplete. A review of the principal concerns over the taphonomy of alluvial pollen assemblages follows and highlights the mechanisms that are potentially responsible for the distortion of records from these environments.

Figure 2.1: The Jacobsen and Bradshaw model of pollen recruitment (from Brown, 1997)



2.4.1 Taphonomy of Pollen in Alluvial Sediments

Alluvial sedimentary environments differ markedly from those traditionally used to model the taphonomic processes associated with pollen records. Models of pollen production, dispersal and deposition have typically been confined to consideration of terrestrial woodland environments (Tauber, 1965; Jacobsen and Bradshaw, 1981) or lake sediments (Bonny 1976; Peck 1973). While Scaife and Burrin (1992) have summarised the mechanisms for pollen transport into alluvial sediments, and have incorporated classic airborne models (Anderson 1970; Anderson 1973; Jacobsen and Bradshaw 1981; Tauber 1965; Tauber 1967) and additional sources such as stream-borne pollen (Peck 1973) and palaeopollen (reworked geological palynomorphs) (Hunt, 1987; Davis, 1961; Cushing, 1964, 1967), there remain several critical taphonomic considerations when palynological analysis is undertaken on alluvial contexts. These include:

(i) The potential for fluvial sorting of pollen and deposition in particular sedimentary environments.

(ii) The secondary deposition of reworked pollen from older contexts.

(iii) The scope for differential pre- and post-depositional preservation of various pollen taxa.

2.4.1.1 Fluvial Sorting

The recognition that an understanding of fluvial processes is critical in the interpretation of pollen assemblages occurred within the early phases of the development of palynology as an analytical tool (Erdtman, 1943). A number of taphonomic studies have been undertaken, although existing work concerning the dynamics of pollen within fluvial systems is both limited, and with respect to certain processes, highly contradictory. Many of these studies are concerned principally with the effect of stream-borne pollen upon the composition of lake sediments (Peck, 1973: Bonny, 1976) and with the hydrodynamic properties of pollen within the water body (Catto, 1985; Brush and Brush, 1972), rather than the taphonomic processes leading to palynological records from alluvial sediments.

The distribution of pollen during transportation within a river system has been studied within rivers of very different characteristics in a variety of countries. It has been established that greater concentrations of pollen are transported during higher discharge events than in base-flow conditions (Federova 1952; Peck, 1973; Brown, 1985; Hunt, 1987; Traverse, 1990; Chmura and Liu, 1990). In most instances, pollen distribution has been analysed across channel cross-profiles, in conjunction with velocity and suspended sediment measurements (Starling and Crowder, 1980; Smirnov *et al.*, 1996). Early studies suggested that pollen, once wetted, acts as any other fine clastic particle and is transported as part of the washload (particles below 0.08mm diameter) (Peck 1973). This implies an even distribution of pollen through the cross-section profile as, along with other fine material, it is kept in suspension by the upward turbulence of the water. This also explains the greater concentration of pollen in floodwaters as high stream powers carry a greater quantity of fine sediment. More recent investigations have indicated a non-uniform distribution of in-stream pollen, with load concentrated in the zone of maximum water velocity and also in the bed-load (Starling and Crowder, 1980). The reasons for this cross-sectional distribution are not fully explained, as it is not clear whether pollen is concentrated in these areas of the stream due to the increased entrainment capacity of the rapidly moving water and the bouncing of particles along the bed of the stream. Starling and Crowder (1980) state that pollen concentration is correlated with the silt portion of the suspended inorganic sediment load and also with fine sediments trapped within the bed material. Smirnov *et al.*, (1996) attribute the cross-sectional variation in concentration found by Starling and Crowder (1980) to a delay in mixing of pollen deposited immediately onto the surface of the water, and that peaks in concentrations close to the bed of the river are due to the resuspension of pollen grains which have previously become adhered to larger particles of sediment. Crowder and Cuddy (1973) also found that overall pollen concentrations in Wilton Creek, Ontario were highest when pollen fell directly onto slow moving water and is thus independent of water velocity and sediment loads. Flume-based experiments by Brush and Brush (1972) also demonstrate that the floating time of most pollen grains was negligible and even the number of winged (saccate) grains that remain floating for any period of time are insignificant, while Campbell and Chmura (1994) found no percentage differences in taxa between samples when analysing pollen distributions in river cross-sections. This contradicts the evidence from within lake environments (Hopkins, 1950; Davis and Brubaker, 1973) where *Pinus* pollen deposited upon the surface remained afloat significantly longer than other taxa. It should be noted, however, that the conditions associated with lacustrine environments are significantly less turbulent than would be expected within a stream or river, although cut-offs may provide still, lacustrine-like conditions following flood-water incursion. Also, movement of instream material is not simply related to particle weight, with channel hydraulics and factors of the bed conditions such as armouring and sheltering effects also influencing transport (Laronne and Carson, 1976).

The inter-species variability in pollen transport has been recognised, if not analysed, by Starling and Crowder (1980) as an important consideration and it is accepted that "some differentiation of types during transport is to be expected" (Brush and Brush 1972; Page 360). Indeed, Muller (1959) has found that modern pollen grains settled gradually and selectively within the (entirely fine-grained) deltaic environment of the Orinoco River, resulting in lighter grains travelling further than heavier ones and being deposited with finer grained sediments. Brush and Brush (1972), Davis (1967) and Crowder and Cuddy (1973) have found, via laboratory experiment, lake sediment traps and fluvial cross-profiles respectively, that each individual pollen type has a particular fall velocity. Despite the fact that lakes and laboratory conditions cannot be directly equated with alluvial environments, it does suggest that pollen spectra within alluvial sediment may be taphonomically biased.

Fall (1987), in a study from Canyon de Chelly, north-eastern Arizona, has grouped several pollen types into those which settle out with clays (*Pinus*, *Quercus*, *Populus*) and those deposited with coarse-grained sediments (Chenopodiaceae-*Amaranthus*, *Artemisia*, other Tubiliflorae). However, these results contradict the findings of Grichuk (1967) who found a greater incidence of coniferous pollen with coarser-grained alluvium. The results of Fall (1987) have been criticised by Hall (1989) who highlights the lack of consideration paid to sorting which results in higher pollen concentrations in fine-grained deposits and that which results in differential sedimentation according to grain-size or morphology. These findings are emphasised by Delcourt and Delcourt (1980), who attribute the larger quantities of pollen deposited with fine sediment to either non-deposition of pollen in coarser sediments (due to rapidly flowing currents), or the post-depositional infiltration of pollen between the sand grains during non-flood river stages. Catto (1985) has also analysed inter-species variability within sediments of different grain sizes, finding *Picea*, *Betula*, *Alnus* and Poaceae in the silt units and Cyperaceae, *Chenopodium*, *Lycopodium* and Ericaceae in the sand strata. Catto (1985) attributes this sorting to the hydrodynamic properties of the pollen grains but this could also possibly be explained by certain pollen grains becoming adhered to larger minerogenic particles or indeed post-depositional factors.

In summary, the depositional pattern of all pollen types can be seen to positively correlate with the silt-fine sand grain-size fraction of alluvial sediments, although small inter-species differences in settling patterns do exist (Peck, 1973; Stanley, 1966; Muller, 1959; Starling and Crowder, 1980; Delcourt and Delcourt, 1980; Brush and Brush, 1972). An indication of the grain-size of the sediment matrix is a useful addition to data upon palynological records from alluvial environments and an element that has been incorporated into this study. Despite these considerations, studies by Smirnov *et al.*, (1996) have concluded that fluvial transport and depositional sorting of palynomorphs is not responsible for major taphonomic error within alluvial pollen records and reliable vegetation reconstructions can be obtained from alluvial sediments (Brown, 1996).

2.4.1.2 Secondary Deposition

The problem of fluvially reworked and secondary deposited pollen can introduce both temporal and spatial errors (Tschudy, 1969; Scaife and Burrin, 1992) and is the major reason why there have been few applications of pollen analysis on alluvial sediments. Temporal error occurs when palynomorphs from previously deposited older sediments are re-mobilised and incorporated into younger material. In some instances these palynomorphs may be recognisable, for example when pre-Quaternary spores are liberated from geological deposits (Cushing 1964; Wilson, 1964; Traverse, 1990), but when catchment soils or older alluvial units are eroded the older pollen and spores may not differ from the contemporary spectra. Spatial error is introduced when pollen originates from an area upstream of the normal pollen source area and is thus transported away from the life setting (Lawrence, 1968). This pollen need not necessarily be of a chronologically different age and may be penecontemporaneous (Cushing, 1964) with the local pollen record.

The predominantly minerogenic and allochthonous origin (Cundill and Whittington, 1987) of most alluvial sediments therefore complicates the interpretation of palynological records from these environments. Previous studies have demonstrated that large quantities of pollen are transported within fluvial systems (up to 97% of the total pollen input to a lake: Peck 1973) and that the greatest concentrations are found in high discharge events (Brown 1985; Traverse, 1990). It has also been found that "even in the most sluggish stream, pollen grains will be transported in suspension" (Hall, 1985; p. 100), and therefore, high pollen concentrations in floodwaters must be derived from previously deposited sedimentary contexts. Scaife and Burrin (1992) highlight the reworking of upper soil horizons and particularly acidic podsol soils as a major source of pollen within alluvial systems (see also Dimbleby 1957, 1961a, 1961b). Brown (1985) has taken this a stage further by using the pollen spectra of in-stream suspended organic load to provenance the sediment source, identifying the components derived from channel banks, hill-slopes or eroding bedrock.

The secondary deposition of pollen is not unique to alluvial sediments and must also be considered during the analysis of lake (Mackereth, 1965, 1966; Davis, 1967) and marine sediments (Manten, 1966; Stanley, 1966). Indeed, in the majority of lacustrine contexts the reworking of surface deposits, which often occurs due to the seasonal overturn of thermally discrete water layers, is frequently considered advantageous, as it produces a smoothed record that is devoid of annual fluctuations (Birks and Birks, 1980). However, alluvium differs from lacustrine sediments in that material from certain contexts is potentially subject to episodic and repeated transfer within the fluvial sediment system. This, therefore, makes the choice of alluvial sedimentary context critical when selecting sites for palaeoecological analyses (see Section 2.5).

By default, fluvial sorting (see Section 2.4.1.1) also has a role in the secondary deposition of pollen (Campbell, in press) as differential resuspension and sorting of pollen occurs according to grain morphology (Davis and Brubaker, 1973). Beaudoin and Reasoner (1992), however, found that this differential focusing of pollen grains was not the case in sediments from Lake O'Hara, Canada. Pollen movement within alluvial systems appears, therefore, to be a factor of the individual site and sediment type.

2.4.1.3 Differential Pollen Preservation

Pollen production varies according to the vegetation type (Andersen, 1967, 1970, 1973), but is commonly measured in millions of grains per m^2 per year. As pollen concentrations preserved within sediments rarely approach this figure, by implication most pollen is destroyed before or soon after its incorporation into the sediment. However, there have been few systematic studies of the processes of pollen destruction

(Campbell, in press). The preservation of pollen in sediments can be related to pre- and post-depositional factors, both of which can have an important bearing on the pollen record contained within alluvial sediments. A number of studies have been undertaken in the context of peat, lake and soil deposits that have considered post-depositional pollen preservation. However, pre-depositional pollen preservation, *i.e.* losses through transport processes, could, in theory, be more important for alluvial pollen records.

Pre-depositional pollen preservation

The pre-depositional preservation of pollen within alluvial contexts is intimately linked to the processes of fluvial sorting and secondary deposition discussed above. Little work has been undertaken upon this topic and the assumption has been that fluvial transport of pollen grains has led to damage through collision with clastic particles (Catto, 1985; Faegri and Iversen, 1989). This is because within non-alluvial deposits, degradation (*sensu* Cushing, 1964, 1967) has been found to coincide with minerogenic lenses in otherwise organic rich profiles (*e.g.* Birks, 1970; Edwards *et al.*, 1991). However, in a laboratory experiment Campbell (1991) found this is not the case and that damage to pollen grains is more likely to result from repeated post-depositional wet-dry phases, as hypothesised by Holloway (1981). Campbell (1991) cites the influence of pollen surface boundary layers (Crane, 1986) in explaining the overall lack of damage to pollen grains and the susceptibility of larger grains to be slightly more affected. Campbell (1991), however, is unclear with respect to his categories of pollen deterioration and does not use equivalent classes to those outlined by Cushing (1964, 1967) and subsequently refined by Birks (1970) and Lowe (1982). All mechanical damage appears to be related to splitting of the pollen wall, rather than an all round pattern of abrasion (degradation) which a number of authors have suggested may be related to pollen transport (Birks, 1970; Cushing, 1964, 1967).

The preservation of pollen within various parts of stream profiles has been analysed by Starling and Crowder (1980). They found, contrary to Campbell's (1991) laboratory experiments, "that pollen in the bed load of the river was more corroded (abraded) than that nearer the surface" (Starling and Crowder, 1980; p. 316). This suggests mechanical abrasion of pollen grains via collision with minerogenic particles, which is likely to be greater at or near the bed of the river. However, once again definitions of deterioration classes are inconsistent as corrosion of pollen grains (*sensu* Cushing, 1964, 1967) are commonly believed to be due to biochemical action (Delcourt and Delcourt, 1980). Smirnov *et al.*, (1996) attribute the findings of Starling and Crowder (1980) to pollen deposition immediately onto the surface of the stream from local sources. They also found spatial heterogeneity in the pollen concentrations of cross-profiles, but attribute this to resuspension of grains from bed material and input from tributaries and aerial sources. Smirnov *et al.* (1996) conclude that fluvial transport of palynomorphs should not cause distortion in the pollen assemblages of sediments.

Post-depositional Pollen Preservation

It has long been recognised that the post-depositional preservation of pollen grains is an important facet of pollen taphonomy and that different species have varying resistance to a range of environmental conditions. Early work on this topic was undertaken by Havinga (1964, 1967, 1985) and Sangster and Dale (1961, 1964) who discovered that different sedimentary environments preserved pollen to varying extents and that lack of oxidation is critical in the survival of pollen grains. Havinga (1964, 1967), following

Godwin (1956) related pollen survival directly to the sporopollenin content of the exine of the pollen grain. From this measure, plus experimental research on a range of taxa, he constructed a hierarchical classification of the susceptibility of pollen grains to post-depositional decomposition. The influence of different sediment types upon pollen survival is particularly critical within alluvial deposits, as significant and abrupt changes in sediment texture, moisture and organic content are common within sedimentary sequences.

Elsik (1966) has also cited the physical morphology of the pollen grain as an important factor in determining the likelihood of non-preservation, with species having a greater surface area more likely to be preferentially removed from the sediment. Fungal attack by chytridiaceous species (Goldstein, 1960) and the bacteria Actinomycetes are also believed to facilitate decomposition of pollen and spore walls (see King *et al.*, 1975; page 182). This process appears to be marked in penecontemporaneous sediments, with the rate of destruction increasing with humification (Königsson, 1969). In common with processes of pre-depositional pollen preservation, wet-dry cycles are also likely to play a major role in post-depositional taphonomy (Holloway, 1981). This is likely to be particularly true of alluvial contexts, where entire sediment bodies are subject to such cycles (Burrin and Scaife, 1984, Waller, 1993; Cundill and Whittington, 1987).

Examples of the exact effect of differential post-depositional pollen preservation are scarce, particularly those which may be relevant to alluvial sediments. However, some studies are of interest here. In particular, the problem with selective decomposition of *Populus* grains has been well documented, with the early work of Sangster and Dale (1961, 1964) highlighting the apparent weakness of the exine of this pollen type. This feature has been held responsible for the under-representation of the species in North-American pollen diagrams (Lichti-Federovich and Ritchie, 1968; Erdtman, 1943) from lake and mire sediments respectively. Conversely, *Artemisia*, Chenopodiaceae, *Taraxacum* type and *Dryopteris* type and other thick-walled pollen and spores are frequently over-represented in alluvial sediments, where decomposition has removed the evidence of most other taxa (Burrin and Scaife, 1984; Lewis and Wiltshire, 1992). Havinga (1963) has found that in sand spectra the dominance of *Alnus* pollen, combined with high *Calluna* values, frequently arose from the decomposition of *Quercus* pollen, previously present in large quantities. This has particular relevance to upland alluvial situations within the British Isles as alder often occurs as a floodplain taxon within heather dominated uplands (Chambers and Price, 1985; Brown, 1988; Tallantire, 1992). Fall (1987) has also found a higher incidence of crumpled and torn pollen within sandy horizons of an alluvial sequence in Arizona. It is not clear whether Fall (1987) attributes this to pre- or post-depositional decomposition of the pollen grains, but Campbell's (1991) laboratory study suggests damage is caused almost exclusively by redeposition of pollen previously subjected to wet-dry cycles and biochemical action.

2.4.2 Summary

The identification of pollen that has been subjected to pre and post-depositional influences can be seen to be of critical importance in the palynological analysis of alluvial sediments. Characteristic physical elements of the pollen grains themselves may facilitate the identification of the potential sources and processes that have led to the fossil record. The preservation state of fossil pollen grains has been used to attempt to derive additional palaeoenvironmental information and to analyse whether the record contained within the sediment is representative of conditions at the time of deposition. The techniques for this, together with a review of the literature and the methodology adopted in this study, are presented in Chapter 3.

2.5 Utility of Palaeochannel Fills for Palaeoenvironmental Analyses

Within alluvial valley fills there are a large variety of sedimentary contexts, with a range of depositional patterns and forms reflecting different sediment regimes and channel and floodplain environments (Allen, 1965; Brown, 1997). These have been classified by Lewin (1992a, 1992b) into 6 prototypes, which can be considered, in combination with their associated lithofacies type (Miall, 1983), for their suitability for palaeoenvironmental analyses.

(i) *Lag Deposits* consist of coarse gravel derived from the basal erosion surface produced by migrating streams. They are unsuitable for palynological studies due to the aerobic and coarse-grained nature of the sediments (Brown, 1996).

(ii) *Channel Deposits* also comprise fairly coarse sediments and are similarly unsuitable for pollen preservation. Features such as channel bed and bar deposits which represent evidence of accretion in meandering and divided gravel bed rivers (Passmore, 1994) are, however, useful in identifying former river courses and can be used for assessing planform changes over time.

(iii) *Channel Marginal Deposits* include crevass splays and levees, which are frequently fine-grained, but tend not to allow water retention (Brown, 1996) and are consequently unsuitable for palynological analysis. Occasionally, in aggrading lowland U.K. river valleys, they have provided useful palaeoenvironmental information where they have been buried by later alluvium (Scaife and Burrin, 1992).

(iv) *Colluvial Deposits* occur within areas of active slope erosion and can consist of reworked material of a variety of grain sizes. Due to the reworked and usually unstratified nature of these deposits they are typically unsuitable for palynological investigation.

(v) *Backswamp Deposits* derive from low energy slack-water environments that are remote from the active channel zone. They can be fine-grained and organic rich and hence suitable for palynological studies. However, this type of environment is typically associated with low-gradient, alluviating floodplains and laterally stable channels and hence are rarely developed in high relief incising upland British river valleys (Macklin *et al.*, 1992a).

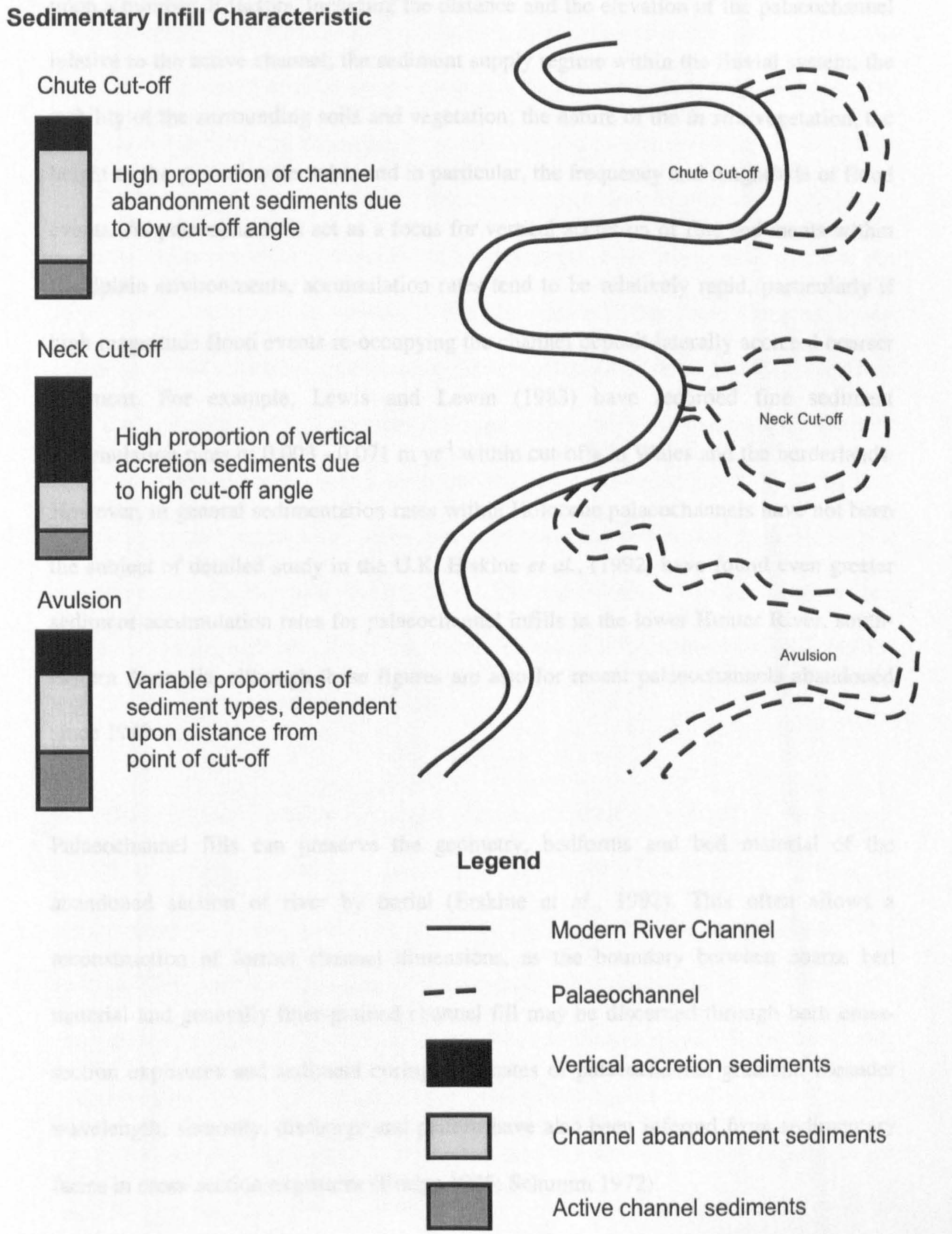
(vi) *Channel Fill Deposits* are variable in character, but tend to be fine-grained, organic and relatively stable, thereby providing a likely source of polleniferous sediment (Delcourt and Delcourt, 1980). They are present in many mid-latitude valley floors prone to channel avulsion and / or cut-off and here palaeochannel features (Schumm, 1972; Chen, 1996) offer ideal opportunities for palynological investigations. The formation, character, processes and benefits of using palaeochannels for palynological study will be considered below in greater depth.

2.5.1 Definition and Formation

Palaeochannels are abandoned river courses that are characteristic of valley floors with channels that are prone to lateral migration or episodic avulsion. They are common on laterally migrating, low gradient reaches of meandering (Leopold and Wolman 1957; Erskine and Melville, 1982) and anastomosing (Schumm 1972; Smith 1983) rivers. Abandonment can occur through a variety of processes the nature of which is believed to be dependent upon slope gradient (Tower 1904). However, only those created by chute, neck and mobile bar cut-off and avulsion (Leopold and Wolman 1957; Lewis and Lewin 1983; Waters, 1992) (see Figure 2.2) are suitable for palaeoenvironmental reconstruction. Of the other processes by which palaeochannels are formed, bend flattening tends to lead to a complex stratigraphy (Erskine *et al.*, 1992) from which interpretations are difficult and artificial cut-offs are generally of a relatively recent origin. Chute, neck and avulsion type cut-offs are useful within palaeoenvironmental studies, as in contrast to many other forms of planform change, such as progressive lateral and downstream meander loop migration, the evidence of channel alteration is not wholly or partially destroyed by the process itself (Schumm, 1969).

Many studies have analysed the dynamics of meander loops in terms of their response to flood events, sediment supply and alterations in anthropogenic activity (*e.g.* Hooke and Harvey, 1983; Hooke, 1984). However, many of these studies have been concerned principally with river channel changes over historic or engineering (*sensu* Hickin, 1983), as opposed to Holocene, time-scales. Nevertheless, it is widely accepted that floods have played a critical role in the formation of palaeochannel features, with channel diversion frequently being associated with high-stage scouring of thalwegs in curved-channel segments (Bridge, 1985). River channels and alluvial valley floors more generally can be seen to be amongst the most sensitive and susceptible environments in the landscape of temperate regions to both changes in hydroclimate (Macklin *et al.*, 1992a) and human agency (Burrin and Scaife, 1988). Frequently, these alluvial environments respond rapidly to small- to medium-scale changes in certain environmental variables (Rumsby and Macklin, 1994) which can be critical in exceeding threshold conditions and disrupting natural equilibria (Schumm and Lichty, 1965; Burrin and Scaife, 1988). Changes in the planform of alluvial valley floors and the development of palaeochannel features may represent distinct changes in climatic and anthropogenic regimes (Macklin *et al.*, 1992a).

Figure 2.2: Types of cut-off leading to palaeochannel formation



2.5.2 Sedimentation Patterns within Palaeochannels

Once abandoned, the sediment accumulation rate within a palaeochannel is dependent upon a number of factors, including the distance and the elevation of the palaeochannel relative to the active channel; the sediment supply regime within the fluvial system; the stability of the surrounding soils and vegetation; the nature of the *in situ* vegetation, the height of the ground-water table and in particular, the frequency and magnitude of flood events. As palaeochannels act as a focus for vertical accretion of fine sediments within floodplain environments, accumulation rates tend to be relatively rapid, particularly if high magnitude flood events re-occupying the channel deposit laterally accreted coarser sediment. For example, Lewis and Lewin (1983) have recorded fine sediment accumulation rates of 0.003 - 0.071 m yr^{-1} within cut-offs in Wales and the borderlands. However, in general sedimentation rates within Holocene palaeochannels have not been the subject of detailed study in the U.K. Erskine *et al.*, (1992) have found even greater sediment accumulation rates for palaeochannel infills in the lower Hunter River, south-eastern Australia, although these figures are also for recent palaeochannels abandoned since 1949.

Palaeochannel fills can preserve the geometry, bedforms and bed material of the abandoned section of river by burial (Erskine *et al.*, 1992). This often allows a reconstruction of former channel dimensions, as the boundary between coarse bed material and generally finer-grained channel fill may be discerned through both cross-section exposures and sediment coring. Estimates of palaeochannel gradient, meander wavelength, sinuosity, discharge and pattern have also been inferred from sedimentary facies in cross-section exposures (Bridge 1985; Schumm 1972).

The precise character of the sedimentary infill is dependent upon both the type and angle of cut-off which the palaeochannel has undergone (Bridge, 1985). Typically utilised models suggest that chute cut-offs (Figure 2.2) tend towards bedload infill at the upstream end, where water velocities can remain relatively high, with progressively finer-grained and organic deposition downstream in slack water conditions (Allen 1965; Bridge 1985; Fisk 1947; Waters 1992). Meanwhile, neck cut-offs (Figure 2.2) tend to be quickly blocked during low stage flows by clay plugs in the slack water areas at the active channel margins. As a result of this, the channel fill is often fine-grained and organic-rich due to suspension deposition from ponded water (Allen 1965; Bridge 1985; Fisk 1947; Waters 1992). Palaeochannel fragments cut off by avulsion events have very different stratigraphies dependent upon the location and relative elevation of the new channel. Avulsion tends to be associated with extreme flood-events, aggradation and tectonic tilting (Bridge and Leeder, 1979; Qinghai *et al.*, 1996) resulting in new channels being significantly lower than former examples and consequently being infilled with fine-grained sediments (Figure 2.2).

The relatively low floodplain elevations of palaeochannels often facilitate the periodic influx and subsequent ponding of floodwaters (Bridge 1985; Waters 1992). This may be compounded by a combination of relatively high ground water levels (Brown and Keough 1992) and the deposition of fine-grained alluvial material in the low energy environment, forming an impermeable basal layer to the palaeochannel that aids water retention (Brown 1996). This enables palaeochannels to remain as perched aquifers after cut-off has occurred (irrespective of whether there is a tendency for net incision of the river, Brown 1996).

Periodic wetting and the water retention properties of these palaeochannel environments typically promote the development of relatively stable floodplain wetlands, in which colonisation by a range of aquatic plant species and the progressive succession and terrestrialisation of the environment (Brown, 1996; 1997; Van der Valk, 1981) is associated with the accumulation of organic-rich sediment. In common with lake and peat bog sediments, the anaerobic conditions which prevail prevent the decomposition of organic material (Moore, 1987b) and these progressively infill the palaeochannel. This is extremely useful from a palaeoecological perspective as not only does it enhance the preservation of pollen and plant macrofossils but also provides organic material for radiocarbon dating and allows insights into successional pathways (Janssen *et al.*, 1995).

2.5.3 Palaeochannel fills as records of flood events

Floods, and particularly moderate-large scale events, play a critical role in fluvial sediment transfers and the development of channel and floodplain environments, and in recent years investigations of palaeoflood hydrology have gained impetus with the recognition that long-term palaeohydrological data will assist the forecasting and management of river channel and floodplain environmental change (Knox, 1995). Particular attention has focused on slackwater facies in arid environments (*e.g.* Baker *et al.*, 1983; Webb *et al.*, 1988; Baker and Pickup, 1987; Enzel *et al.*, 1993) where, in the context of vertically-stable bedrock channels, it has proved possible to reconstruct former flood magnitude and frequency. In temperate regions such as NW Europe, by contrast, estimates of flood frequency and magnitude over Holocene timescales are typically hindered by the paucity of well-dated Holocene alluvial sequences that preserve well-defined sedimentary evidence of individual flood events (Macklin and Needham, 1992; Macklin *et al.*, 1992b; Butzer, 1980). Here, episodes of enhanced Holocene flooding tend to be indirectly inferred from broadly synchronous periods of increased fluvial activity reflected, for example, in meander avulsions (*cf.* Starkel *et al.*, 1996) and episodes of basin-wide alluviation and/or channel incision (Macklin *et al.*, in press).

Lithostratigraphic analysis of organic-rich palaeochannel fills does, however, offer a potential means of accessing readily dateable sedimentary records of flood frequency for moderate to large-scale events that temporarily re-occupy former watercourses. These will be manifested as discrete, inorganic sediment lenses or beds that are interbedded within peaty channel-fill sequences (Erskine *et al.*, 1992; Malik and Khadkikar, 1996; Moores *et al.*, 1998). Using these techniques it may be possible to extend the Holocene flood record beyond documented periods and hence promote analyses of fluvial response to past fluctuations in climate and anthropogenic activity (Costa, 1978).

2.5.4 Palynology of palaeochannel environments

Debates surrounding the taphonomy of alluvial pollen have been outlined above, with the principal cause for concern being the possibility of secondary pollen deposition in alluvial contexts. Palaeochannel sediments may facilitate the identification of reworked pollen grains due to the possibility of a relationship between sediment type and pollen taphonomy. If detailed lithostratigraphic logs are combined with palynological analyses, as recommended by Grichuk (1967), minerogenic rich sediments which are presumed to have a higher proportion of allochthonous pollen, can be investigated and compared with adjacent sediments in terms of their palynomorph content. The analysis of the preservation state of individual pollen grains may also highlight reworked and secondary deposited taxa (Section 2.4.1).

During periods where sedimentation within the palaeochannel is primarily from autochthonous (non-flood) sources, it is assumed that the source of pollen within the sediment will conform to standard models of aerial deposition. Models of aerial pollen transfer have analysed different pathways (Tauber, 1965, 1967) and different spatial areas (Janssen, 1973) when considering the source of pollen in sediments. Jacobsen and Bradshaw (1981) have attempted to combine these models and relate pollen source directly to site size, based upon the fundamental premise that as site size increases so does the area from which pollen found within the sediments originates. On the basis of this, Brown (1996) has surmised that a cut-off feature of approximately 30 metres diameter would have a pollen composition comprised of 8% regional, 13% extra-local and 79% local pollen (Figure 2.1). Palaeochannels are of course very different in size and may experience alteration of their dimensions throughout the period that they are infilling, via truncation by successive younger channels. Unless reoccupation of the palaeochannel occurs these alterations will result in the shrinkage of overall channel dimensions leading to an increasingly local pollen source.

The predominantly local nature of the pollen derived from palaeochannel contexts has important implications for the interpretation of palynological analyses from these sediments (Janssen *et al.*, 1995). Floodplain and immediate valley side vegetation will contribute the majority of the pollen record, with the wider regional vegetation signal contained as a diluted component. Thus, the pollen record will primarily reflect changes in local environmental conditions, with broader-scale fluctuations perhaps reflected in the nature of sedimentation within the palaeochannel. Any human activity within the immediate valley floor environment should register markedly within the pollen record from palaeochannels, whereas such small-scale local changes may not be visible within the wider regional signal from larger upland sites (Bradshaw, 1988). This has particular implications for the detection of the onset of arable agriculture, an important event in prehistory and one which has attracted much attention from palynologists (Edwards and Hirons, 1984). Cereal pollen grains are notoriously poorly registered in the pollen record, as most species are both poor pollen producers and only locally dispersed. This has led to the development of numerous methodologies to attempt to detect cereal pollen grains within large sites with a regional pollen signal (Edwards, 1983; Edwards and McIntosh, 1988; Turner, 1975; Clary, 1989). However, the use of local-scale diagrams can avert this concern, providing that suitable sites for analysis which are proximal to areas of past activity can be found. Palaeochannels may provide just such conditions, as they are adjacent to river corridors known to be a focal point for past human communities and also may be proximal to high, dry terraces suitable for arable cultivation (Passmore and Macklin, 1997). In addition, Bradshaw (1988) has highlighted that the use of sites in which the pollen has been transported only a small distance is the only way to increase the spatial precision of past vegetation assemblages. Many authors have highlighted that this local approach to landscape reconstruction is critical, particularly in the context of archaeological sites (Edwards, 1991a, 1991b; Huntley, 1997).

2.6 Summary

The benefits of palaeochannels for palaeoenvironmental analyses can be summarised:

1. Sediment accumulation within palaeochannels may be relatively rapid, facilitating high temporal resolution analysis of pollen, plant macrofossils and other palaeoecological techniques.

2. Palaeochannels offer relatively stable contexts within alluvial environments and therefore, minimise the likelihood of reworking and secondary deposition of sediment and associated pollen.

3. The waterlogged and stable nature of palaeochannel features may facilitate the preservation of pollen and also organic material, which allows radiocarbon dating of sedimentary sequences.

4. The small site size of palaeochannels means that aerial deposited pollen is of a predominantly local source and records reflect predominantly floodplain vegetation.

5. Palaeochannels are within floodplain areas that are likely to have been preferentially utilised by humans over many millennia and this may be reflected in the palynological record. The proximity of high, dry terraces that may have been used for cereal cultivation is also critical in light of the dispersal characteristics of this type of pollen.

6. The sedimentary sequence within palaeochannels offers the opportunity for the identification and dating of discrete flood units. This may have implications for interpretation of the wider catchment vegetation, human activity and climatic factors.

Chapter 3

Sites and Methods

3.1 Sites

Within the North Tyne basin there are a number of upland sites with potential for palaeoenvironmental investigation. To fulfil the aims of this thesis, in terms of analysing large-scale spatial variability within the pollen record, it was necessary to attain an approximately even distribution of sites across the basin. A further consideration was to find upland sites with a peat sequence containing a long Holocene record and, if possible, rapid sediment accumulation rates to provide the opportunity for high-resolution analyses. Three sites lying within the uplands of the North Tyne catchment, but also distributed between the headwaters and lower reaches of the North Tyne system were chosen (See Figure 1.1).

Initially, it was envisaged that palynological analyses of suitable palaeochannel fills (see Chapter 2) would provide a series of relatively short, high-resolution snapshots of the local vegetation history of Holocene valley floors. It was anticipated that these would facilitate a re-examination of the corresponding periods within chronologically longer upland peat sediment, with a view to directly contrasting vegetation histories at these differing spatial scales. Preliminary analysis of palaeochannel fills at Brownchesters, however, revealed a series of sediments that not only provided dateable records for the almost the entire period of peat accumulation at the upland sites, but also extended the chronological range of sediments to the Early Holocene, for which no upland analogue existed. This prompted a re-evaluation of strategy and it was decided to focus principally upon the valley floor sites, as these provide a unique and hitherto un-exploited opportunity for palaeoenvironmental reconstruction.

3.1.1 Upland Sites (Figure 1.1)

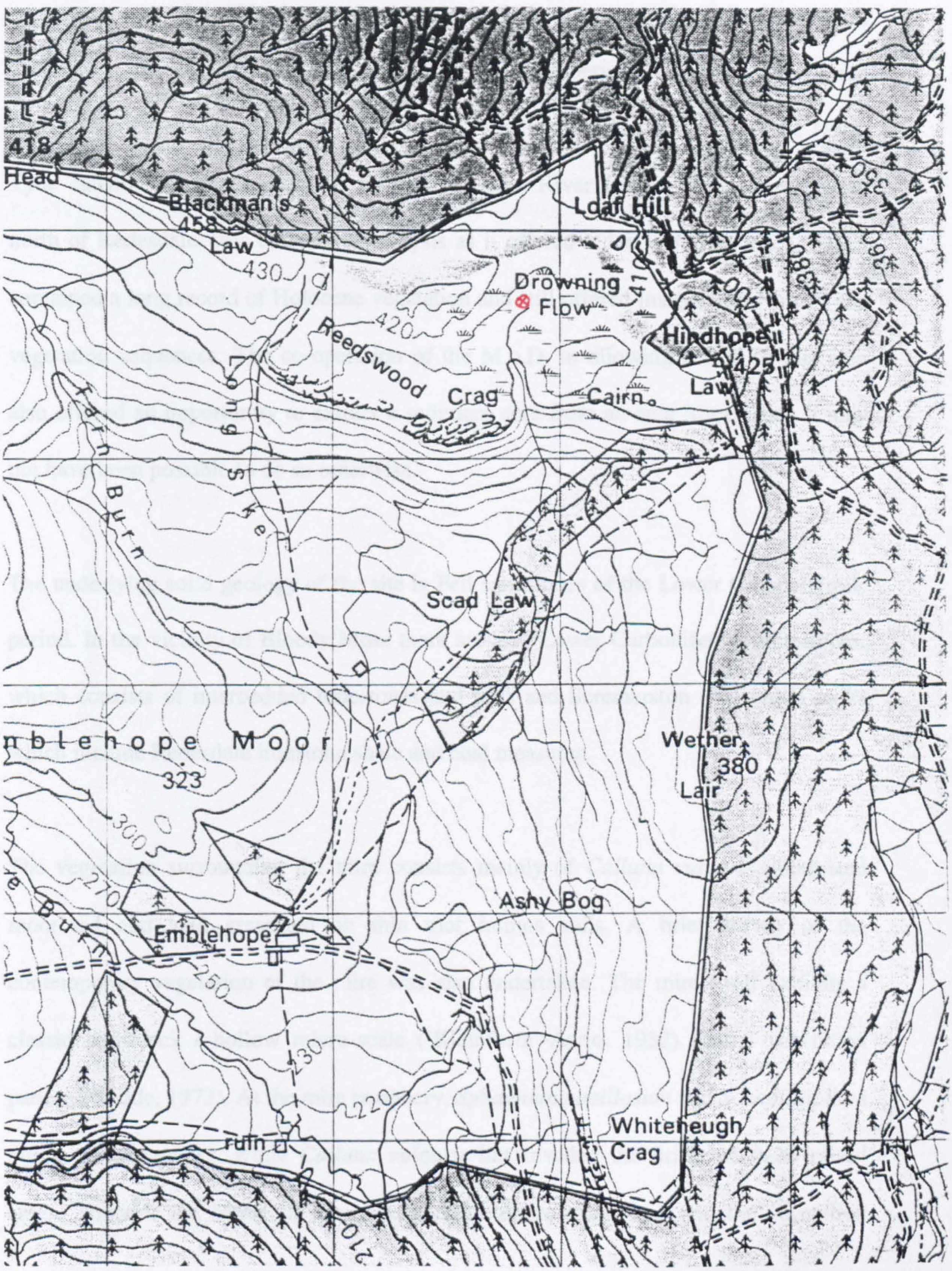
Drowning Flow (Figure 3.1)

Drowning Flow (NY 760975) is an upland blanket / saddle mire (approx. 400m OD) on the interfluve between the headwaters of the Tarset Burn (which drains into the North Tyne) and Hindhope Burn (which drains into the River Rede). The site also lies within the confines of the Northumberland National Park, occupying an unafforested area of moorland between the commercially planted Kielder and Redesdale Forests. It is considerably larger than Bloody Moss measuring approximately one kilometre in diameter. Drowning Flow lies in an area of Lower Carboniferous geology, consisting mainly of Scremerston Coal Group rocks with Limestone group rock outcrops on the nearby Reedswood Crags.

The vegetation surrounding Drowning Flow varies considerably. To the north and east sides there is commercially planted coniferous forest, consisting mainly of Sitka and Norway Spruce. This area is extensively drained and little understory vegetation survives as the trees have all reached canopy closure. The rest of the area surrounding this site is dominated by *Calluna vulgaris* moorland and acid grassland. The mire shows considerable vegetation diversity, possibly as a result of localised peat cutting and drying of the mire surface due to drainage. The mire shows extensive hummock and hollow patterning, which alters in composition according to hydrological conditions. In the drier area hummocks are dominated by *Empetrum nigrum* and *Calluna vulgaris*, with wetter more extensively distributed hummocks consisting of *Sphagnum magellanicum* and *S. capillifolium*. Many large hollows contain natural pools that are dominated by *Sphagnum cuspidatum* and occasionally *Eriophorum angustifolium*. Other species present at Drowning Flow include *Eriophorum vaginatum, Erica tetralix, Sphagnum recurvum, S. papillosum, Cladonia impexa, Narthecium ossifragum, Vaccinium oxycoccus, Vaccinium myrtillus* and *Pleurozium schreberi*.

The peat depth at Drowning Flow was assessed along two perpendicular transects prior to coring. Sediments were not logged during this process, but a location was identified where a total of 7.36 metres of peat was present.

Figure 3.1: Map of Drowning Flow study site



Bloody Moss (Figure 3.2)

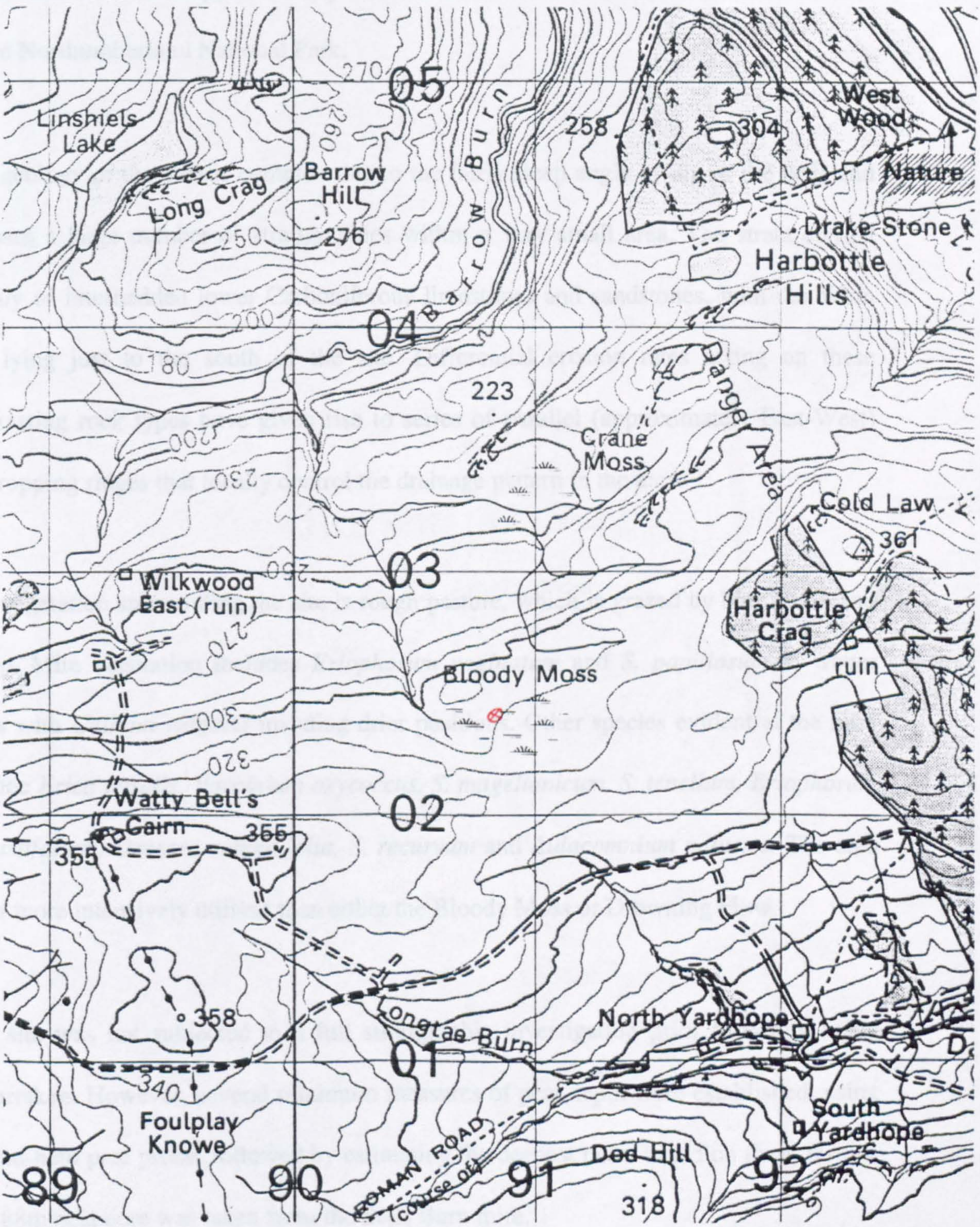
Bloody Moss (NT 910024) lies within the Otterburn Military Training Area, which constitutes part of the Northumberland National Park. It is a small saddle / spur mire (Lindsay *et al.*, 1988) immediately below the interfluve between the West Cleugh and Crane Sike streams at 310 metres OD. The mire, although lying just outside the North Tyne catchment, draining instead into the adjacent River Coquet basin immediately north of Redesdale, was chosen for analysis as it offered a deep peat sequence, which contained a long record of Holocene vegetation and still offered insight into North Tyne vegetation sequences. The co-operation of the M.o.D. in allowing access to this area also offered an opportunity to extract a sediment core from an area from which it may not have been possible to do so otherwise.

The underlying solid geology of the site is Fell sandstones of the Lower Carboniferous period. In the vicinity of Bloody Moss there are also Lower Carboniferous limestones, which consists of interbedded limestones and grits and Scremerston coal group rocks which include Redesdale ironstone shale and coal measures.

The vegetation surrounding the mire consists mainly of *Calluna vulgaris* dominated moorland and acid grassland on thin mor humus soils. A brief survey of the contemporary vegetation of the mire was also undertaken. The mire itself exhibits a classic hummock / hollow micro-scale ('Kleinform'-Aario, 1932) spatial vegetation pattern (Goode, 1973). At the mire periphery, *Sphagnum papillosum* and *S. capillifolium* dominate hummocks, while *Calluna vulgaris* has invaded the driest of these raised areas. Towards the centre of the mire, conditions become wetter and the vegetation grades into *Eriophorum vaginatum* and *S. papillosum*. Other species evident at the mire include *Erica tetralix, Vaccinium oxycoccus, S. magellanicum, S. tenellum, Eriophorum angustifolium, Drosera rotundifolia, S. recurvum* and *Aulacomnium palustre.*

Due to military restrictions concerning the possibility of buried live munitions, no preliminary survey to establish peat depths was possible. Coring was undertaken where peat depth was estimated to be greatest, close to the centre of the mire and recovered a 6.44 metre peat core.

Figure 3.2: Map of Bloody Moss study site



Sells Burn (Figure 3.3)

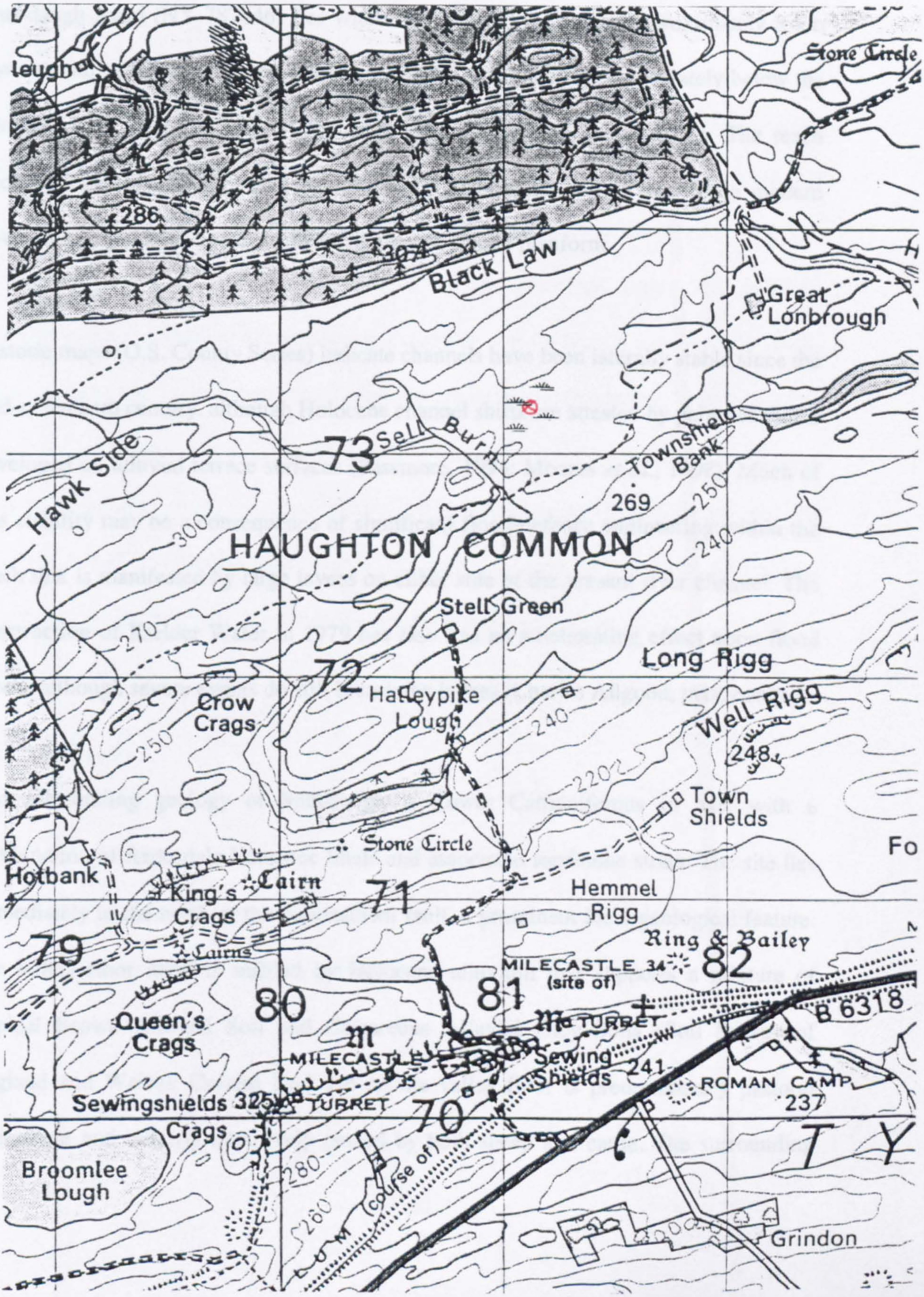
'Sells Burn' (NY 812733) is an un-named blanket mire on the interfluve between Hopeshield Burn, (a tributary of the North Tyne) and Sell Burn (a tributary of the South Tyne). The site lies at approximately 260 metres OD almost at the southernmost extent of the Northumberland National Park.

The geology of the area is complex due to the fairly steep angle of dip of the beds and exposes a large number of stratigraphies within a very small area. The strata consist mainly of interbedded lower Carboniferous limestones and sandstones, with the Whin Sill lying just to the south of the site. Differential erosion rates acting on these contrasting rock types have given rise to series of parallel (approximately East-West) outcropping ridges that locally control the drainage pattern in the area.

The vegetation surrounding the site is rough pasture, which is grazed by both cattle and sheep. Mire vegetation includes *Eriophorum vaginatum* and *S. papillosum* in wetter areas with *Calluna vulgaris* invading drier positions. Other species evident at the mire include *Erica tetralix, Vaccinium oxycoccus, S. magellanicum, S. tenellum, Eriophorum angustifolium, Drosera rotundifolia, S. recurvum* and *Aulacomnium palustre.* The area is far more intensively utilised than either the Bloody Moss or Drowning Flow.

The site was not subjected to a full stratigraphic investigation prior to coring being undertaken. However, several minimum measures of peat depth were established, using a hand-held peat probe, followed by estimating the deepest point based on these results. A 4.88m peat core was taken from the Sells Burn mire.

Figure 3.3: Map of Sells Burn study site



3.1.2 Valley Floor Sites

Snabdaugh Farm

Snabdaugh Farm (NY 787846) lies within the North Tyne basin, approximately 8 km downstream of Kielder Reservoir (catchment area 429 km^2) and immediately below the confluence of the River North Tyne with the Chirdon and Tarset Burns. The reach occupies a small alluvial basin, approximately 750m wide, within which the modern river channel exhibits a gently meandering single-thread planform.

Historic maps (O.S. County Series) indicate channels have been laterally stable since the mid-nineteenth century, although Holocene channel shifts are attested by palaeochannels developed on alluvial terrace surfaces (Passmore, 1994; Moores *et al.*, 1998). Much of this stability may be a consequence of significant flood-defence engineering within the reach that is manifested by large levees on either side of the present river channel. The construction of Kielder Water in 1979 has also had an ameliorating effect upon flood levels, although severe events do still breach the levees (Charles Allgood, pers. comm.).

The surrounding geology of Snabdaugh is Lower Carboniferous in age, with a combination of Redesdale Ironstone Shale and associated sandstone strata. The site lies immediately to the north of the Antonstown fault, a prominent local geological feature. The valley floor itself is infilled by Holocene alluvium that supports a mixture of Typical Brown Alluvial Soil and Calcareous Alluvial Gley Soils (Soil Survey of England and Wales). Current land use on the valley floor is predominantly pastoral agriculture and is fairly intensively grazed by both sheep and cattle. The surrounding valley sides, which are covered with peat deposits and podsolic soils, are used for rough sheep grazing.

Brownchesters

Brownchesters Farm (NY 889922) lies 1 km southwest of Otterburn village on the valley floor of the River Rede (Figure 1.1). The study reach occupies a small alluvial basin up to 600 m wide and extends over a valley length of 1.2 km (Figure 5.1). The modern river channel is deeply entrenched on the east side of the valley floor and, like the North Tyne, exhibits a meandering planform that is locally confined by flood embankments constructed sometime before the mid-nineteenth century. In addition, the river immediately upstream of the study reach features a weir construction and millrace associated with Otterburn Mill. A number of terrace surfaces and palaeochannel features are clearly visible within the study reach. The geology of the Otterburn area is a mixture of Lower Carboniferous limestone group and Scremerston Coal Group.

3.2 Methods

3.2.1 Coring

A variety of coring techniques has been employed in this study, dependent upon the sedimentary environment under investigation.

Upland Sites

The upland sites have all been cored using either 40mm or 80mm diameter Russian peat augers (Jowsey, 1966). This allowed semi-circular sediment cores to be extracted in continuous sub-sections and subsequently extruded into PVC piping. This technique minimises contamination and allows secure stratigraphic control over sampling. These cores were then wrapped using clingfilm and polythene bags for removal and refrigerated storage (4°C) in the laboratory.

Valley Floor Sites

The valley floor sites have all been cored using a pneumatic 'Cobra' corer or, in a few cases, a hand held sand auger. Generally, this was done using a 60mm gouge for sampling material, with 'cleaning drives' to minimise contamination using an 80mm gouge. On some occasions, where stratigraphic conformity could be established beyond question, material from the larger gouge was used to bulk dating samples. Multiple, overlapping cores were taken where recovery proved problematic, with great care again being taken to ensure stratigraphic correlation between cores. In addition, on a few occasions a Stitz piston corer was used in conjunction with the Cobra engine. This technique also allows the intact removal of sediment away from the site.

3.2.2 Sedimentary Logs and Subsampling

Cores taken with the Russian augers were described and sub-sampled in the laboratory. Sediment description was carried out using standardised Troels-Smith methods (Troels-Smith, 1955), with additional data on sediment colours made in comparison with standard Munsell colour charts. Samples were taken from a 1 cm slice of peat and the sampling resolution varied through the core.

Cores taken with either the pneumatic Cobra corer or hand held sand augers were described in the field, prior to sub-sampling. Visual estimates of modal grain-size were noted by comparison with standard Phi-scale geological templates along with sediment structure, composition and colour. Sub-sampling was almost always continuous, but was carried out at varying intervals, dependent on the nature of the sediment. The sampling frequency was increased for sediment which was likely to have accumulated slowly, *i.e.* the organic rich horizons, and reduced for sediment which was likely to have accumulated rapidly *i.e.* coarser, more minerogenic horizons.

3.2.3 Radiocarbon Dating

Assays for radiocarbon dating analysis were sent to Beta Analytic, Florida. All samples underwent standard preparations and counting procedures. Within this thesis all dates are expressed as calibrated calendar ages BC / AD achieved by calibration procedures according to Stuiver *et al.*, (1993), all dates expressed as years BP are uncalibrated radiocarbon dates unless otherwise stated.

Figure 3.4: Prehistoric time-chart showing the correspondence between calendar dates, archaeological periods and radiocarbon dates (not to scale). Adapted from Darvill (1987)

Date (BC / AD)	Geological Period		3 Age System	Archaeological Period		Date ^{14}C BP
1,000,000	Quaternary	Pleistocene	Stone Age	Palaeolithic		
500,000						
100,000					lower	
30,000					middle	
10,000						
		Holocene / Flandrian			upper	10,000
				Mesolithic	early	8500
6000						
					late	6500
				Neolithic		5200
3500					early	
2900						
2500					middle	4000
					late	
2000			Bronze Age			3700
					early	
1500						
1000					middle	2800
600					late	
			Iron Age		early	2300
					middle	
1 BC/AD					late	
AD 43			The Roman Period			1800

3.2.4 Pollen Preparation

Pollen samples from the upland mire sites were prepared using standard pollen techniques (Moore *et al.*, 1991; Faegri and Iverson, 1989). This comprised NaOH digestion to break down organic materials, HF treatment to remove minerogenic material from the sample, acetolysis (acetylation; Charman, 1992) to remove cellulose, followed by staining with safranin and mounting in glycerol jelly.

Pollen samples from the valley floor sites underwent an additional preparation process, prior to staining. This stage aids the removal of what is often a high proportion of minerogenic material from the alluvial samples. This 'Amsterdam' technique (Munsterman and Kerstholt, 1996) uses sodium polytungstenate as a heavy liquid medium for separating pollen and other organic material from silt and clay sized minerogenic particles. This was found to be far more effective than either sieving techniques (Cwyner *et al.*, 1979) or sodium pyrophosphate (Bates *et al.*, 1978; Heusser and Stock, 1984) in concentrating pollen from these types of sediments.

3.2.5 Pollen counting

Pollen counting was undertaken on an Olympus microscope at a magnification of x400 (x1000 oil immersion for problematic grains). A total of >200 tree and shrub species was counted for each level where concentrations would allow. Samples from the valley floor sites were also classified into deterioration categories based upon Cushing's (1964) classification. A review of this methodology is outlined below.

3.3 Methodological Issues

The literature review contained within Chapter 2 has demonstrated that the identification of sediment, or more particularly pollen, derived from older reworked deposits is of fundamental importance to the application of palynological techniques on alluvial sediments. Cundill and Whittington (1987), in their criticism of the interpretation of palynological results from Macklin (1985), outline a number of ways in which these inherent problems with alluvial pollen records can be minimised. These methods have been considered within this study and a number of techniques employed to identify potentially reworked pollen are discussed and applied here.

3.3.1 Deterioration Index

The concept of analysing the preservation state of individual pollen grains was first employed by Cushing (1964) to facilitate limited inferences about pre- and post-depositional taphonomic processes. This system is based upon a classification separating deteriorated (corroded, degraded, crumpled [exine thinned / exine not thinned] and broken) grains from those concealed, indeterminable and well-preserved (Cushing, 1964; 1967). This method has been employed and slightly adapted by a number of authors (*e.g.* Birks, 1970; 1973; Birks and Peglar, 1979; Lowe, 1982; Tipping 1987; Tipping, 1995a, 1995b, 1995c, 1995d; Tipping *et al.*, 1994; Waller, 1993), but has not become standard practice in Holocene palynology. It therefore remains difficult to accurately compare the results of different analysts, despite Cushing's (1967) original pleas and a more recent observation that preservation analyses should become routine (Tipping *et al.*, 1994).

The system does offer a number of possibilities for this study as Cushing (1964) also indicates that the differentiation between corroded and degraded pollen grains may hold clues to their spatial and temporal origin. This is an area that has received relatively little attention, especially with regards to pollen that may have been transported by fluvial processes. Similar techniques have been used to differentiate between fossil and modern grains in pre-Pleistocene palaeopalynology, whereby older grains are seen to exhibit distinctive deterioration (Elsik, 1966) and differential staining (Muller, 1959). The application to Holocene palynology is somewhat more difficult and Muller (1959; Page 9) has gone so far as to state that "the separation of reworked older Holocene pollen from recent pollen is next to impossible." Here, via a combination of techniques, the distinction between reworked and contemporaneous pollen is attempted.

As there has been some confusion regarding the types of deterioration and their probable causes, the precise nature of corrosion and degradation are defined below.

Corrosion

Corrosion usually occurs as localised damage and takes the form of radial perforations or channels in the exine of mature pollen grains that are believed to be caused principally by microbial attack (Cushing, 1964, 1967; Elsik, 1966; Havinga, 1967; Birks, 1970). Four genera of chytridiaceous fungi (Goldstein, 1960) and the bacteria *Actinomycetes* (Elsik, 1971) are believed to facilitate corrosion (see King *et al.*, 1975; Fig.1, p.182) leading to "absorption or enzyme solution of the spore walls rather than physical abrasion" (Elsik, 1966; p. 516). It is particularly prevalent in penecontemporaneous, recently deposited and reworked, pollen (Cushing, 1964) and the rate of destruction can be seen to increase with humification (Königsson, 1969; Birks, 1970). The susceptibility of pollen grains to corrosion also varies between species (Cushing, 1964, 1967; Sangster and Dale, 1961, 1964; Havinga, 1964, 1967), with species such as *Populus* particularly susceptible to post-depositional removal (Sangster and Dale, 1961, 1964) and Filicales spores known to be extremely resistant (Cundill and Whittington, 1987). As mentioned in Chapter 2, wet-dry cycles have been shown to be critical for pollen preservation (Holloway, 1981; Campbell and Campbell, 1994; Waller, 1993) as periodic oxidation increases bacterial activity. This is particularly relevant within fluvial environments in temperate regions, where water tables locally fluctuate upon a seasonal basis. Thus, post-depositional corrosion may occur in organic-rich sediments that are strongly influenced by hydrological regimes. It should also be noted that corroded grains may become remobilised and undergo secondary deposition and thus may also exhibit degradation characteristics.

Degradation

Degraded pollen grains are recognisable by their amorphous nature (Cushing, 1964, 1967; Lowe, 1982), with degradation usually affecting the entire pollen exine. Structural and sculptural elements of the pollen grain become difficult to resolve, with severe examples leading to difficulties in identifying and distinguishing grains from other organic particles. Degradation, along with crumpling and breakage, appears to be correlated with more minerogenic sediments within a number of peat profiles (Birks, 1970; Havinga, 1985). Thus, this form of pollen deterioration has been linked to transportation of pollen grains prior to deposition (Birks, 1970; Cushing, 1967). Lowe (1982), however, has questioned this interpretation stating that the processes responsible for creating amorphous (degraded) pollen grains are not yet known. Additionally, Waller (1993) has identified poor pollen preservation, due to inwash from secondary or penecontemporaneous sources, within the silty horizons of a fluvial profile in southern England. This relationship has been confirmed by the presence of Pre-Quaternary spores within the same facies, although the precise type of deterioration exhibited by the pollen grains has not been discerned.

3.3.2 Methodology Adopted

In this study all pollen grains from alluvial contexts were classified into categories similar to Cushing (1964, 1967) and as used by Birks (1970, 1973), Birks and Peglar (1979) and Tipping (1995d). However, important modifications to the method were made in order to facilitate the identification of any pollen grains that may have been fluvially reworked. Thus, rather than corroded grains being preferentially recorded to degraded grains if the pollen exhibits more than one characteristic, the hierarchy was reversed for the following reasons. Firstly, as outlined above, degradation of pollen grains may originate from mechanical damage caused during transportation of the pollen. Therefore, recording degradation in preference to corrosion may assist the identification of secondary deposited pollen. Delcourt and Delcourt (1980) for example, found a greater proportion of degraded pollen within an alluvial sequence when a completely non-hierarchical classification was used. Secondly, this technique provides a rapid means of assessing the state of pollen preservation without the comprehensive, but complex, 23-class system employed by Delcourt and Delcourt (1980). In addition, crumpled and broken grains were recorded together within a single category, as the mechanisms for the formation of these forms of pollen grain deterioration are believed to be the same. The categories were thus: degraded, corroded, crumpled / broken.

To complement the analysis of the preservation state of each pollen grain, careful sedimentary logs were taken of cores, in order that minerogenic bands more likely to contain reworked pollen could be identified. Grichuk (1967) has highlighted the need for the close correlation of palynological and geomorphological data and Cushing (1967) also noted a relationship between preservation and lithology. Pollen concentration curves were also produced for each alluvial record so that fluctuations in the quantity of pollen within the sediments could be analysed. This would highlight potential percolation of pollen and spores down through the profile (Dimbleby, 1957, 1962) and also sediments with extremely high concentrations derived from *in situ* vegetation (Brown, 1996). Special note was taken of any pollen samples which exhibited unusual floral signatures, such as abnormally high Filicales, *Pteridium* and Compositae liguliflorae values, which may have arisen due to poor pollen preservation (Cundill and Whittington, 1987; Tipping *et al.*, 1994).

3.3.3 Diagram Preparation

Pollen and charcoal diagrams were produced using the computer program Tilia version 2.0 and associated graphing package TiliaGraph version 2.0b.5 (Grimm, 1987). Diagram zonation was undertaken by a combination of the clustering program CONISS (Grimm, 1987) and subjective methods. Pollen nomenclature follows Flora Europaea (Tutin *et al.*, 1964, 1968, 1972, 1976, 1980), with herbaceous taxa arranged in alphabetic order of the family and trees arranged according to standard British practice (*cf.* Godwin, 1975).

The positive identification of cultivated cereal grains has been the subject for much palynological literature (Anderson, 1979; Dickson, 1988; Edwards and McIntosh, 1988). Problems arise due to the morphological similarities between ubiquitous wild grass pollen and the larger cultivated varieties from the same family (Poaceae). Differentiating these types has previously been done on the size of the grain (Firbas, 1937), the diameter of the annulus (Beug, 1961) and the nature of the surface sculpturing (Rowley, 1960; Nilsson *et al.*, 1977). Using a combination of these techniques, Anderson (1979) distinguished 4 distinct groups of grasses that have been used with occasional modification by numerous authors. These are wild-grasses (<37μm), *Hordeum* group, *Avena-Triticum* group and *Secale cereale.* Edwards (1989) has highlighted, however, that frequently problems concerning preservation make full identification impossible and that 'cereal-size' is the closest taxonomic level for some grains. This has also been employed in this study for grains that are large enough to fall into one of the cereal categories. In addition, a 'cereal-type' group has been used to group those grains that exhibit more than one characteristic, but cannot be confidently assigned to a specific group, for instance due to them being obscured or deteriorated in some way. Particular note should be taken of grass species that produce large pollen grains that may potentially be confused with cereals. In the environments dealt with in this study *Glyceria* spp. is particularly likely to occur in the stagnant water conditions provided by palaeochannels.

The summary pollen diagrams within the main body of the thesis (Figures 4.1-4.3, 5.4, 5.5, 5.7, 5.8, 5.10, 5.12) have been constructed for clarity and the emphasis of certain features within the diagram. The composite curves for the 'Other Trees / Shrubs /

Herbs' are constituted by species which attain only low percentages of the overall pollen sum. Composite curves for the 'Anthropogenic Indicators' and 'Cultivated Plants' are derived from species defined by Birks (1990) and Behre (1981, 1988) and have been produced to emphasise periods where these taxa occur together thereby representing anthropogenic involvement with the vegetation.

Cultivated Plants (Behre, 1981)

Secale, Avena / Triticum, Hordeum, Vicia

Anthropogenic Indicators (Birks, 1990)

Artemisia, Bidens, Cannabis, Centaurea, Chenopodiaceae, *Cirsium,* Cruciferae (Brassicaceae), *Filipendula,* Liguliflorae, *Malus, Malva, Papaver, Plantago lanceolata, Polygonum persicaria, Potentilla,* Ranunculaceae (excluding *R. trichophyllus* type), *Rumex, Spergula, Stellaria, Urtica, Valerianella*

3.3.4 Geomorphological Mapping

The differentiation of alluvial and colluvial landform assemblages by detailed field mapping and survey is of primary importance in the interpretation of former landscapes. The identification of discrete terrace units and associated palaeochannels allows an insight into valley floor development and reflects periods when fluvial processes such as incision and alluviation have occurred. Mapping was undertaken to provide a topographical and geomorphological context to pollen and sedimentological analyses at each of the valley floor sites.

Mapping was undertaken by detailed walking of each site, demarcating terrace scarps and palaeochannel features including planform geometry. Relative age differentiation and morphostratigraphic correlation of terrace fragments was also done with reference to aerial photographs, modern and also past editions of Ordnance Survey maps. A number of cross profiles of the valley floor were surveyed using a Leica TC400 total station. Additional spot-heights on terrace fragments and palaeochannels were located between surveyed cross-profiles.

Chapter 4

Palaeoecology of upland bogs and mires

4.1 Introduction

In this chapter, the results of stratigraphic investigations, radiocarbon dating programmes and palynological analyses undertaken upon each upland site are outlined. Within each section, preliminary interpretations of the results are summarised, with discussion of certain problems associated with the results gathered. The full results of the Troels-Smith sediment description (Troels-Smith, 1955) for each site are shown in Appendices 10.3-10.5. Here, only major stratigraphic changes that are significant in the development of the mire are highlighted.

4.2 Drowning Flow

4.2.1 Stratigraphy

The Drowning Flow peat core is dominated by a high percentage of *Sphagnum* peat throughout much of its 736-cm length. Small changes in composition, colour and humification are visible and can be related to changes within the environment conditions at the site. For instance, dark, highly humified peat is suggestive of relatively dry conditions where aerobic decomposition of the accumulating organic matter has had an opportunity to occur due to the length of time spent in the acrotelm before incorporation into the catatelm occurs. Conversely, lighter, less-humified peat suggests rapid accumulation due to wet surface conditions at the bog (Barber, 1985).

A mixture of sand and silt with highly humified peat (720-736 cm) dominates the basal sediments at Drowning Flow. This progressively grades into wholly organic moss and sedge peat and from about 712 cm upward no minerogenic material is present in the core. This mixture of moss peat and sedge peat (Troels-Smith, 1955) continues in varying quantities between 510-712 cm, with some levels also containing small quantities of *in situ* wood remains. This indicates fluxes in woodland at the site, with re-invasion of the mire surface by trees occurring periodically, due either to climatic factors or variations in the intensity of anthropogenic impact at the site. Between 435-510 cm the peat becomes slightly more humified, as proportions of highly humified peat increase, indicating slower peat accumulation possibly due to drier climatic conditions. This beginning of this period dates to *ca.* 2500 BC (Figure 4.4), a time when climate is believed to have affected *Pinus sylvestris* ranges in northern Scotland (Gear and Huntley, 1989) and may have caused the humification changes visible here. This more humified peat is replaced by poorly humified moss peat between 420-435 cm, before reverting to slightly more humified peat up to 247 cm depth. Between 190-247 cm the peat becomes lighter in colour and contains a higher proportion of herbaceous peat (predominantly *Eriophorum vaginatum*), reflecting a change in the vegetation composition of the mire surface at this time. Another well-humified band occurs between 176-190 cm, before moss-dominated peat occurs once again. This principally moss peat continues between 31-176 cm, until below the peat surface detrital plant material occurs (12-31 cm) with more humified peat towards the modern mire surface.

4.2.2 Dating

A total of four bulk peat samples were submitted for radiocarbon dating from this sediment core (Appendix 10.1). The samples were selected to specifically target changes in the palynological record and to derive an accurate as possible chronology for the entirety of the core. The dates were taken at depths of 721-728, 513-520, 305-312 and 181-188 cm (Beta-94637→94634) (Table 4.1). Quoted intercept dates are derived from where the radiocarbon curve intercepts the calibration curve, which is frequently not the same as the calibrated midpoint.

Depth (cm)	Lab Ref. (Beta)	^{14}C Date BP	Calibrated Calendar Date (2σ)	Intercept Date
181-188	94634	1880 ± 50	AD 45-245	AD 130
305-312	94635	2880 ± 70	1265-855 BC	1020 BC
513-520	94636	3940 ± 70	2590-2205 BC	2460 BC
721-728	94637	6030 ± 70	5050-4805 BC	4925 BC

Table 4.1: Radiocarbon dates, lab references and calibrated dates from Drowning Flow

The dates indicate that sediment accumulation rates at Drowning Flow appear to have remained relatively constant, at a rate of around 0.12 cm year $^{-1}$ as seen on the age-depth calibration curves (Figures 4.4 and 4.5). This rate of sediment accumulation is slightly faster than documented rates of raised mire peat formation in Northern England which tend to average approximately 0.07 cm year $^{-1}$ (Barber *et al.*, 1993).

4.2.3 *Palynology* (See Figure 4.1, Appendix 10.7)

Pollen analysis has been undertaken on the entire 728-cm sequence at Drowning Flow to gain an understanding of vegetation change throughout the period during which sediment has been accumulating at the site. The diagram has been divided into pollen assemblage zones in order to aid the description and interpretation of the palynological analyses. Zonation was based upon significant and major fluctuations in the pollen spectra using the computer programme CONISS (Grimm, 1987) and subjective assessment.

Zone A (728-640 cm) (ca. 4925-4000 BC)

This zone is characterised by high percentages of arboreal taxa, with *Alnus* values of around 20%, Coryloid type 35%, *Quercus* 10% *Ulmus* 5% and *Pinus* 5%. Low *Calluna vulgaris* levels of only 1-2% within the zone are the principal reason for the distinction of the zone boundaries. In the lower part of the zone levels of grasses peak at around 20%, combined with Ericaceous values averaging around 10%, indicates partially cleared ground locally within a largely forested wider landscape. In the basal pollen sample (732cm) there are also a number of pollen grains of a variety of herbaceous taxa, (*e.g. Rumex, Succisa*) supporting the possibility of some small-scale woodland clearance. These species may colonise disturbed ground arising from the activities of Mesolithic communities in the area (See Chapter 7). At the top of the zone (640 cm) *Ulmus* pollen frequencies decline markedly, consistent with the elm decline documented across north-west Europe. This chronostratigraphic marker horizon can thus be assigned a date of *ca.* 4000 BC and the zone therefore spans the period *ca.* 5000-4000 BC. This fits very well with the interpolated date, derived from the age-depth diagram (Figure 4.4), a depth of 640cm having an age-equivalence of *ca.* 5200 BP.

Zone B (640-432 cm) (ca. 4000-1800 BC)

This zone is characterised by an increased level of *Calluna vulgaris* values that rise to values of 10-15% of the terrestrial pollen sum. Much of this occurs as a consequence of the virtual disappearance of Ericaceous taxa from a depth of *ca.* 500 cm. Coryloid type values increase slightly, attaining values of over 50% within samples in the middle of the zone. Other tree taxa, including *Alnus*, *Betula*, *Pinus*, *Quercus* and *Ulmus* decline marginally in comparison to Zone A and suggests a continued opening of the forest cover and the development of more scrub woodland and heathland within the landscape. This vegetation response may be due to climatic factors or, more likely the use of these upland environments for grazing purposes, this is discussed further in Chapter 8. Herb presence is slightly more diverse although Poaceae levels decline slightly. The *Sphagnum* curve shows major fluctuations from values of *ca.* 90% of the total pollen sum to just 5%. This could represent changes in response to a combination of climatic and anthropogenic pressure upon the mire surface and the wider environment, as well as local factors affecting spore production.

Zone C (432-272 cm) (ca. 1800-780 BC)

This zone is characterised by rising and sustained high levels of *Calluna vulgaris* pollen (reaching approximately 60%). Much of this rise in *Calluna vulgaris* percentages reflects progressively declining levels of both *Alnus* and Coryloid type. Other arboreal taxa, such as *Quercus* and *Pinus* and also levels of Poaceae, remain relatively static, although herb diversity increases. Overall this zone indicates an increase in anthropogenic impact upon the vegetation, with the continued removal of woodland and its replacement by *Calluna vulgaris* heathland suitable for grazing animals. This is supported by the first appearance of *Pteridium* spores within the zone that are likely to be a consequence of intensified grazing of areas of *Calluna vulgaris*. It is thought that this may equate to expansions in population levels during the Early Bronze Age, which is discussed further in Chapter 7. In addition, the first appearance of large grass pollen grains at the top of the zone indicates that cereals were being grown in the vicinity of the site *ca.* 1000 BC. The *Sphagnum* record also remains highly variable within this zone, indicative of changing moisture conditions upon the bog surface and which could be testament to anthropogenic impact, in terms of cultivation and grazing in the area altering local hydrological conditions.

Zone D (272-144 cm) (ca. 780 BC – AD 610)

This zone is characterised by high *Calluna vulgaris* percentages, although some fluctuations are present in the early part of the zone. *Alnus* and Coryloid type percentages continue to decline, with *Alnus* dropping to values of just 5% at a date of *ca.* AD 130. Herb diversity continues to increase and the first sustained appearance of *Plantago lanceolata* pollen (an important anthropogenic indicator) occurs towards the top of the zone. Levels of grasses and tree taxa such as *Pinus* and *Quercus* show little variation and maintain relatively low percentages of around 5%. The zone is characterised principally by a marked and sustained rise in the levels of *Pteridium* pollen. This may well reflect increased usage of these upland environments for grazing during the Iron Age and Romano-British periods. The occurrence of the species in these quantities is likely to indicate either over-burning or overgrazing of the *Calluna vulgaris* heathland vegetation and is probably a direct consequence of anthropogenic impact.

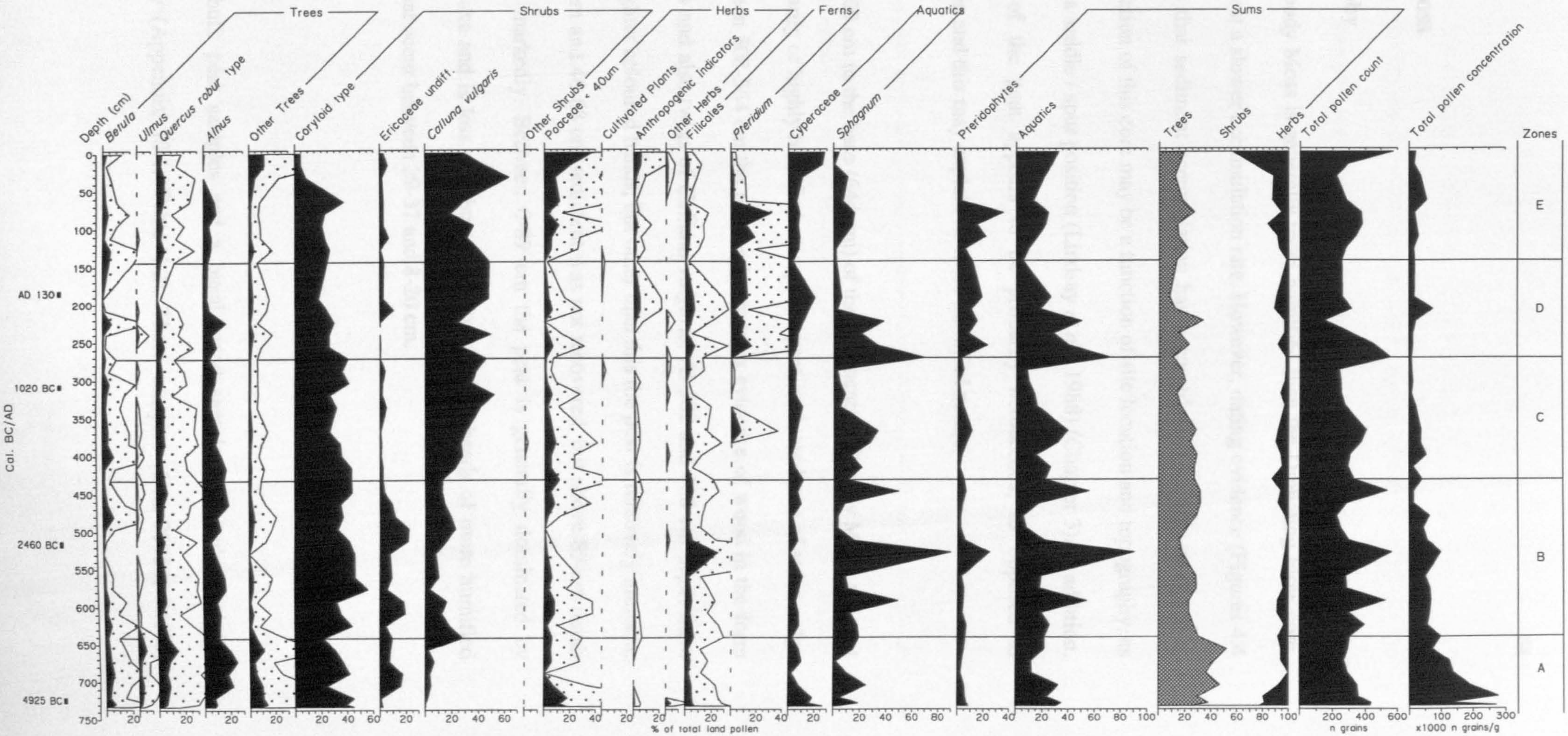
Zone E (144-0 cm) (ca. AD 610 – present)

Calluna vulgaris again dominates this zone, initially falling to around 30% before peaking at *ca.* 70% and then falling once again in the uppermost samples. Levels of both *Alnus* and Coryloid type show a progressive decline through the zone with levels falling to negligible values within the uppermost samples. *Quercus* values increase very marginally throughout and *Pinus* peaks towards the top of the core. The zone has been delimited, however, on the basis of the Poaceae curve that rises through the zone and peaks at around 40%. This indicates a continued deforestation of the area in the latter part of the diagram, with the recent *Pinus* peak related to modern day commercial afforestation (Appendix 10.7). *Pteridium* values decline markedly in the middle of the zone, possibly related to a cessation of intense grazing pressure.

Summary

The 728-cm pollen diagram, spanning approximately the last 7000 calendar years from *ca.* 5000 BC, shows a landscape initially dominated by trees becoming increasingly transformed to *Calluna vulgaris* heathland. Evidence of anthropogenic activity is visible within the diagram, in the form of assorted indicator taxa and cereal pollen. Fluctuations in the *Sphagnum* curve may provide indications of large-scale climatic fluctuations although other evidence suggests that these may be masked by anthropogenic activity altering local hydrological conditions and the highly variable production of spores by this species.

Figure 4.1: Drowning Flow
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

4.3 Bloody Moss

4.3.1 Stratigraphy

The core from Bloody Moss is generally more humified than the Drowning Flow core, which would suggest a slower accumulation rate. However, dating evidence (Figures 4.4 and 4.5) indicates that sediment accumulation has occurred more rapidly at this site. Enhanced humification of this core may be a function of site location and topography, as the mire occupies a saddle / spur position (Lindsay *et al.*, 1988) (Chapter 3). In addition, the composition of the peat appears to be primarily herbaceous, as opposed to bryophytic in origin and this may explain its more humified nature.

From a depth of 100 cm to the base (644-cm) of the sediments at Bloody Moss, the peat is composed primarily of highly humified amorphous peat, with evidence of some sedge component. Between 508-564 cm the peat body contains evidence of wood in the form of birch fragments and also twigs of *Calluna vulgaris*. At 382 and 400-cm depth there are two slightly lighter coloured bands, but other than this the peat is relatively uniform. Between 89-100 cm and 46-68 cm sediment was not recovered, but above 89-cm depth the peat changes markedly. Between 0-89 cm the peat is generally dominated by *Sphagnum* moss taxa and is less well-humified. Two distinct bands of more humified and herbaceous peat occur between 29-37 and 8-20 cm.

4.3.2 Dating

A total of two bulk peat samples and a basal wood sample were submitted for radiocarbon assay (Appendix 10.1: Table 4.2). These samples (Beta-90754, 94633, 94632) were taken from depths of 590-595, 421-428 and 221-228 cm. These dates demonstrate an approximately constant accumulation rate of approximately 0.12 cm year^{-1} which can be seen on the age-depth calibration curve, Figures 4.4 and 4.5.

Depth (cm)	Lab Ref (Beta)	^{14}C Date BP	Calibrated Calendar Date (2σ)	Intercept Date
221-228	94632	1290 ± 110	AD 575-990	AD 705
421-428	94633	2900 ± 70	1285-900 BC	1045 BC
590-595	90754	4930 ± 80	3940-3845 BC, 3830-3620 BC, 3575-3535 BC	3700 BC

Table 4.2: Radiocarbon dates, lab references and calibrated dates from Bloody Moss

4.3.3 Palynology (See Figure 4.2, Appendix 10.8)

Palynological analyses have been carried out on the full sedimentary sequence from Bloody Moss (Figure 4.2). Zonation was based upon significant and major fluctuations in the pollen spectra using the computer programme CONISS (Grimm, 1987) and subjective assessment.

Zone A (644-532 cm) (ca. 4375-2800 BC)

This zone is characterised by rising values of Coryloid type pollen (35-40%), fluctuating *Calluna vulgaris* levels (20%) and decreasing *Alnus* values (25-10%). Levels of *Betula*

(10%) and *Quercus* (5%) remain relatively constant through the zone, while *Pinus* values of around 5% are likely to relate to long distance transport (Huntley and Birks, 1983). *Ulmus* values fluctuate slightly between 2-5% and also disappear from some samples. Herb presence within this zone is sparse although small peaks in Poaceae occur, along with species indicative of anthropogenic impact, such as *Filipendula* and *Rumex crispus*. This zone appears to represent a relatively open landscape, consisting of a combination of hazel scrub and heather moorland. Limited birch, oak and alder cover is also present, although much of this is likely to have occurred at slightly lower altitudes.

Zone B (532-244 cm) (ca. 2800 BC- AD500)

This zone is characterised by a stepwise transition from a landscape with plentiful Coryloid type scrub towards the dominance of *Calluna vulgaris* moorland. *Calluna vulgaris* percentages rise from around 20% at the bottom of the zone to almost 80% at the top with Coryloid type dropping concomitantly from values of 40% to 15%. *Alnus* values decline through the zone in a stepwise fashion from around 15% to *ca.* 3%. *Quercus* and *Ulmus* values fall, with *Betula* levels remaining around 10%. Quantities of Ericaceous taxa increase, fluctuating slightly, with occasional peaks of around 15%. Levels of herbaceous taxa also increase both in terms of quantities and diversity. Poaceae species show a progressive increase through the zone, with the exception of the top samples where levels are temporarily reduced. Of the other herb taxa anthropogenic indicator species, such as *Plantago lanceolata* and cereals become visible in the pollen record for the first time. This appears to suggest increasing using of these upland environments during the Late Neolithic and Bronze Age periods.

Zone C (244-0 cm) (ca. AD 500 – present)

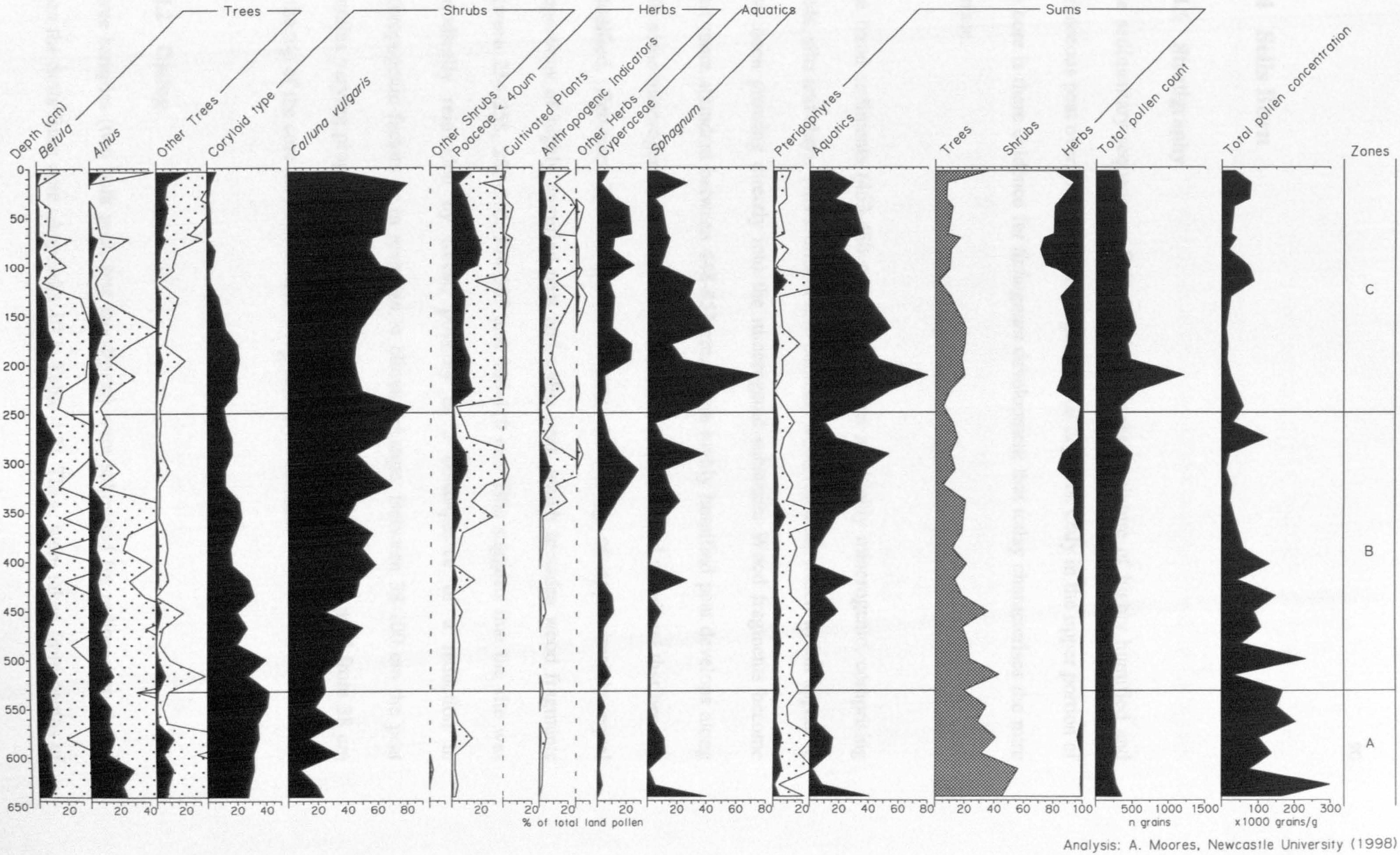
The early part of the zone shows a temporary regeneration of a number of woodland taxa, including small rises in *Alnus*, *Quercus*, *Betula*, *Salix* and *Fraxinus*. Coryloid type values again exceed 20%, whilst *Calluna vulgaris* drops to around 40%. This suggests a reduction in grazing intensity within this upland environment, although the continuous presence of cereals and other anthropogenic indicator taxa may relate to a decrease in the extent of agriculture and a switch to more locally intensive techniques. The temporary increase in trees may relate to the site's position with respect to the Roman frontier, as forest regeneration occurred following the withdrawal of troops from the region (Chapter 7). This is, however, short-lived and *Calluna vulgaris* values recover to around 80% at a depth of approximately 110 cm. This is combined with a decline in almost all arboreal taxa, many of which become virtually absent from the rest of the diagram. Only within the uppermost samples does *Pinus* show a slight rise, which can be related to commercial afforestation within the region (Charlton, 1987). A number of herbaceous taxa show continuous percentages through the zone, including cereal pollen and other anthropogenic indicators. The zone is characterised by a rise in Poaceae pollen which fluctuates slightly but which consistently has values of *ca.* 15%. *Sphagnum* values fluctuate markedly in the zone and may indicate an increase in anthropogenic activity within the area. Overall, the zone reflects an open *Calluna vulgaris* dominated landscape, with little tree cover and probably small areas of grassland within which cereal cultivation was occurring.

Summary

The diagram demonstrates a progressive and stepwise transition from an upland landscape dominated by hazel scrub and *Calluna vulgaris* heath with a few isolated stands of trees to one almost entirely dominated by heathland and grassland. This change in the landscape occurs over a period of around 2000 years, between approximately 3000-1000 BC. Increasing levels of herbaceous taxa, grasses and also cereal pollen indicates evidence of anthropogenic involvement in this transition.

Figure 4.2: Bloody Moss

Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

4.4 Sells Burn

4.4.1 Stratigraphy

The sedimentary sequence at Sells Burn comprises a mixture of highly humified and herbaceous peat overlying very minerogenic basal deposits. Only in the upper portion of the core is there evidence for *Sphagnum* development that today characterises the mire surface.

The basal sediments (453-488 cm) at Sells Burn are highly minerogenic, comprising sands, silts and clays. This sediment also contains wood remains, which would appear to have been growing directly into the minerogenic substrate. Wood fragments become even more abundant between 448-453 cm, where highly humified peat develops along with some minerogenic sediments. This indicates a birch / hazel woodland that became paludified. Between 200-448 cm is a peat comprising of approximately equal proportions of highly humified peat and sedge peat, which includes wood fragments between 254-258, 288-310, 374-385 and 406-410 cm. This suggests that the site was periodically reinvaded by forest, possibly as a consequence of a reduction in anthropogenic factors or in response to climate change. Between 38-200 cm the peat contains varying proportions of sedge peat and highly humified peat, until from 38 cm to the top of the core the moss content progressively increases.

4.4.2 Dating

Three samples (two bulk peat, one wood/peat) were submitted for radiocarbon dating from the Sells Burn core (Appendix 10.1: Table 4.3). These were taken from depths of

213-220, 313-320 and 449-456 cm returning dates of BC 1045-825, BC 1965-1630 and BC 4090-3810 respectively. In common with the Bloody Moss and Drowning Flow cores these dates provide a relatively constant rate of sediment accumulation throughout the period analysed, averaging 0.08 cm yr^{-1}. This can be seen on the age-depth calibration curve, Figures 4.4 and 4.5.

Depth (cm)	Lab Ref. (Beta)	^{14}C Date BP	Calibrated Calendar Date (2σ)	Intercept Date
213-220	94638	2800 ± 50	1045-825 BC	925 BC
313-320	94639	3490 ± 70	1965-1630 BC	1765 BC
449-456	94640	5180 ± 60	4090-3925 BC, 3875-3810 BC	3975 BC

Table 4.3: Radiocarbon dates, lab references and calibrated dates from Sells Burn

4.4.3 Palynology (See Figure 4.3, Appendix 10.10)

Zone A (464-400 cm) (ca. 4100-3200 BC)

This zone is characterised by pollen of several arboreal taxa, with *Betula* (30%), *Alnus* (20%) and Coryloid type (25%) and to a lesser extent *Quercus* (5%) dominating. All of these taxa fluctuate within the zone, indicating the dynamic, non-stable nature of the woodland that prevailed during this time. Herb presence in the zone is low, with only traces of Poaceae and taxa indicating anthropogenic disturbance, such as *Stellaria holostea* and *Rumex* type. Fern spore levels are very high in the basal pollen sample, however, this is characteristic of poor pollen preservation within these deposits (Tipping *et al.*, 1994, Cundill and Whittington, 1987), rather than a genuine Pteridophyte dominated landscape. Levels of aquatic species are extremely low within this zone. This zone can therefore be seen to represent a wooded landscape dominated by birch, alder and hazel and to a lesser extent oak, with relatively little open ground herbaceous flora.

Zone B (400-160 cm) (ca. 3200-75 BC)

The early part of this zone is characterised by a rapid decline in *Betula* and *Alnus* percentages and the rise of percentages of *Calluna vulgaris*, which quickly attains levels of 20% of the terrestrial pollen sum. Coryloid type and also *Quercus* percentages remain relatively stable throughout the zone. At *ca.* 320-cm *Alnus* levels recover, with a corresponding decline in *Calluna vulgaris* values. *Alnus* then declines progressively through the zone, whilst *Calluna vulgaris* values recover, with some peaks reaching 35%. The first appearance of Ericaceous taxa also occur at the same time as the early rise in *Calluna vulgaris*, although they achieve a representative values of only around 10%. Herb presence is moderately more varied in this zone, although Poaceae levels remain low. Significantly, anthropogenic indicator taxa, (including *Plantago lanceolata*) achieve a constant presence. Cyperaceae levels also increase in a similar fashion slightly higher up the core. This zone represents a rapid transition from a wooded environment to a landscape with a high proportion of heathland and probably patches of forest.

Zone C (160-48 cm) (ca. 75 BC – AD 1300)

This zone is characterised by the rapid decline in all arboreal taxa and the rise in *Calluna vulgaris* percentages to over 80% of the terrestrial pollen sum. The *Alnus*, *Betula* and Coryloid type curves all demonstrate similar profiles, with a decline followed by a brief regeneration at approximately 100-cm depth. The recovery of woodland is matched by a peak in the levels of grasses and suggests a brief cessation of grazing activity leading to re-invasion by trees, with specific areas cleared and covered by diverse herbaceous vegetation. The first occurrence of cereal pollen occurs at this depth and suggests a transition in the nature of anthropogenic manipulation of the natural vegetation. A large peak in *Sphagnum* coincides with the initial forest-heath transition and reflects the changing hydrological conditions associated with an alteration of the vegetation.

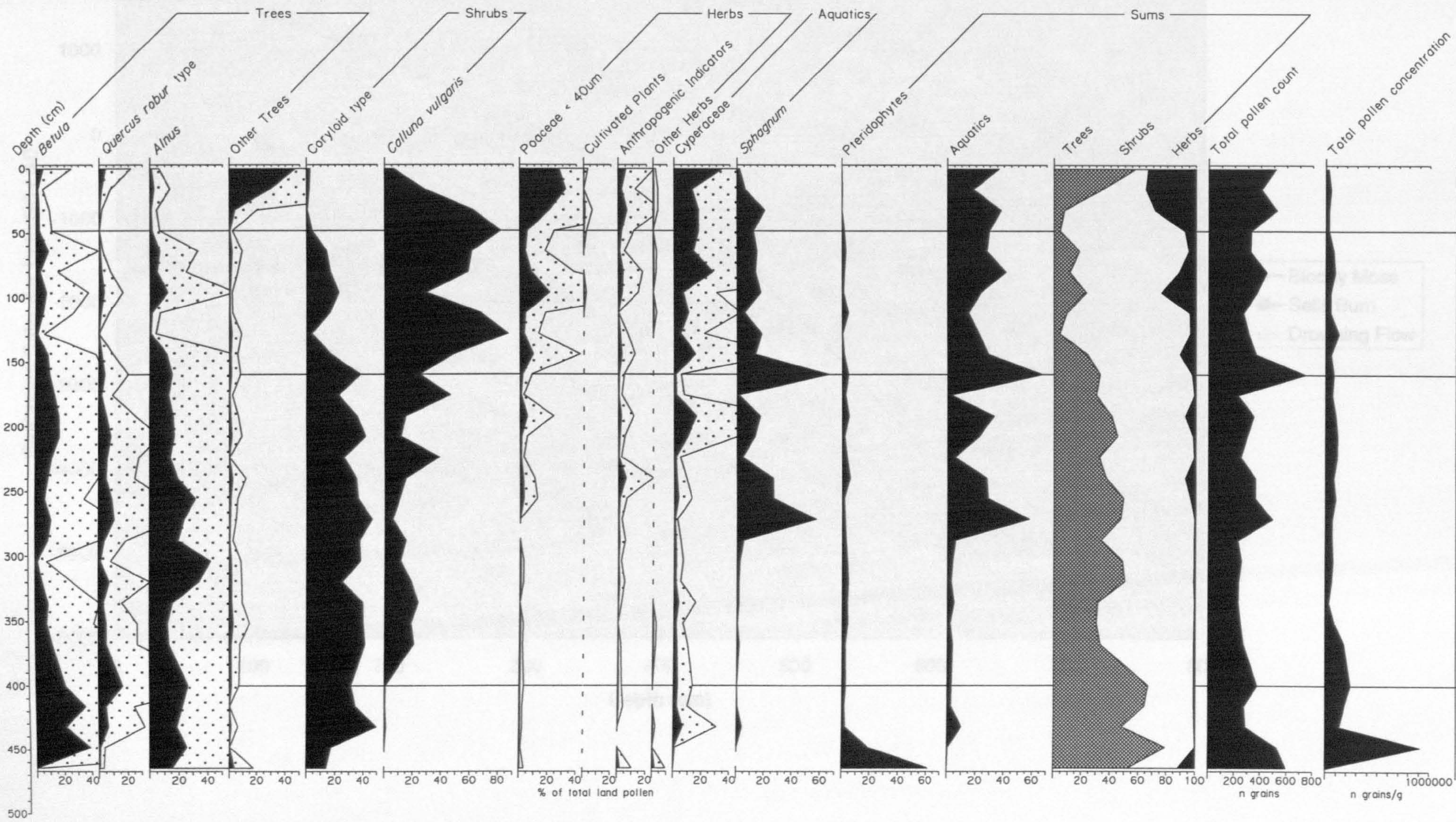
Zone D (48-0 cm) (ca. 1300 AD – present)

This zone contains only a few pollen samples, but is markedly different in character to Zone C. *Calluna vulgaris* values decrease from around 80% to just 10% of the pollen sum, without any response in the *Alnus*, *Betula* or Coryloid type curves. The decline in heathland is marked by increases in both the *Pinus* curve and also the Poaceae curve, with a number of other herbaceous taxa also demonstrating small peaks. This is likely to reflect the onset of commercial afforestation and the advent of extensive farming practices in the area around Sells Burn. Cereal pollen also becomes continuously present, although in small quantities.

Summary

The diagram from Sells Burn contains a higher percentage of arboreal taxa than the other upland diagrams presented here. This is probably due to the lower altitude of the site and its topographic position. The transition to heathland dominated vegetation occurs slightly later at this site and is combined with small incidences of anthropogenic indicator taxa and cereal pollen.

Figure 4.3: Sells Burn
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

Figure 4.4: Calibrated Age Depth Curve for Upland Sites

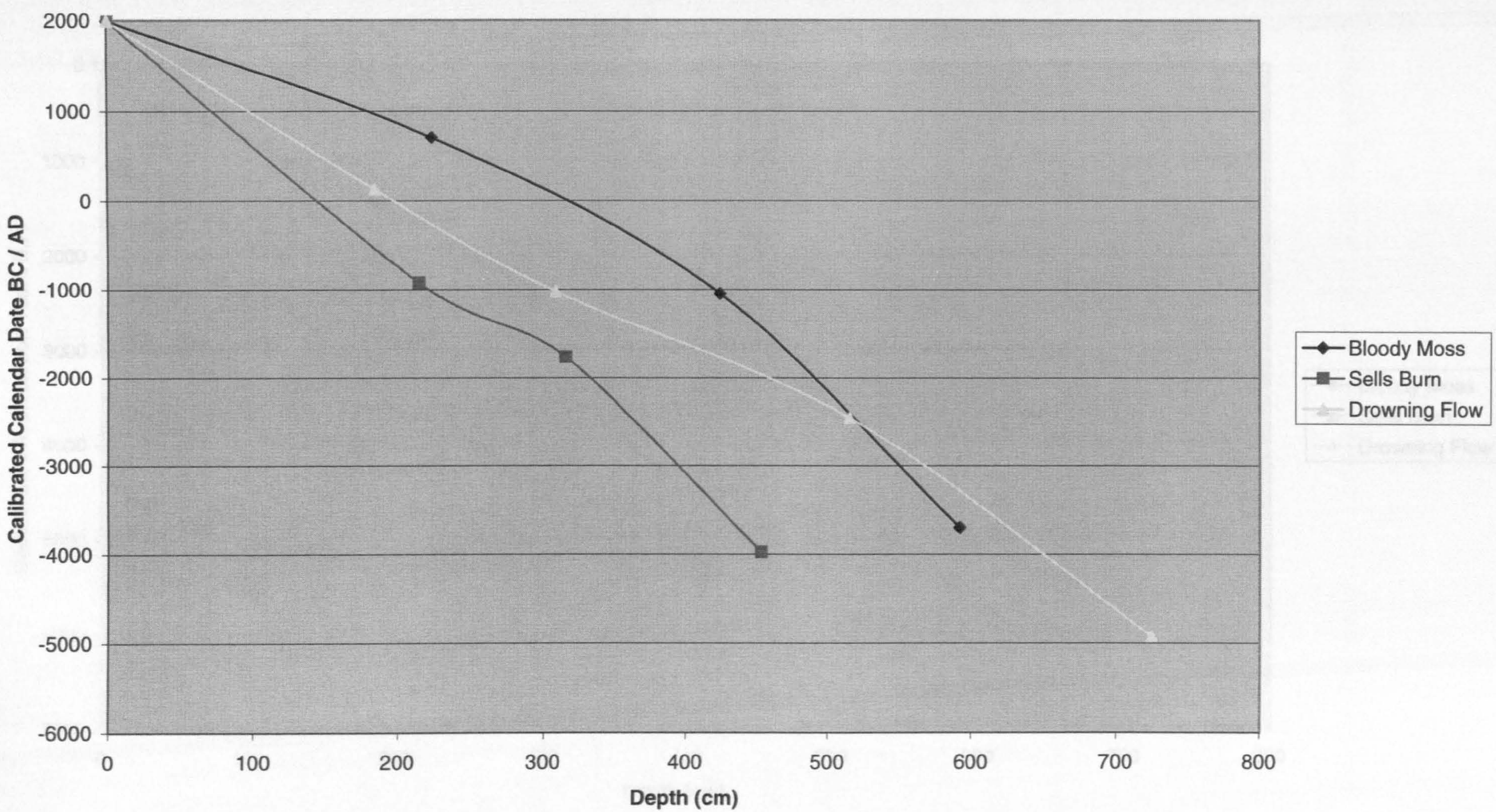
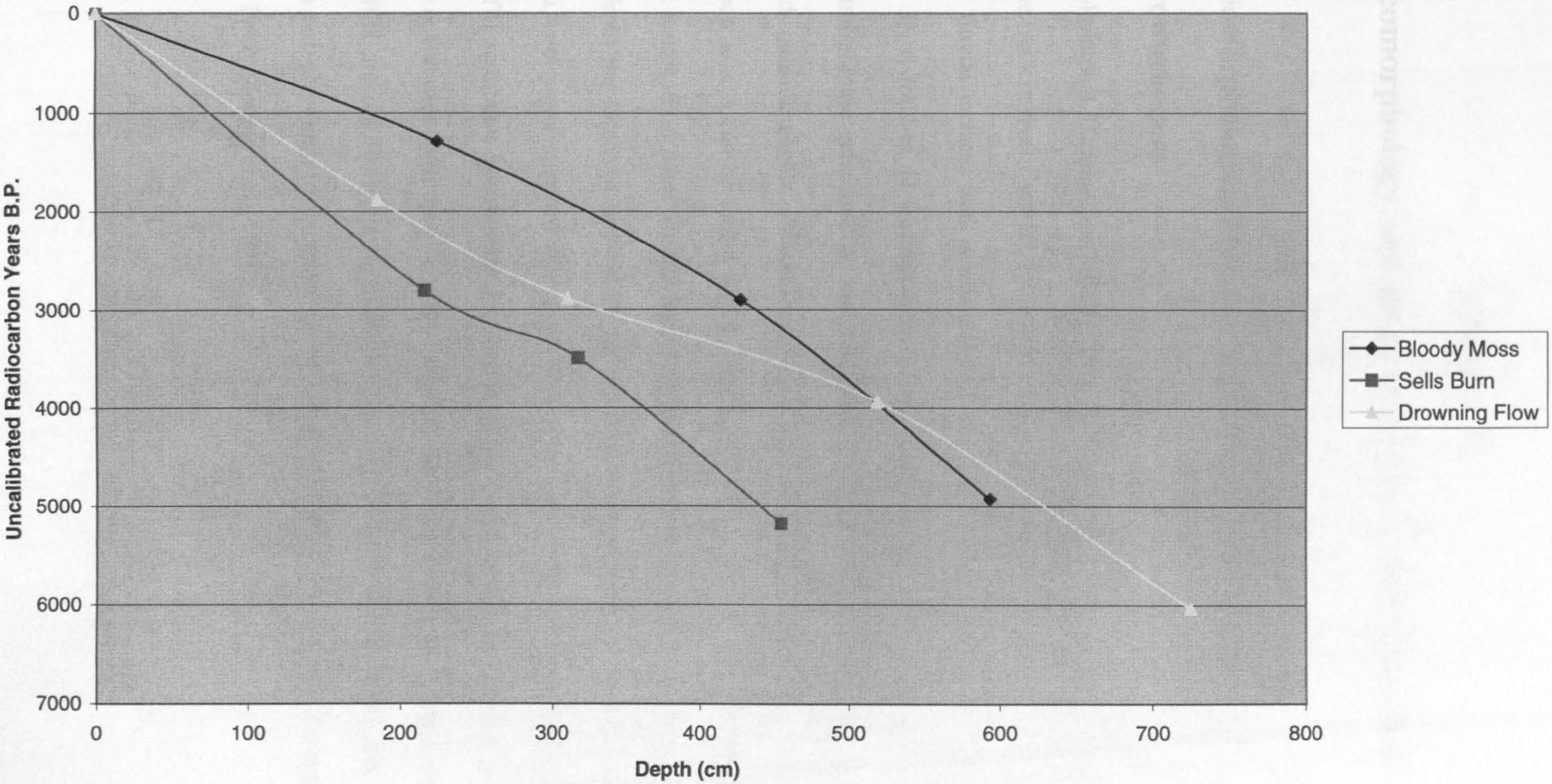


Figure 4.5: Uncalibrated Age-Depth Curve for Upland Sites



Chapter 5

Geomorphology and palaeoecology of valley floor sites

5.1 Geomorphological Mapping and Sediment Stratigraphy at Brownchesters

Geomorphological mapping and coring at Brownchesters has focused upon the western side of the modern river channel, downstream of the bridge carrying the B6320, where a series of fluvial terraces and palaeochannels are clearly visible on the valley floor (Chapter 3). A total of 11 discrete terrace units have been identified on the basis of morphostratigraphic relationships and radiocarbon assays obtained from within the associated palaeochannels (Moores *et al.*, 1998). Full core logs and details of radiocarbon assays can be found within Appendices 10.2 and 10.6. Unless otherwise stated all radiocarbon dates are quoted as calibrated calendar dates, with single dates derived from the intercept point with the dendrochronological curve and age ranges quoted at two-sigma standard deviation. Given the likelihood of basal minerogenic channel fill sediments accumulating at a relatively rapid rate (*cf.* Lewis and Lewin, 1983), it is assumed here that ^{14}C dates obtained from the lower part of organic-rich channel fills are not likely to significantly post-date channel abandonment and thus provide a *post-terminum* for meander cut-off (Macklin and Needham, 1992; Brown and Keough, 1992; Moores *et al.*, 1998).

5.1.1 Late-Glacial Terraces: T1 &T2

On the western side of the modern channel, the valley floor is dominated by two extensive terraces, designated T1 and T2, that lie up to 6m and 5m respectively above present river levels (Figure 5.1). The surface of these high-elevation terraces locally feature fluvial palaeochannels and / or Holocene gullies, that preliminary coring has shown to be infilled with inorganic, homogenous grey clays. No palynological analyses have been undertaken upon these sediments due to the absence of organic material and their gleyed nature making them unlikely to preserve pollen grains. Although no radiocarbon data is available for these units, their extent and relative height is broadly comparable to the uppermost fills in alluvial sequences recorded elsewhere in the Tyne basin (Passmore, 1994; Passmore and Macklin, 1994). In common with other documented alluvial sequences in upland northern Britain (*e.g.* Harvey, 1985; Tipping, 1995b), these features are believed to be outwash terraces formed during the late-Devensian de-glaciation.

Figure 5.1: Geomorphological map of Pleistocene and Holocene river terraces and palaeochannels at Brownchesters Farm showing cross profiles and core locations

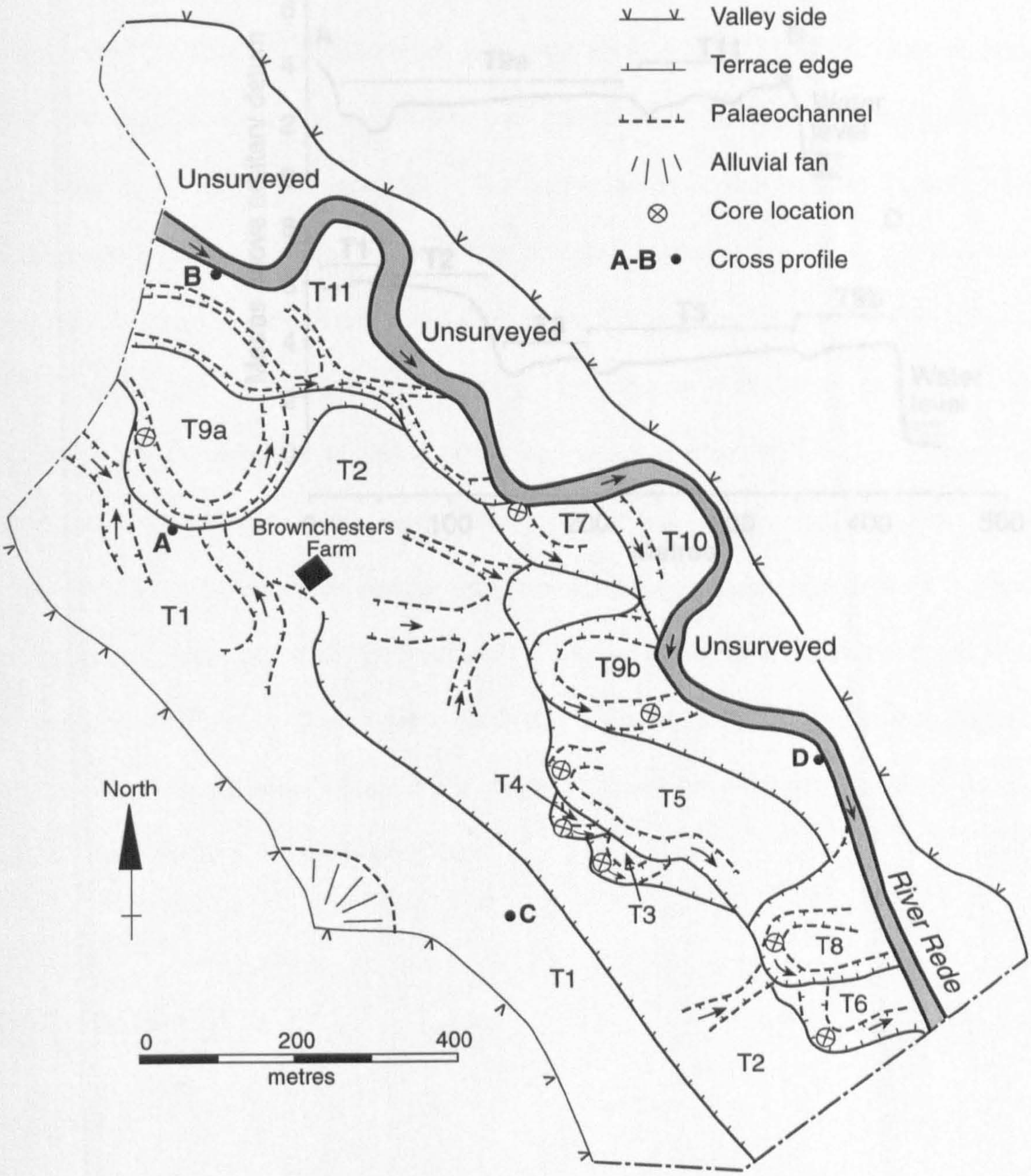
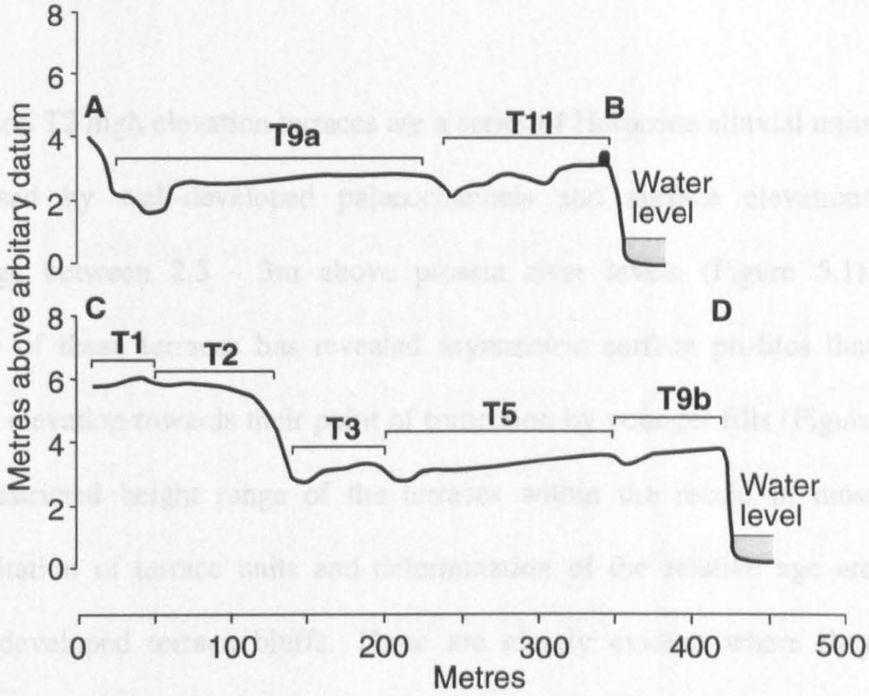


Figure 5.2: Surveyed cross profiles of the valley floor at Brownchesters Farm



5.2 Outline of Holocene Terrace Formation, Nomenclature and Pollen Results

Inset below the T1 and T2 high elevation terraces are a series of Holocene alluvial units that are characterised by well-developed palaeochannels and surface elevations restricted to a range between 2.5 - 3m above present river levels (Figure 5.1). Topographic survey of these terraces has revealed asymmetric surface profiles that progressively rise in elevation towards their point of truncation by younger fills (Figure 5.2). Despite the restricted height range of the terraces within the reach, in most instances the delimitation of terrace units and determination of the relative age are facilitated by well-developed terrace bluffs. These are clearly evident where they coincide with palaeochannels developed upon the younger unit, with marked vertical discrepancies occurring at the point of cut-off (Figure 5.2). The maximum elevation of the Holocene floodplain is attained immediately adjacent to the present active channel, where coarser grained sediments from overbank flows has formed low-relief levees (Allen, 1965; Brown, 1996) (Figure 5.2).

5.2.1 Terrace T3

Morphology

The T3 unit survives as a single, small terrace fragment inset immediately below T2 (Figure 5.1). It is truncated at the upstream end by a T4 palaeochannel and by a T5 palaeochannel at its downstream limit. The terrace contains evidence of a well-defined meander loop, approaching 100 metres in length. The preserved portion of this palaeochannel is interpreted as the apex of a former meander bend that has undercut the higher T2 terrace unit.

Stratigraphy (Figure 5.3)

Five metres of sediment have been obtained from this palaeochannel, although some sediment was lost between 268-333 cm and 394-408 cm (Figure 5.3). The basal 28-cm of sediment comprises gravel in a coarse-sand matrix and is interpreted as former active riverbed material (Erskine *et al.*, 1992). Overlying sediment (408-472 cm) comprises grey silty-clays, with some light brown minerogenic banding. The transition to fine-grained sedimentation in a low energy environment most probably reflects isolation of the channel as a detached oxbow lake (Page and Mowbray, 1982; Allen, 1965). This is supported by pollen evidence (Figure 5.4) that shows traces of *Potamogeton*, a taxon usually found submerged within standing freshwater (Clapham *et al.*, 1964). This unit gives way to a slightly coarser clayey-silt that is increasingly sandy down profile and contains frequent dark, well-humified organic lamina *ca.* 1mm in thickness (344-394 cm). This is indicative of an increasingly stable and relatively slowly accumulating sedimentary environment, which has periodically allowed the growth of aquatic plants within the palaeochannel. This is briefly replaced by a more consistently organic unit (341-344 cm), which contains numerous visible plant remains, including seeds and leaves and suggests stable vegetation growth both within and adjacent to, the palaeochannel cut-off. Between 164-341 cm are a number of silt, peaty-silt and silty-peat dominated units, which contain varying amounts of organic material and wood fragments. This indicates small fluctuations in the relative stability of the palaeochannel, with more mineral-rich sediments derived from allochthonous input from floodwaters. These units are indeed interrupted at a depth of 240-243 cm by two noticeably coarser laminae approximately 5 mm in thickness and composed of light grey fine sand / silt. These are indicative of the influx of overbank floodwaters into the palaeochannel, carrying a more minerogenic sediment load which is deposited within the low energy environment (Erskine *et al.*, 1992). Highly organic peat with varying quantities of wood between 164-240 cm, suggests progressive terrestrialisation of the palaeochannel and the reduced incidence of intrusive flood-events. From 164 cm to immediately below the topsoil at 50-cm, sediments are predominantly fine-sandy silty-clays and fine sandy-clayey-silts with varying amounts of organic material. This appears to be a continuation of palaeochannel terrestrialisation occurring as the environment becomes progressively drier. At 129-137 cm, however, peat formation briefly resumes and may indicate a shift in local hydrologic conditions, a temporary re-wetting of the palaeochannel or a response to an alteration in climatic conditions. An alluvial topsoil caps the modern palaeochannel surface.

Dating

The precise timing and rate of sediment accumulation within this channel is difficult to discern, due to an apparent reversal in the radiocarbon dating sequence. Two dates have been obtained from the palaeochannel at a depth of 242-250 and 146-156 cm (Beta-96126, Beta-119823: Appendix 10.2). The upper of these dates has been obtained from a bulk peat sample and has been returned at 8100-7900 BC, while the lower date has been obtained from wood fragments preserved in the core and has returned a date of 7595-7445 BC. The reason for this reversal is unclear, as the oldest and uppermost date has been obtained from *in situ* organic sediments that are believed unlikely to have been derived from allochthonous sources. Although dendrochronological calibration curves during this period are less accurate than at many other times during the Holocene and are also subject to dating plateaux, these limitations are probably insufficient to account for the reversal alone. It is possible that the dated wood (Beta- 96126) may have been *in situ* root material and therefore younger than its stratigraphic position suggests (Brown *et al.*, 1994; Brown, 1997). Nevertheless, both dates fall within 500 radiocarbon years of each other, and as a consequence the sediment can be seen to have been accumulating *ca.* 8000 BC.

Furthermore, examination of the pollen records from this core support this, as fluctuations in characteristic pollen spectra, derived from numerous type-site pollen records appear to correlate very well with a chronology derived from the lower, younger date. This is discussed further below.

Palynology (Figure 5.4, Appendix 10.11)

Pollen preservation was limited to 80–395 cm, where sediments were finer-grained and more organic in nature. Some portions of the diagram (Figure 5.4), notably between 260-330 cm, have few pollen samples due to a combination of poor sediment recovery and the non-polleniferous nature of the material. The diagram can be divided into three Zones for the purposes of description and interpretation (Figure 5.4).

Zone A (395-230 cm)

This zone is dominated by high percentages of Coryloid type (60%) and *Betula* (20%). Traces of other tree species are present including *Salix*, *Quercus*, and *Ulmus* which occur in quantities which suggest that they were growing locally and *Pinus* pollen which is likely to result from long-distance transport (Huntley and Birks, 1983). Herb diversity is very high and contains evidence of some cereal pollen along with a number of other anthropogenic indicator species (discussed in Chapter 7). *Potamogeton* occurs in low quantities throughout the zone, demonstrating that the palaeochannel environment at this time consisted at least in part of standing water and this supports interpretations based upon the sediment stratigraphy of the core (Clapham *et al.*, 1964). Overall, this zone is indicative of a typical early Holocene valley floor woodland, comprising of predominantly early colonising species with only traces of the more thermophilous trees.

Zone B (230-150 cm)

This zone is characterised by increasing percentages of arboreal species, notably *Pinus* and *Quercus* that are believed to have spread into Britain at around 8500 BP (Birks, 1989; Huntley and Birks, 1983). The date of 8510 ± 70 BP uncalibrated radiocarbon years at 242-250 cm corresponds well to this chronology and supports the use of the lower date (Beta-96126) in fixing the chronology for the core. Increases in these taxa are associated with a decrease in Coryloid type levels, while other taxa including herbs remain at roughly similar levels. This Zone reflects the progressive succession of trees of a more thermophilous nature into the woodland environment, with overall arboreal cover relatively stable.

Zone C (150-80 cm)

The most notable feature of this zone is the migration of *Alnus* into the site and the subsequent domination of this species. The spread of *Alnus* has been the focus of many studies, most of which have utilised mire sediments to analyse the expansion of this wetland taxon (Chambers and Price, 1985). A number of authors have hypothesised that alder spread predominantly through fluvial transport, concentrated within wet, floodplain corridors for its initial expansion (Bennett and Birks, 1990; Chambers and Elliott, 1989; Tallantire, 1992) and that waterlogging favoured the species over birch and willow which had previously dominated floodplain environments (Brown, 1988). The results presented here appear to support this hypothesis, as the date of *ca.* 8005 BC at 146-156 cm for the rise in alder pollen is much earlier than the documented alder rise in northern Britain at between 7000-7500 BP (Birks, 1989) and earlier even that found by Chambers and Price (1985) in north-west Wales. Although the date at this depth may be erroneous due to contamination and renders the precise timing of the alder rise difficult to ascertain, it does appear that alder migration at this site concurs with existing models of a patchy riverine distribution (Bennett and Birks, 1990; Tallantire; 1992). Other arboreal species in this zone all reduce slightly as a consequence of alder expansion with herbaceous taxa remaining fairly constant.

5.2.2 Terrace T4

Morphology

The T4 unit is a small fragment of terrace inset immediately below the gravel terrace of T2 and truncates the T3 unit. In common with T3, a well-defined palaeochannel is present upon the terrace surface, and has a planform resembling a meander loop approximately 75 metres in length, the assumed apex of which has undercut the T2 terrace unit. On the basis of morphostratigraphic relationships, this unit is interpreted as having formed through simple meander loop cut-off by the palaeochannel associated with terrace T5.

Stratigraphy (Figure 5.3)

Six metres of continuous sediment have been recovered from the palaeochannel associated with this terrace. The basal 30 cm of this core are comprised of former channel bed material, consisting of gravel (1 cm B-axis) in a coarse sand matrix. Overlying this, between 520-550 cm depth is a progressively fining upward sequence from coarse sands to clayey silty sand. This is likely to represent the depositional sequence immediately following abandonment, where the energy status of the meander loop is gradually reducing allowing increasingly finer material to be deposited (Allen, 1965; Erskine *et al.*, 1992, Waters, 1992). Overlying sediment between 384-520 cm comprise light grey silty clays with finer sandy laminations at intervals through it. This suggests a low energy environment, which is occasionally encroached by higher energy floodwaters, responsible for relatively rapid deposition of sandy lenses. Above this are two units of well-sorted and bedded sands (370-384 and 365-370 cm), that are also interpreted as being indicative of the encroachment of relatively high-energy floodwaters into the palaeochannel (Costa, 1978; Knox, 1985). Subsequent to this are a series of laminated units, comprising of alternating bands of silty-clays and fine to medium sands, which occasionally contain fragments of wood and other organic remains. Five distinct units can be identified with these characteristics, collectively spanning a depth of 266-365 cm. These suggest a period where conditions were relatively unstable in the palaeochannel, as minerogenic input was fairly high. The first peat units develop above this series, initially comprising of organic rich silts but becoming increasingly peaty up profile (218-266 cm). Between 224-241 cm a large wood fragment has been radiocarbon dated (Beta-96127, Appendix 10.2). The sediments between 160-218 cm are comprised of slightly silty peat, which contains fine minerogenic laminae between 160-178 cm. The development of peat in these valley floor localities indicates that palaeochannel conditions were stable enough to allow vegetation to grow, although the laminae probably demonstrate that minor incursion of floodwater into the palaeochannel did occur. Between 112-160 cm deposition reverts to minerogenic silts and fine sandy sediments and consequently a more unstable regime. More peat between 78-112 cm punctuates this, before silt dominated units occur between 56-78cm immediately below well-developed alluvial topsoil.

In summary, the sedimentary profile from this channel provides one of the most detailed records of flood history from this reach. Almost the entire sediment sequence contains evidence of what is interpreted as floodwater encroachment into the palaeochannel, in the form of laminations of coarser material (Costa, 1978; Knox, 1985). These vary from sub-millimetre clay and fine-medium sand bands, indicative of minor floodwater incursions to up to 5cm of well sorted grey medium to coarse sand, suggestive of fairly major overbank flooding. The dates for the adjacent and younger T5 terrace palaeochannel (abandoned *ca.* 3950 BC) suggest that this was the active channel during *ca.*1000 years of sediment accumulation in the T4 channel. Thus, the proximity of the active channel to this T4 palaeochannel during the period 5030–3950 BC may be the reason for the well-preserved and fine resolution flood record available from these sediments.

Dating

Two radiocarbon dates have been obtained from this channel at depths of 80-95 cm (peat) and 224-241 (wood) cm, these have returned dates of 3045-2870 / 2795-2770 BC and 5240-4825 BC (Appendix 10.2). No date has yet been submitted from any of the basal sediments of this palaeochannel and thus the timing of channel abandonment of this terrace unit is difficult to speculate upon. It is likely, however, that sediment accumulation rates were likely to have been significantly quicker in the lower portion of the core due to the predominantly minerogenic nature of the material. Sediment accumulation rates in the upper part of the core appear to be far slower and are amongst the slowest encountered at Brownchesters. This may be a consequence of the distance of the channel from the contemporary active channel once the T5 channel had been abandoned, the lack of *in situ* vegetation development due to local hydrological conditions or a hiatus in sediment accumulation.

Palynology (Figure 5.5, Appendix 10.12)

Palynological results from this palaeochannel are restricted to the uppermost 365 cm of the sediment core where preservation of pollen grains is sufficient to allow counting. The diagram is difficult to divide into Zones owing to the diagram reflecting overall a relatively static flora. The results show vegetation characterised by a mix of predominantly arboreal tree and shrub taxa. *Alnus* and Coryloid type again form the major species present, consistently attaining values of 30% in the core. *Quercus*, *Betula*, and *Ulmus* are also present at levels generally between 10 and 20%, reflecting the local presence of these species (Huntley and Birks, 1983). *Pinus* values of a similar magnitude (10-20%) usually reflect long distance transport when considering mire deposits, but the small diameter of this palaeochannel probably means that this taxon was growing fairly proximal to the valley floor in limited numbers. Herb presence is limited, although there are slight indications of a number of species that are frequently derived from anthropogenic vegetation disturbance, such as Ranunculaceae, *Plantago lanceolata* and Liguliflorae (Behre, 1981, 1988; Birks 1990). Occasional cereal grains are also present in the core, in both the uppermost and lowest pollen samples. The results from the radiocarbon assays from the core are confirmed by the presence of a clear and well-defined elm decline, which occurs at a depth of 130 cm. This event has been synchronously dated across north-western Europe to *ca.* 4000 BC (Peglar, 1993a, 1993b, Peglar and Birks, 1993; Edwards and McIntosh, 1988) and thus provides an independent chronostratigraphic marker horizon within the profile.

Figure 5.3: Simplified lithostratigraphy and ^{14}C dates for palaeochannel sediment cores T3 and T4 at Brownchesters Farm

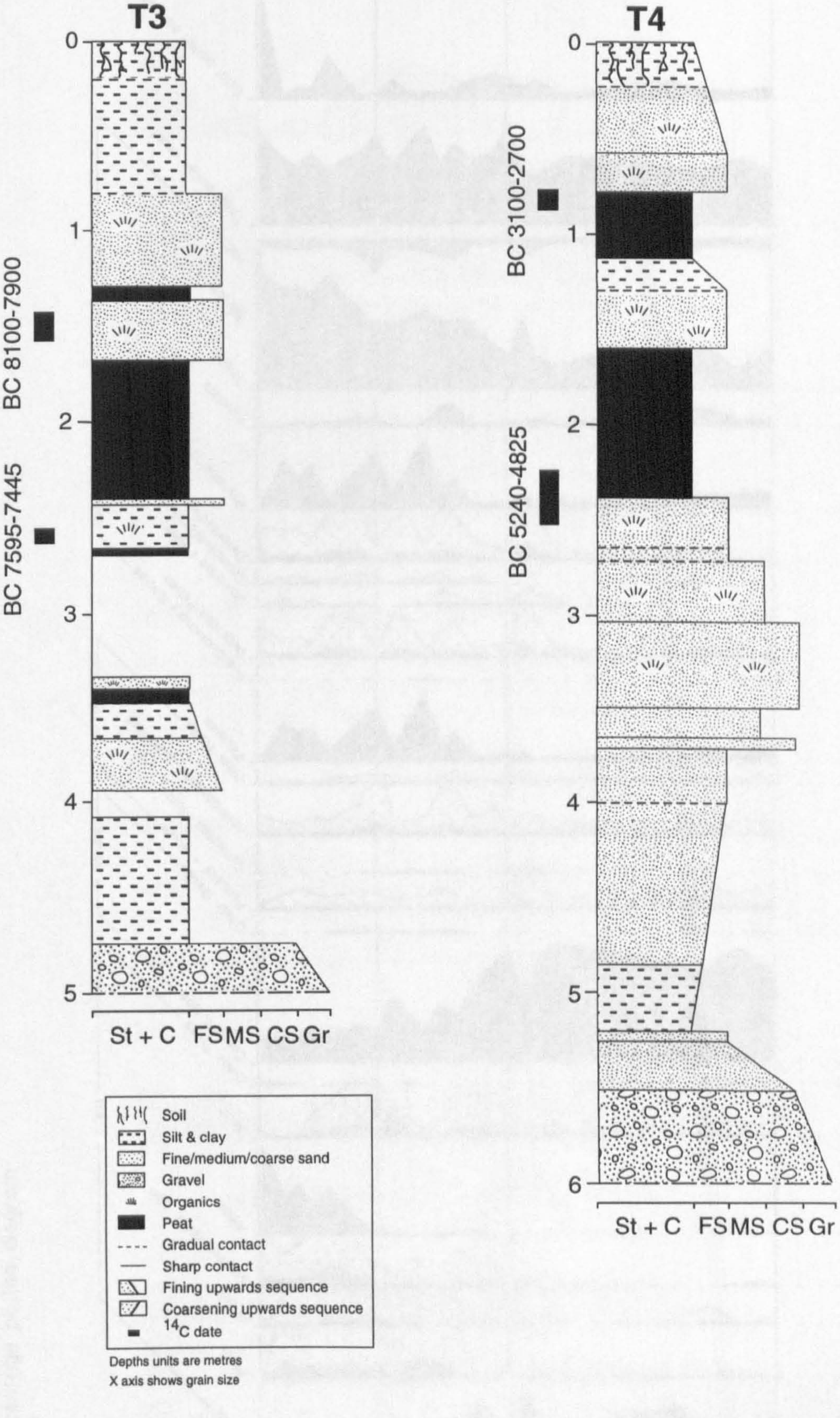
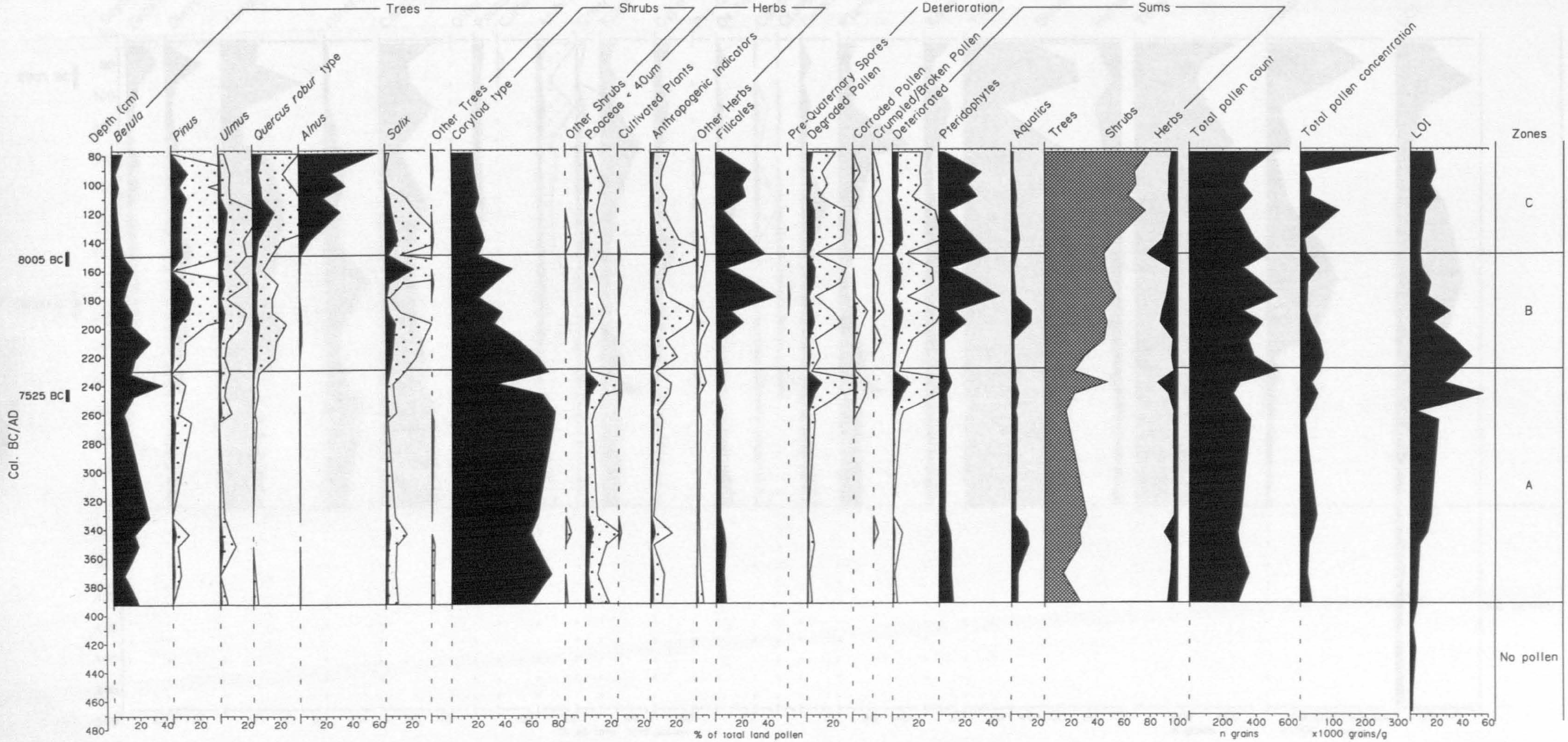


Figure 5.4: Brownchesters Farm Terrace T3

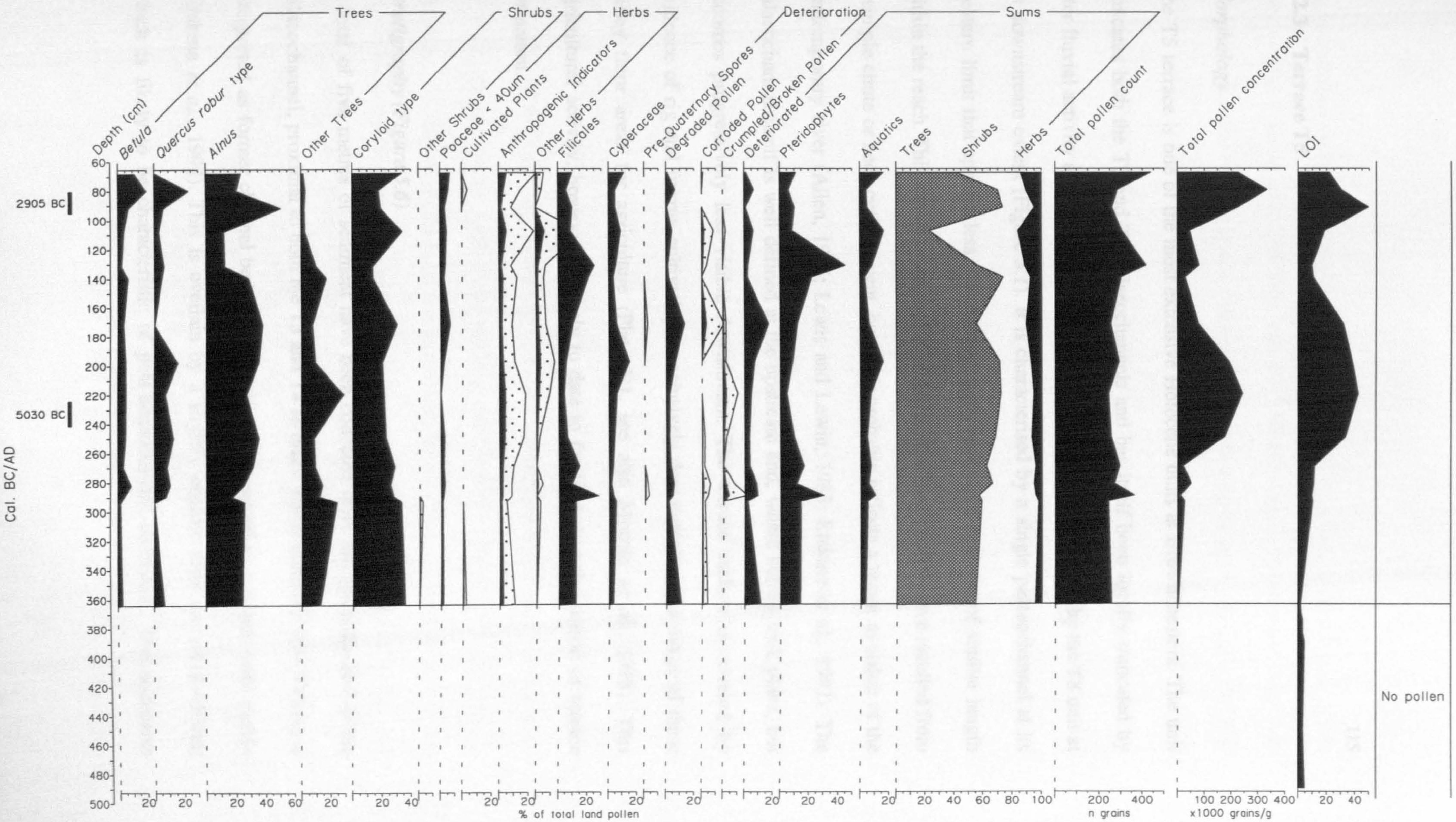
Summary percentage pollen diagram

Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

Figure 5.5: Brownchesters Farm Terrace T4
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

5.2.3 Terrace T5

Morphology

The T5 terrace is one of the most extensive Holocene units at Brownchesters. The unit truncates both the T3 and T4 palaeochannels and has itself been locally truncated by later fluvial activity associated with the T9 unit at its upstream end and by the T8 unit at its downstream extent (Figure 5.1). It is characterised by a single palaeochannel at its western limit that appears less sinuous than palaeochannel fragments of similar length within the reach. This suggests channel abandonment is less likely to have resulted from a simple chute or neck cut-off event, but more probably reflects a major avulsion of the contemporary river (Allen, 1965; Lewis and Lewin, 1983; Erskine *et al.*, 1992). The palaeochannel itself is well defined at the upstream end, where coring took place, but becomes progressively less visible downstream. The terrace surface is covered by evidence of rig and furrow cultivation, conclusively demonstrating the usage of these valley floor areas for agriculture (Plate 6.1, see also Moores *et al.*, 1998). This agricultural activity, however, is likely to date to far later than the period of terrace formation.

Stratigraphy (Figure 5.6)

A total of five metres of sediment have been collected from the upstream end of the palaeochannel, proximal to both the T3 and T4 terraces. Basal material (450-500cm) is interpreted as former channel bed material, comprising gravel in a coarse sand matrix (Erskine *et al.*, 1992). This is overlain by a slightly organic sand unit (418-450cm) which is likely to be characteristic of post-abandonment sediments. The sediments deposited above this unit (278-418 cm) are peat / silts, with occasional laminae of fine silty sand and sandy silts (388-389, 360-363, 340-342 cm). Frequent wood fragments occur in a number of the organic rich peat units, including between 342-360, 324-340, 310-324 and 288-300 cm. A large piece of wood was recovered from 278-288 cm. These sedimentary units and wood fragments indicate stability of the palaeochannel environment in terms of vegetation, with floodwater incursions into the former channel of a relatively minor nature (Waters, 1992). The presence of large quantities of wood within the sedimentary sequence indicates *in situ* tree growth and although no wood fragments have been identified, likely ecological conditions suggest it is to be either alder or willow which occupy these floodplain environments (Brown, 1988). Between 252-278 cm a distinctive minerogenic unit is present within the sedimentary profile. This comprises of a number of alternating bands of light grey sandy-silt / silty-sand with peaty-silt. In total six thin lenses of coarser material occur at depths between 252-254, 256-258, 260-261, 268-270, 271-273 and 275-277 cm. This indicates a minor change in regime within the channel environment as minerogenic matter is almost certainly derived from overbank flood events. Peat accumulation resumes within the channel at 166-252 cm and once again demonstrates some evidence of minerogenic laminations through a number of the units. Wood is also present between 190-200 and 179-185 cm. Between 134-166 cm sedimentation is again more minerogenic in character with peaty-silts laminated with silty sand lenses. Wood is also present through many of these units. Peat formation again resumes between 84-134 cm, although sandy-silt laminae are still present. This becomes increasingly silty up-profile between 55-84 cm as water table depths presumably limit peat formation. Between 38-55 cm silty-clay sediment caps the palaeochannel with brown alluvial topsoil developed above 38cm depth.

In summary, this palaeochannel provides one of the most consistently organic sedimentary profiles. This has facilitated in-depth analysis of the sediments and also radiocarbon dating. The predominantly organic sedimentation style also allows periods of minerogenic inwash to be more clearly seen and as a consequence episodes of increased fluvial activity can be discerned.

Dating

Two radiocarbon dates have been obtained for this sedimentary profile. These have been taken at depths of 140-142 (Beta-96124) and 340-350 cm (Beta-96125) on wood recovered from the sedimentary profile (Appendix 10.2). Dates of 2570-2145 BC and 4055-3715 BC have been returned from these assays. It can therefore be seen that sediments within this T5 channel were accumulating contemporaneously with sediments in the channel from T4. As a consequence it may be possible to trace certain major events in the palaeoenvironmental record between the two sediment cores.

Palynology (Figure 5.7, Appendix 10.13)

Palynological results from this palaeochannel have been obtained from almost the entire sedimentary sequence, with even the material immediately overlying the former channel bed gravel yielding adequate pollen for counting (Figure 5.7). The diagram has been divided into three zones on the basis of major changes in the pollen curves to aid with description and interpretation of the pollen spectra.

Zone A (450-350 cm)

This zone is characterised by relatively stable percentages of all major taxa. The principal species visible in the pollen record are *Alnus* (20%), Coryloid type (20%) and *Quercus* (15%) along with Poaceae (5%) and *Filicales* (10%). The presence of *Ulmus* pollen (5%) is also important in defining a chronology for sedimentation. The zone has been differentiated on the basis of the presence of *Potamogeton* pollen and the stability of the alder curve. *Potamogeton* is indicative of open water conditions and thus the palaeochannel can be deduced to have been an oxbow lake at this time. Terrestrialisation of the palaeochannel is marked by an increase in alder percentages, which occurs concomitantly with an increase in the quantity of wood found within the sedimentary profile (Appendix 10.6). In addition, this zone boundary has been dated at 4055-3715 BC and it is noticeable that cultivated taxa and also other anthropogenic indicators occur at around this time. The environment was thus fairly well wooded, comprising a mix of arboreal taxa, with small openings in the forest cover suggested by the levels of grasses and cultigens.

Zone B (350-150 cm)

This zone is dominated by rising and high percentages of *Alnus*, which attains maximum values of approaching 80%. Other arboreal taxa initially remain relatively stable, although at a depth of approximately 300 cm, levels in *Ulmus* fall sharply, at a date later than the elm decline which is visible in mid-Holocene pollen records across north-west Europe and dated to *ca.* 4000 BC (Peglar, 1993; Peglar and Birks, 1993). Following this *Quercus* levels also decline, although this is more likely an artefact of the large percentages of locally growing alder, rather than a genuine decrease in oak cover in the wider valley floor environment. A virtually constant level of anthropogenic indicator taxa through this zone supports this interpretation. However, Brown (1996) has highlighted that the decrease in diversity associated with alder woodland is not necessarily an artefact of other species being 'drowned out' and that this floodplain environment is relatively species poor.

Zone C (150-60 cm)

This zone is characterised by rapidly falling *Alnus* percentages and a corresponding increase in Poaceae percentages. The values of all other trees, with the exception of *Betula,* also decline, although Coryloid type shrubs maintain values of around 20% apart from at the top of the core. A massive peak in *Betula* levels towards the top of the zone is almost certainly due to very local sources as some of the pollen grains were found in immature clumps and is associated with a large rise in pollen concentration. The grass percentage rise is associated with increases in levels of anthropogenic indicator taxa and other herbaceous species and is interpreted as clearance of the valley floor woodlands by human activity. This rise has also been radiocarbon dated to 2570-2145 BC.

5.2.4 Terrace T6

Morphology

The T6 terrace unit is at the downstream end of the Brownchesters study reach (Figure 5.1). The unit forms the higher of two terraces that contain extremely well defined and highly sinuous meander loops, both of which are truncated by the present-day active channel at their downstream ends. The T6 terrace palaeochannel is truncated at the upstream end by the T8 unit, with what has been interpreted as the former meander bend apex lying immediately below the high T2 terrace unit (Figure 5.2).

Stratigraphy (Figure 5.6)

The sedimentary sequence from this palaeochannel is relatively shallow at just 340cm, but in common with many of the Brownchesters palaeochannels it contains a large proportion of organic rich sediments. Between 334-340 cm is fine gravelly sand, interpreted as former bed material. Within this unit a solid piece of wood was recovered which was subsequently used for radiocarbon dating. This bed material is overlain by fine sandy-clayey-silt between 325-334 cm, which becomes laminated with peats between 300-325 cm. This reflects increasing stability of the palaeochannel following cut-off and abandonment as plant material begins to colonise the channel (Brown, 1996, 1997). Between 271-286 cm this process continues with the development of peat, which contains significant amounts of wood towards the base of this unit. Between 268-271 cm an extremely well defined coarsening upward minerogenic horizon occurs, comprising light grey silty sands. This can be equated with a progressively rising flood regime where increasingly larger grain sizes are transported into the palaeochannel environment (Costa, 1978). Between 166-268 cm an extensive series of peat units have developed which appear to be devoid of any minerogenic laminae, but are punctuated by frequent wood fragments. Between 158-166 cm a continuous piece of wood was recovered which was used for radiocarbon dating. This is interpreted as indicating an extremely stable palaeochannel environment that has not been subject to any major flooding. At a depth of 146-158 cm the peat becomes more minerogenic and silty, although wood is still plentiful within the core. This probably reflects sedimentation occurring above the local water table, rather than floodwater input into the channel, as all the subsequent sedimentary units are more minerogenic in nature. Indeed, the next sedimentary units 52-146 cm are a combination of sandy clayey silts and silty clays, many of which contain occasional organic flecks and the unit between 62-82cm also demonstrating some evidence of laminations. Overlying these units to the top of the sequence is alluvial topsoil.

Dating

Two radiocarbon dates have been obtained from this core. The first of these dates has been obtained from wood from the basal sediments of the core at a depth of 337-340 cm (Beta-96123; Appendix 10.2). This has returned a date of 2585-2140 BC and provides a very good approximation for the timing of channel abandonment on this fragment of terrace T6. The second date has been taken upon wood recovered from a depth of 158-166 cm (Beta-96122; Appendix 10.2) and has returned a date of 1890-1520 BC. Thus, it can be seen that accumulation of sediment in this channel has occurred relatively rapidly, despite its predominantly organic nature. Sedimentation in this channel also marginally overlaps infilling occurring within the palaeochannel associated with terrace T5.

Palynology (Figure 5.8, Appendix10.14)

The pollen results from the palaeochannel associated with terrace T6 are in many respects very similar to those from the T5 unit (Figure 5.8). In common with T5, pollen recovery from all but the basal sediments was sufficient to allow counting, giving a diagram spanning depths from 80-328 cm. The diagram is again divided into three zones based upon changes in pollen spectra, in order to aid description and interpretation of species fluctuations.

Zone A (328-260 cm)

This zone is characterised by an abundance of *Potamogeton* pollen, indicative of an open water environment within the palaeochannel. The diagram also records high percentages of *Alnus* (reaching 40%), *Quercus* (declining from 40%) and Coryloid type (stable at around 20%). Grasses and *Filicales* achieve maximum values approximately 20% and cultivated taxa and anthropogenic indicator species are present in small quantities throughout the zone. Thus, pollen results from within this zone indicate a relatively wooded environment, dominated by alder and oak, with a hazel understorey. Clearings within the forest appear to have supported a range of herbaceous taxa, some of which indicate the presence of human activity and floodplain agriculture on the valley floor.

Sub Zone B (260-160 cm)

This zone is dominated by large percentages of *Alnus* pollen (approaching 70%) and a decline in all other arboreal taxa, with the exception of Coryloid type that maintains levels around 20%. Towards the top of the zone *Alnus* levels also begin to decline, although this species remains the main constituent of the diagram. Levels of Poaceae and *Filicales* are suppressed, probably as a result of the high, local coverage of alder. Anthropogenic indicator taxa remain at approximately 5% throughout the zone, although cultigens are mainly absent, possibly due to the shielding effect of *in situ* alder trees. *Potamogeton* levels drop dramatically at the base of the zone, indicative of the slight desiccation of the palaeochannel environment and midway through the zone a peak in *Sphagnum* spores is suggestive of a growth of this moss within the confines of the channel.

Zone C (160-80 cm)

This zone is characterised by a rise in the levels of Poaceae (attaining over 60%) and other herbaceous taxa, including anthropogenic indicator species and cultivated taxa. *Alnus* percentages decline throughout the zone to levels of approximately 10% and other tree species are reduced to insignificant (<5%) levels. Coryloid type pollen remains at approximately 20% through the zone. These results suggest a significant opening of the woodland canopy and the use of cleared areas for crop cultivation and pastoral agriculture. This increase in what can be interpreted as anthropogenic activity on the valley floor has been radiocarbon dated to 1690 BC. Channel conditions remain wet, as indicated by rising levels of Cyperaceae, but it appears that alder is no longer a significant component of the *in situ* flora. Pollen concentrations decline as the sediments become progressively less organic in nature.

Figure 5.6: Simplified lithostratigraphy and ^{14}C dates for palaeochannel sediment cores T5 and T6 at Brownchesters Farm

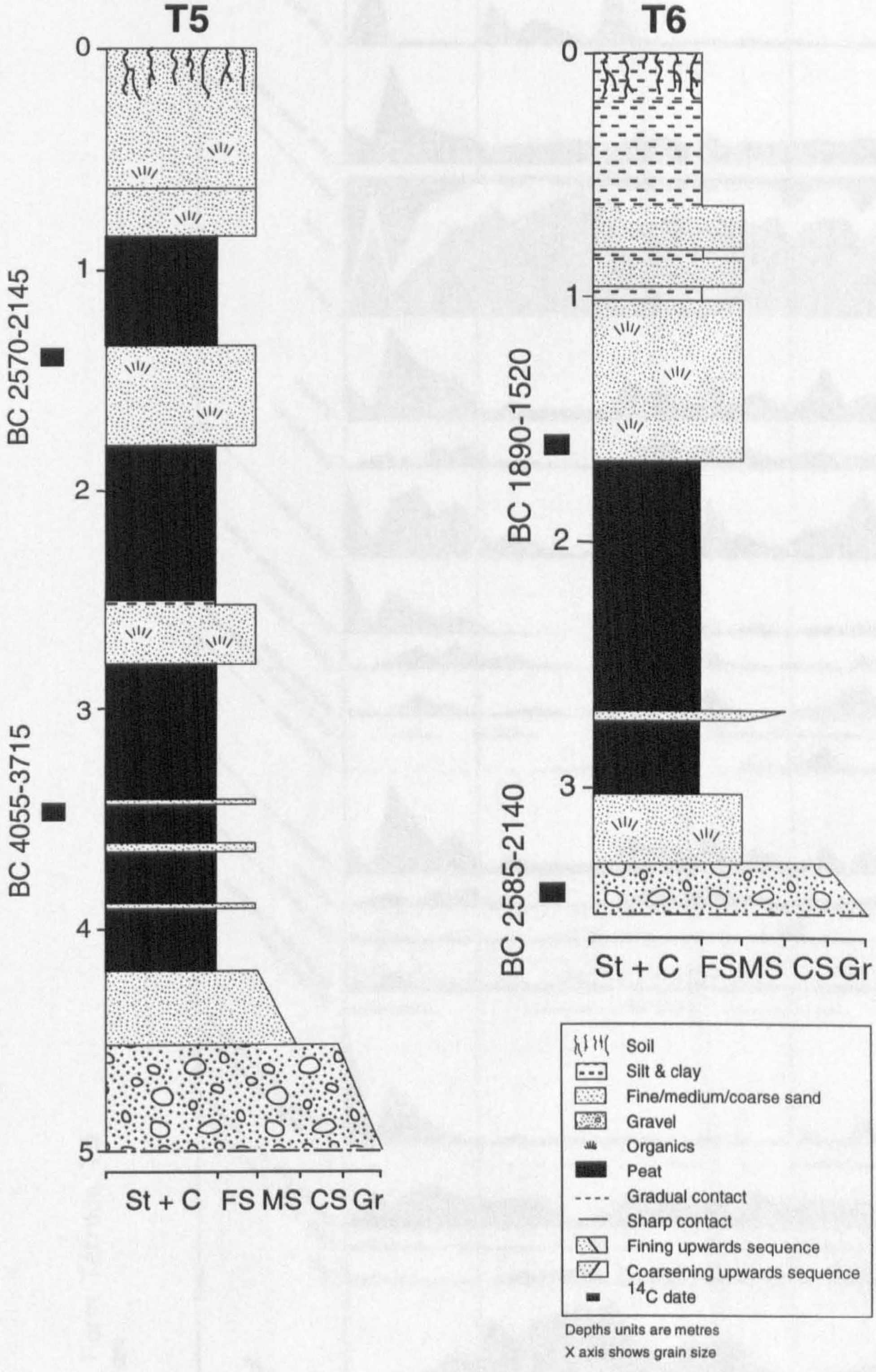
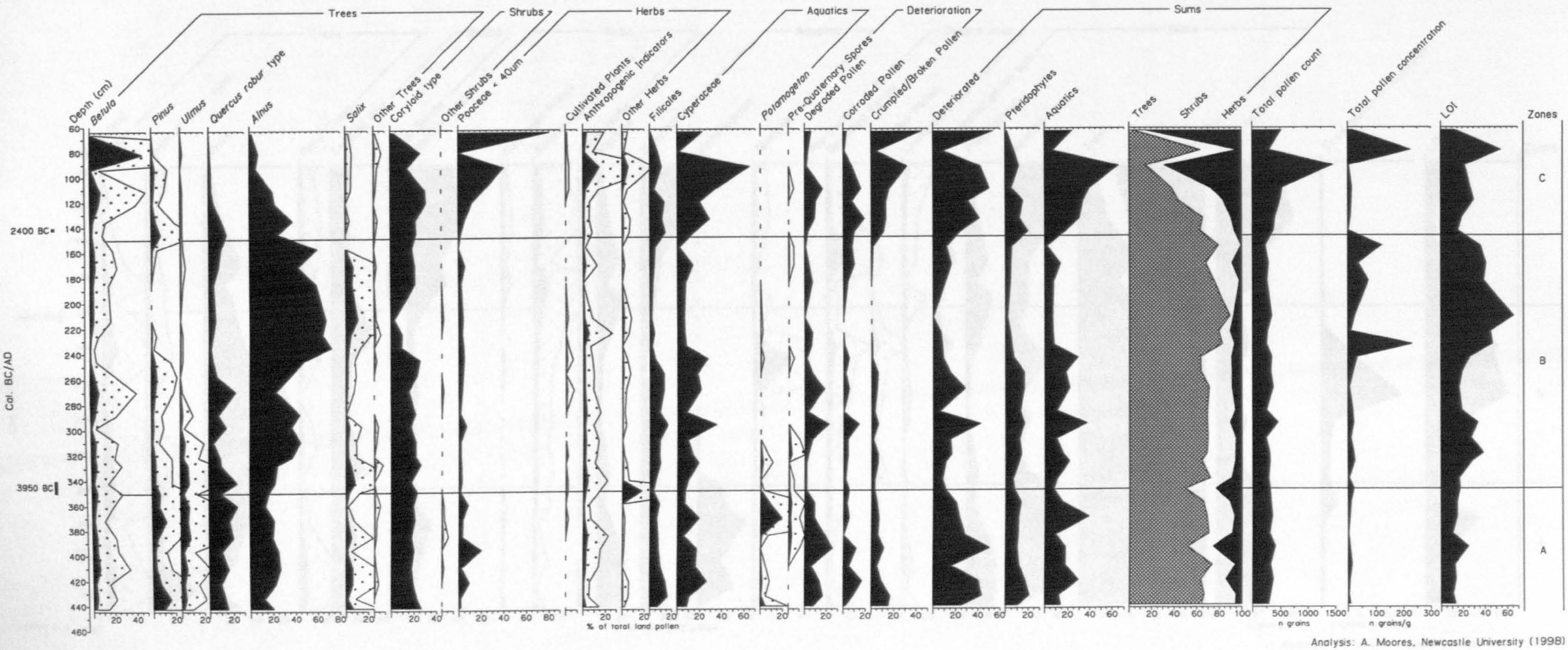
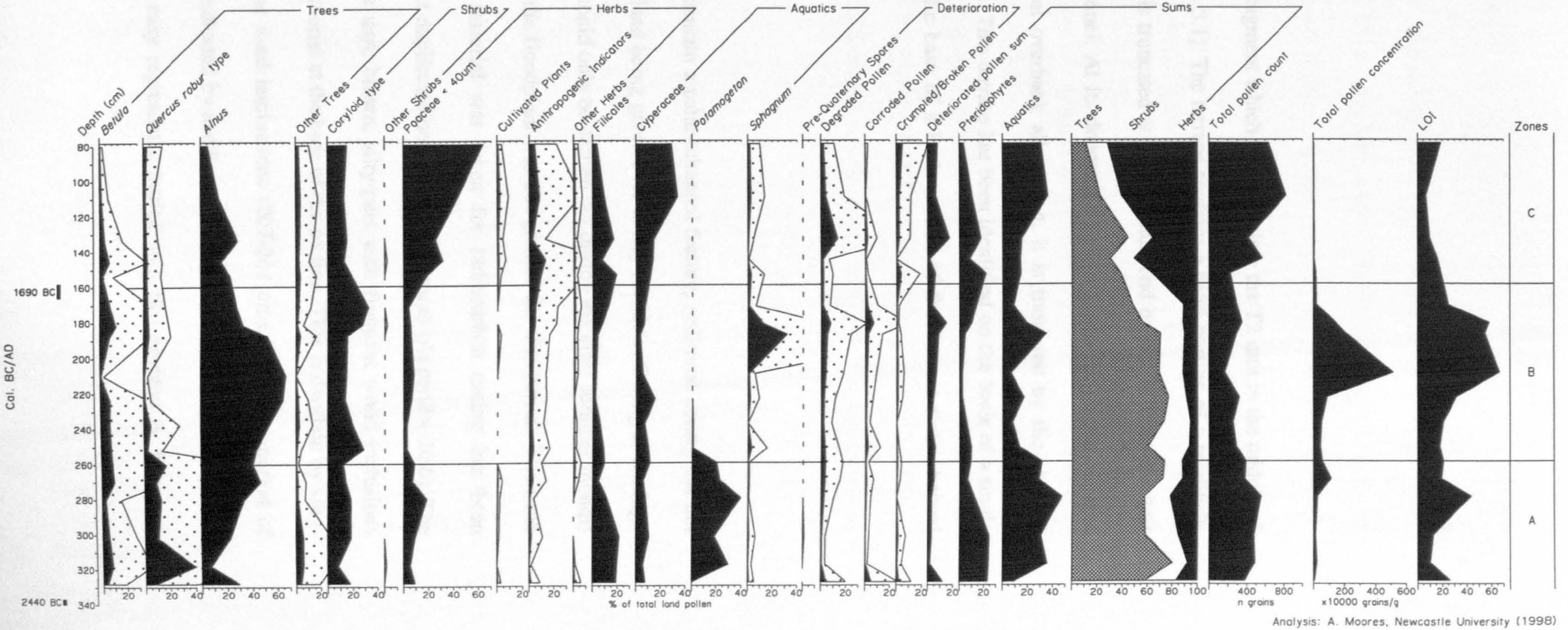


Figure 5.7: Brownchesters Farm Terrace T5
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

Figure 5.8: Brownchesters Farm Terrace T6
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

5.2.5 Terrace T7

Morphology

The T7 unit is a small terrace fragment which is inset below the T2 unit in the middle of the present study reach (Figure 5.1). The terrace contains a short portion of a relatively straight palaeochannel, which is truncated at its upstream end by the T11 terrace unit and also the modern river channel. At its downstream end, where the channel is less well defined due to subsequent overbank alluviation, it is truncated by the channel associated with the T10 terrace. This terrace has been identified on the basis of a single radiocarbon date taken from the base of a bank section of the current river channel (Figure 5.9).

Stratigraphy (Figure 5.9)

Although the T7 terrace does contain a palaeochannel feature, sediment coring has not yet been carried out due to the land being given over to hay meadow. Owing to the high water tables at the site, coring could only be carried out during the drier summer months and permission to this area of the floodplain was not granted for this period. The bank section from which organic material was taken for radiocarbon dating has been described by Ellis (1995) and is duplicated here for completeness (Appendix 10.6). The lowest unit (261-306 cm) is a dark brown, silty-peat with frequent wood inclusions overlaying sandy gravel bed material at the base of the section. This is overlain by silty-clay unit with evidence of fine sand laminations (207-261 cm). A second period of relatively stable conditions is indicated by another organic peaty-clayey-silt horizon at a depth of 197-207 cm, which may represent a buried soil, this horizon is, however, undated. Between 120-197 are silty-clays, which grade between 75-120 cm into a clayey-sandy-silt. Between 28-75 cm is an unstructured silty-sand, overlain by a finely laminated and well-defined sand horizon, which is likely to represent overbank flooding. Between 0-24 cm is a sandy alluvial topsoil.

Dating

A single radiocarbon date has been submitted from wood at the base of the bank section at a depth of approximately 300 cm (Beta-80068). This has returned a date of 200-800 BC (Appendix 10.2). Further dating and also palynological analysis of this unit, in order to facilitate the derivation of accumulation rates and vegetation reconstruction, is planned, should the opportunity to take a full sediment core from the palaeochannel arise.

5.2.6 Terrace T8

Morphology

The T8 terrace is towards the downstream end of the study reach, truncating the palaeochannels associated with Terraces T5 and T6 (Figure 5.1). The terrace is fairly small in extent, yet contains one of the longest sections of palaeochannel in this study reach, owing to the highly sinuous planform morphology of the river when it occupied this terrace. This palaeochannel is itself truncated at both its upstream and downstream ends by the modern river channel, where it becomes less well defined due to overbank levee features which have accumulated adjacent to the channel (Allen, 1965, Brown, 1996). The terrace is inset below the high T2 terrace unit, which at this point contains evidence of a former channel or gully feature upon it which runs down towards the apex of the T8 palaeochannel meander bend.

Stratigraphy (Figure 5.9)

A three-metre sediment core was taken from the apex of the meander bend where the infill sequence was likely to be longest. This comprised of basal sandy gravel between 278-300 cm, which is interpreted as former channel bed material. Overlying this (250-278 cm) are fine sandy-silts which contain frequent 2-3mm medium-coarse sand laminations. This is almost certainly deposited rapidly after channel abandonment, with the coarser horizons relating to periodic inundation by high stage events. The following unit (220-250 cm) is again predominantly silt, although it becomes increasingly organic up-profile and again contains several 2mm thick sand-silt laminae below 239 cm. The increasingly organic profile continues between 206-220 cm with a silty-peat unit. These indicate a progressive stabilisation of the palaeochannel environment, as sedimentation becomes more autochthonous. From 159-206 cm sedimentation is again more minerogenic, comprising of peaty-clayey-silts which become slightly more grey in colour up the sequence. This indicates a moderately less stable palaeochannel environment, which is receiving minerogenic material from allochthonous sources. Between 100-136 cm the sediment consists of a light brown silty peat, punctuated at a depth of 130-132 cm by a light grey sandy-silt unit, which is likely to relate to an overbank flood event encroaching into an otherwise stable environment. A peaty-clayey-silt overlies this between 63-100 cm, which becomes sandy and less organic between 51-63 cm, probably representing sedimentation above the water table. Alluvial topsoil occurs above 51 cm.

Dating

A single radiocarbon date was submitted for assay from peat at the top of the infill sequence and has returned a date of 635-865 AD (Beta-119822; Appendix 10.2). The onset of sediment accumulation, and consequently an estimate of channel abandonment, is difficult to speculate upon. However, it seems likely, based upon average accumulation rates, that the sediment sequence from this unit overlaps with the channel fill of the T7 terrace. Correlation between two discrete sedimentary units, without the benefit of numerous radiocarbon dates is extremely conjectural. However, the sand lenses found in this sequence may well correspond to that found within the T7 unit. Coring of the T7 palaeochannel and further dating control are necessary to validate these relationships (Figure 5.9).

Palynology (Figure 5.10, Appendix, 10.15)

Palynological results from this core have been obtained between a depth of 100-277 cm (Figure 5.10). This diagram has not been zoned, owing to the relatively minor fluctuations in the principal taxa of the diagram. Poaceae species and a diverse assortment of herbaceous taxa dominate the diagram. Percentages of arboreal taxa are relatively low, with *Alnus* and Coryloid type levels around 20% and *Betula* and *Calluna* values around 10%. The exception to this stability is the *Salix* curve, which peaks markedly towards the top of the core. This is likely to be due to a very local increase in *Salix* percentages, opposed to an increase over the wider valley floor. One of the most notable and significant features of the pollen diagram is the massive peak in *Avena / Triticum* group pollen which occurs in the upper section of the core. This cereal type, which produces low quantities of pollen and which is poorly dispersed conclusively demonstrates cultivation of wheat / oats on the valley floor at Brownchesters. Numbers of cereal grains in this quantity are extremely rare in fossil pollen deposits and emphasises the importance of these palaeochannel deposits in detecting valley floor anthropogenic activity where regional diagrams would not register this activity.

The *Potamageton* and *Nuphar* curves for this channel are also very interesting, as they appear to contrast with patterns of palaeochannel development witnessed elsewhere within the Brownchesters study reach. Here the *Potamageton* and *Nuphar* curves peak in the middle of the sedimentary sequence opposed to the basal deposits, where palaeochannels commonly exist as oxbow lakes following cut-off (Allen, 1965). This supports the hypothesis that this palaeochannel was terrestrialised rapidly, as no indications of open water taxa are found in the basal deposits. In addition, the pollen diagram would appear to indicate an increase in water levels within the palaeochannel, which is almost certainly due to prolonged reoccupation of the former river course by overbank floodwaters. This event is also reflected within the sediments, where the infilling material alters from peat to organic-rich silt, there is however, no evidence of a large flood event that may be reflected by coarser grained sand material within the profile, although this palaeochannel may have been located some distance from the active river channel at the time.

Figure 5.9: Simplified lithostratigraphy and ^{14}C dates for palaeochannel sediment cores T7 and T8 at Brownchesters Farm

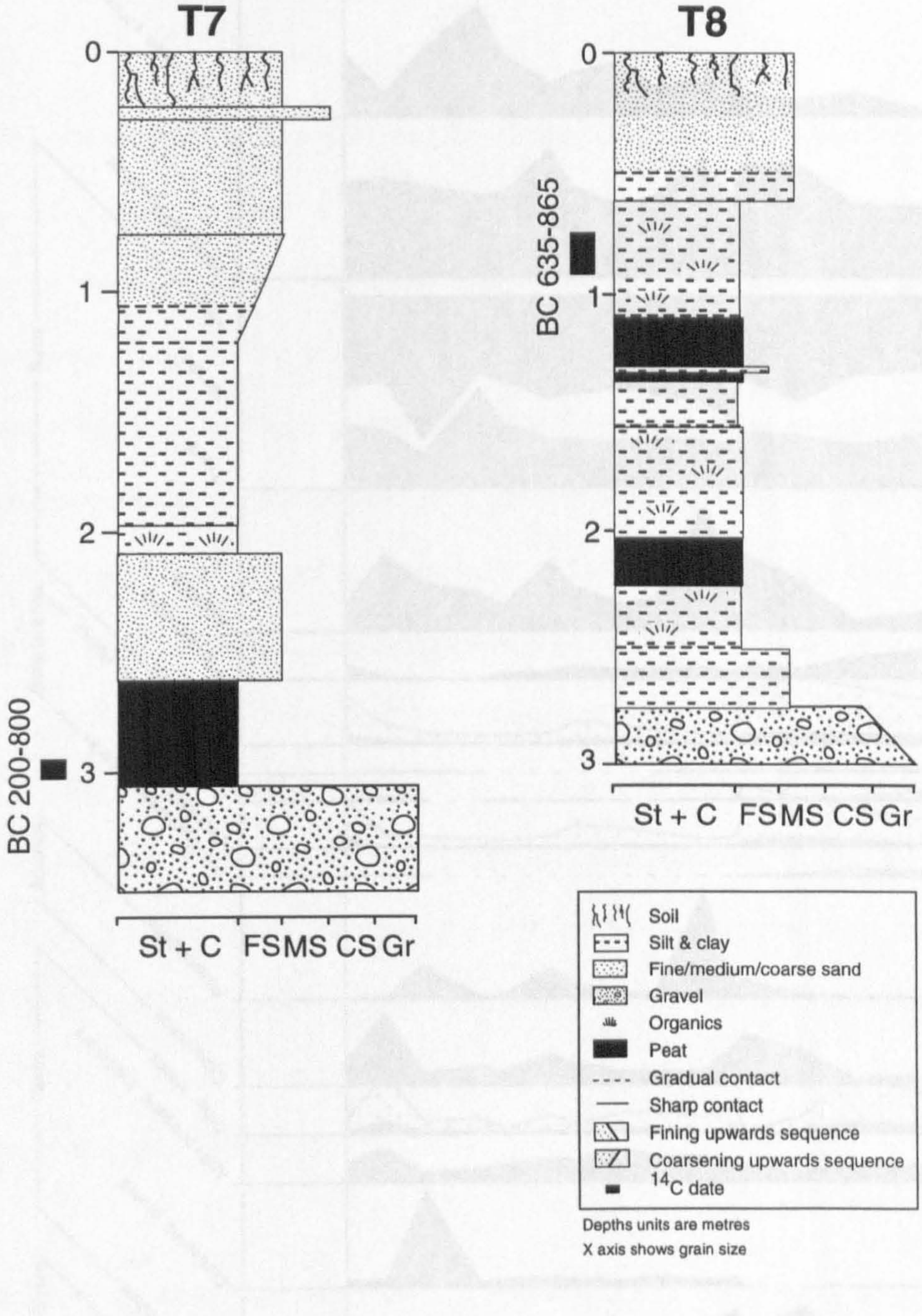
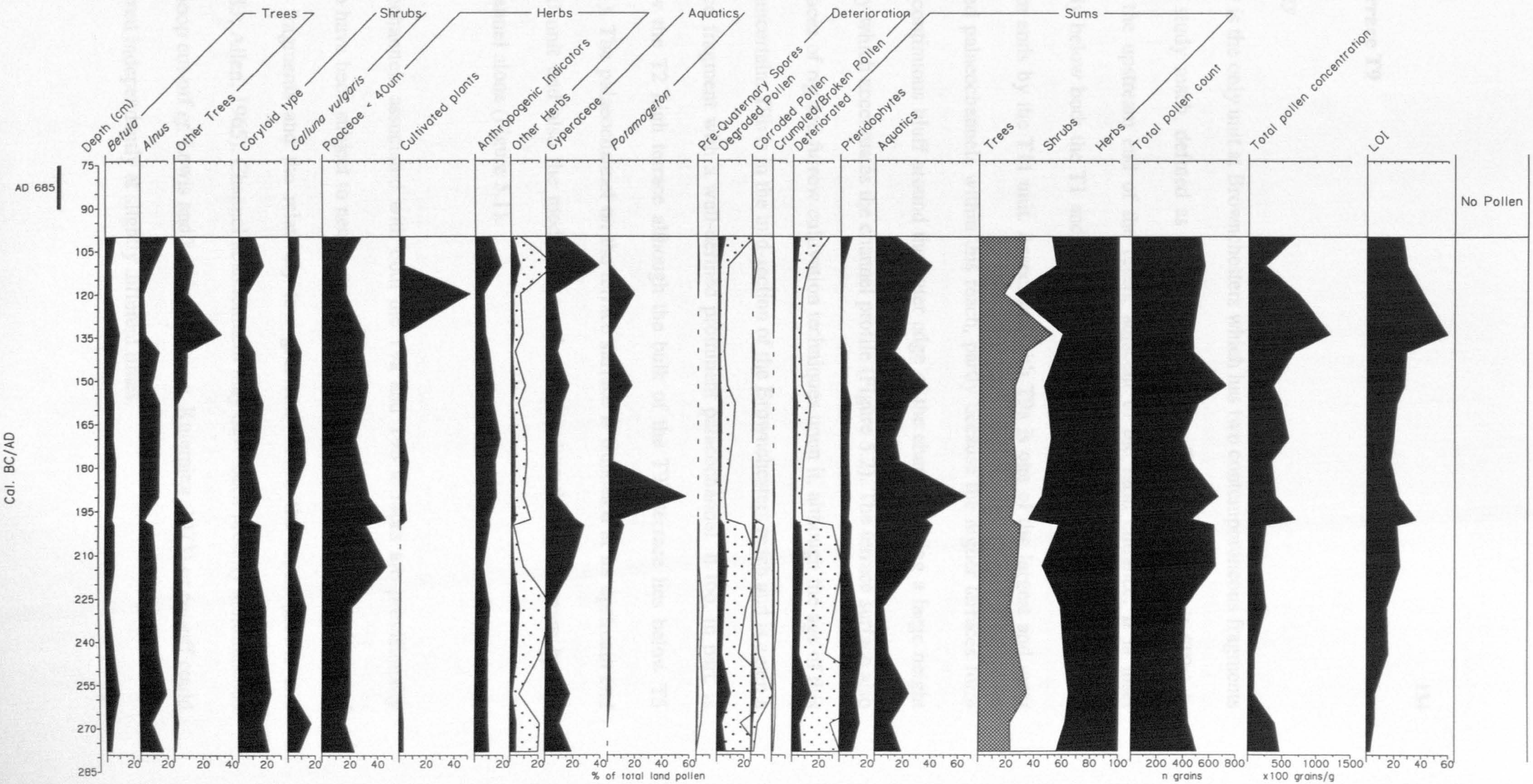


Figure 5.10: Brownchesters Farm Terrace T8
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

5.2.7 Terrace T9

Morphology

Terrace T9 is the only unit at Brownchesters which has two contemporaneous fragments within the study reach, defined as T9a and T9b (Figure 5.1). The first unit (T9a) is located at the upstream end of the reach, adjacent to the farm entrance. It is inset immediately below both the T1 and T2 units and is truncated at both its upstream and downstream ends by the T11 unit. Associated with T9a is one of the largest and most well defined palaeochannels within this reach, partly because the higher terraces form an almost continuous bluff around the outer edge of the channel giving a large height discrepancy which accentuates the channel profile (Figure 5.2). The terrace surface also contains traces of rig and furrow cultivation techniques upon it, although the age of this activity is uncertain. T9b is in the mid-section of the Brownchesters reach and is again a large terrace fragment with a well-defined prominent palaeochannel. It too, in part, is inset below the T2 high terrace although the bulk of the T9b terrace lies below T5 (Figure 5.1). The palaeochannel on the terrace surface is truncated at its upstream end by the T10 unit and also the modern river channel, and at the downstream by the modern channel alone (Figure 5.1).

The palaeochannels associated with both the T9a and T9b terraces are provisionally assumed to have been subject to neck cut-off, owing to the extremely sinuous nature of the extant fragments and the relatively low gradients within the reach (Lewis and Lewin, 1983; Allen, 1965). Channel abandonment may have been broadly simultaneous (*e.g.* multiloop cut-off *cf.* Lewis and Lewin, 1983; *e.g.* Kulemina, 1973) or cut-off could have occurred independently at slightly different times.

Stratigraphy (Figure 5.11)

The sedimentary record from within these two channels is very similar and comprises up to three metres of predominantly organic post-abandonment sediment. Differences in sedimentation patterns can, to an extent, be explained by the different location of the cores within the cut-offs. The core from the upstream palaeochannel was taken from proximal to the point of cut-off, due to problems at the meander apex with sediment recovery caused by the extremely wet nature of the sediment. The pattern of sedimentation within palaeochannels is well documented (Erskine *et al.*, 1992; Waters, 1992; Allen, 1965), as overbank floodwaters which reach the palaeochannel deposit the heavier fraction of their load first, and thus minerogenic material is concentrated at the upstream end of the palaeochannel adjacent to the active river channel. This can be observed with the sediments from the upstream T9 palaeochannel, where organic silts are interbedded with fine-medium sand laminae. In contrast, sediments from the other section of the palaeochannel derived from the downstream end of the cut-off are much less minerogenic, containing an abundance of wood, leaf and other plant fragments (Waters, 1992; Bridge, 1985).

The T9a core is comprised of basal gravels in a coarse sand matrix below 310cm depth and is interpreted as former bed material. This is overlain (216-310 cm) by finely laminated sandy-silts and clayey-silts with frequent organics that represent periodic stability of the palaeochannel with floodwater incursions. This unit is divided by a very well defined grey medium sand lens between 287-290 cm, that probably represents a relatively large scale flood event. Between 122-200 cm are well-laminated peaty-clayey-silts, sandy-clayey-silts and fine-medium sands. This represents a series of periods of stability broken by flood events at a depth of 122-124, 148-150, 153-154, 160, 173-176, 183 and 191-193 cm. This is overlain by two particularly noticeable flood horizons at 120-122 cm comprising of grey medium sands and 110-120cm a laminated silty fine sand. Between 83-110 cm is a fine sandy-clayey-silt which is indicative of a return to slightly more stable conditions within the palaeochannel. This trend continues with the development of peat (43-83cm) which only briefly broken by a clayey-silt unit between 74-77cm. A sandy-silty-clay (30-43 cm) and alluvial topsoil (above 30 cm) overlie this.

The T9b core comprises sandy gravel below 290 cm, overlain by sands to a depth of 286cm. These sediments can be viewed as channel bed and immediate post-abandonment sediments respectively. Between 207-286 cm is a predominantly peaty-clay unit, which contains a distinct flood horizon of sands between 269-270 cm. This is overlain by a peat unit (140-207cm) containing some silt and lots of wood fragments. This is indicative of a progressively more stable environment, with only occasional laminations of fine minerogenic material. Between 137-140 cm is an organic silt, which is replaced by a series of silty clay units (60-137 cm), presumably deposited above the water table in the palaeochannel. Overlying this is a sandy-silty-clay unit (17-60cm) with topsoil above 17cm.

Dating

Dating control upon the sedimentary sequences associated with the T9 terrace is provided by three radiocarbon assays, one upon T9a and two upon T9b. The date from

T9a has been taken on peat from a depth of 50-56 cm (Beta-96121; Appendix 10.2) and has returned a date of AD 1215-1325 and AD 1340-1390. Dating control upon T9b has been provided by a wood sample taken from a depth of 130-135 cm (Beta-90753) which has returned a date of AD 1245-1430 (Appendix 10.2). The second date from T9b, taken upon peat from a depth of 210-220 cm (Beta-90752) has returned a date of AD 600-780 (Appendix 10.2). Thus, it would appear from the similar upper dates that these channels have been accumulating during the same period. This cannot be proven without further radiocarbon dates, however, the assumption here is that these are contemporaneous features.

Palynology (Figure 5.12, Appendix 10.16)

Owing to the contemporaneous nature of these terrace units, palynological analyses have been undertaken upon sediments from only one of the T9 palaeochannels, as they are likely to contain very similar vegetation records. Theoretically, fine, sub-site scale analysis of vegetation history would be possible using the sediments from these palaeochannels, allowing high-resolution, three-dimensional insights into spatial vegetation patterns (*sensu* Turner, 1975). However, due to the time constraints involved this was not undertaken. The sediment core used for pollen analysis was taken from the T9a palaeochannel, at the upstream end of the reach, due mainly to analyses having been carried out prior to the return of radiocarbon dates which revealed the timing of sedimentation within this channel. Pollen was recovered from all but the basal sands and gravel and thus spans a depth of 45-290 cm. The diagram has not been divided into zones as the majority of the principal species show little variation through the core.

The percentages of tree and shrubs, particularly *Alnus*, *Calluna* and Coryloid type are broadly comparable throughout the diagram, attaining values of around 20%. *Betula* values also remain relatively constant at approximately 10%. This probably reflects local stands of mixed woodland in what, as indicated by the levels of *Calluna* that is unlikely to have been growing locally, was a relatively open landscape. *Fraxinus* levels attain a significant and short-lived peak at a depth of around 135 cm and this too is likely to be related to local growth. Other arboreal taxa, such as *Quercus*, *Salix*, *Pinus* and *Ulmus* occur only in very low quantities, supporting the hypothesis of an open landscape. The Poaceae and Cyperaceae pollen curves are the only species that demonstrate any major fluctuations, both remaining relatively stable in the majority of the core, but peaking between 45-80 cm. What is particularly noticeable within the pollen record from this diagram is both the high number and high diversity of herbaceous taxa present in the samples. Although the curves for cultivated plants are relatively low, certainly in comparison with the peaks for *Avena / Triticum* visible in the core from the T8 terrace unit, levels of anthropogenic indicator taxa attain levels of almost 20% at the top of the core *ca.*1285 AD. This suggests fairly intensive utilisation of the valley floor for agricultural purposes, although there is little evidence for cereal production. In contrast with many of the other pollen diagrams from Brownchesters, there is little evidence from the *Potamogeton* or other aquatic curves to suggest that this T9a channel existed as an oxbow following cut-off from the river channel.

Figure 5.11: Simplified lithostratigraphy and ^{14}C dates for palaeochannel sediment cores T9a and T9b at Brownchesters Farm

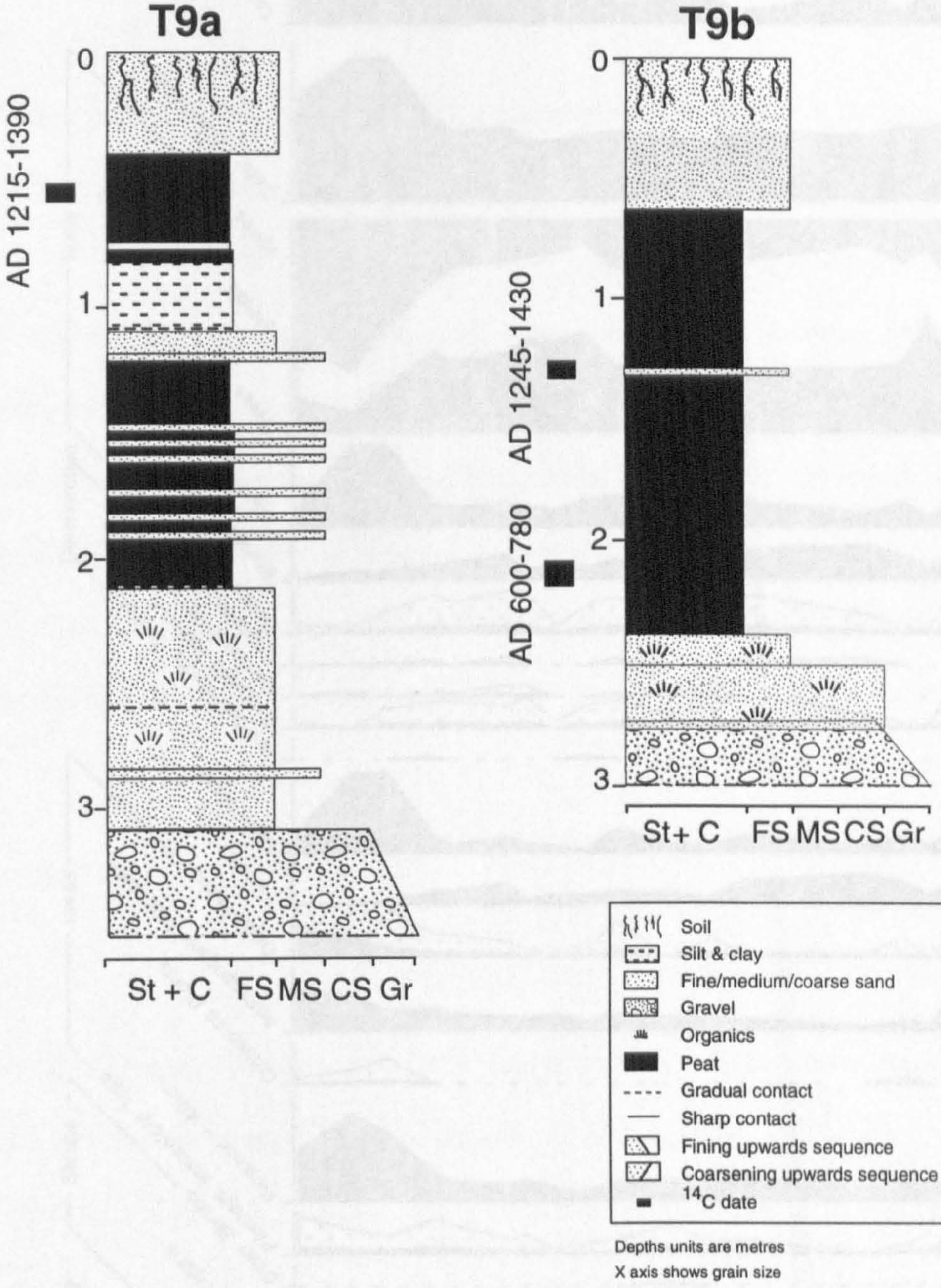
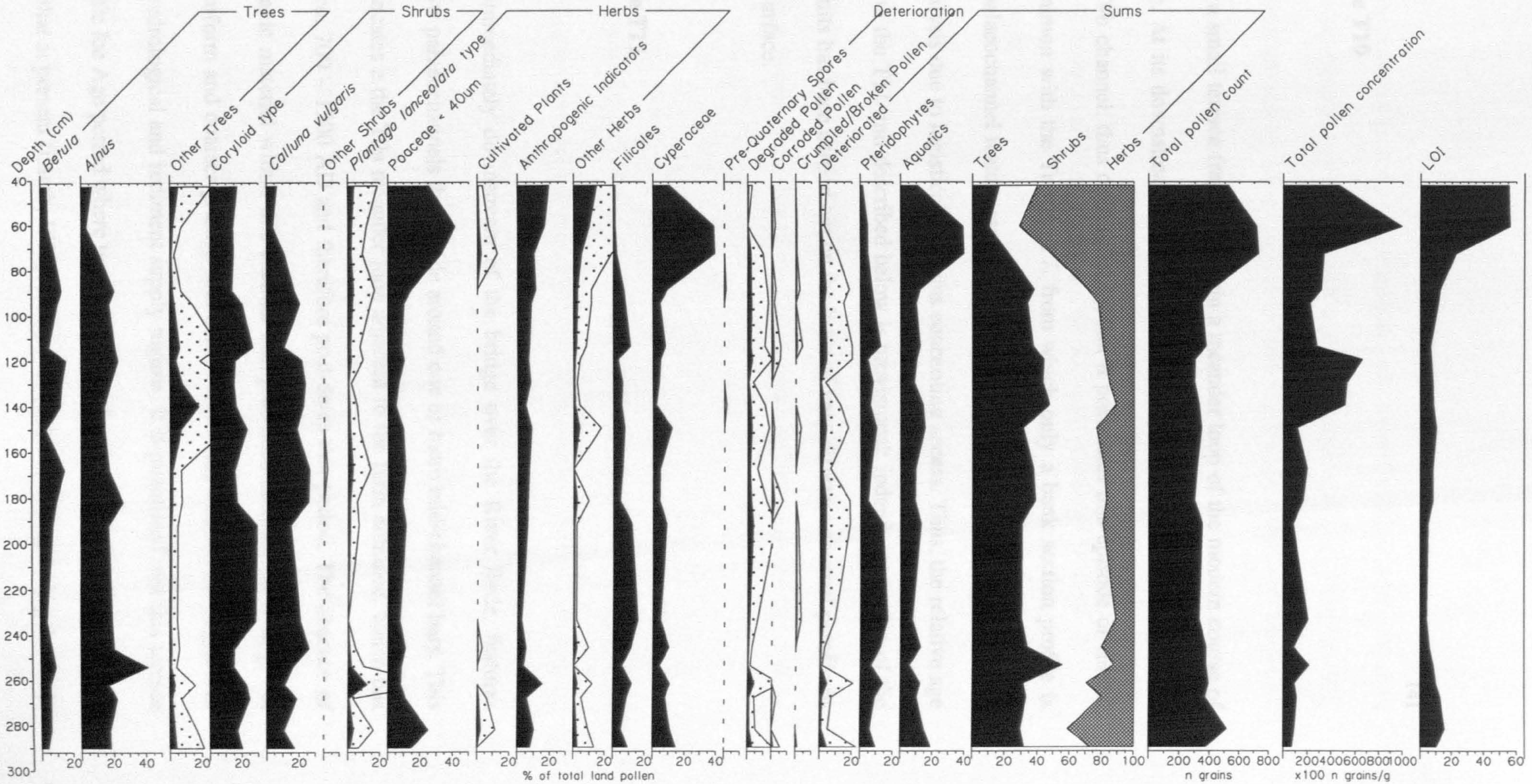


Figure 5.12: Brownchesters Farm Terrace T9a

Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

5.2.8 Terrace T10

Morphology

Terrace T10 is a small terrace fragment within a meander loop of the modern course of the River Rede. At its downstream end the palaeochannel associated with this terrace truncates the T9b channel, thus demonstrating that it post-dates this episode of fluvial activity. In common with the Terrace T7, from which only a bank section profile is available, the palaeochannel feature associated with this terrace also has been subject to sub-surface analysis due to logistical problems concerning access. Thus, the relative age relationship with the T11 unit described below is provisional; indeed, separation of the T10 and T11 units has been carried out on the basis of very different channel planforms on the terrace surface.

5.2.9 Terrace T11

Morphology

Terrace T11, immediately downstream of the bridge over the River Rede, features relatively narrow palaeochannels that divide around one or more mid-channel bars. This terrace also truncates a the T9a meander loop adjacent to the farm entrance, which has been dated to *ca.* 700 – 1200 AD and therefore post-dates this period. The absence of significant organic material within this channel belt precludes radiocarbon dating, but the braided planform and coarser-grained sediment within these channels is suggestive of a different hydrological and sediment supply regime. It is postulated that this terrace dates to the Little Ice Age period where temperatures declined and there was a markedly higher rainfall that at present (Lamb, 1995). Enhanced channel braiding during the Little

Ice Age has been recorded at many sites throughout the South Tyne and Tyne, although the North Tyne has been little studied in this respect (Passmore *et al.*, 1993). To date, stratigraphic investigations have been limited to sand auguring by hand, with sediments not being logged. Further analysis of this terrace unit is planned.

5.3 Geomorphological Mapping and Sediment Stratigraphy at Snabdaugh

Mapping of geomorphological units at Snabdaugh Farm has focused upon the area in front of the farm buildings on the south side of the River North Tyne. This has been complemented by mapping of the floodplain on the opposite side of the river, extending the reach upstream and the surveying of a series of cross profiles across the valley floor Figure 5.13).

Preliminary analyses of the Holocene alluvial history at Snabdaugh are documented in Passmore (1994), Passmore and Macklin (1997) and Moores *et al.*, (1998). In this study, work has focused upon extending the existing mapping carried out by Passmore (1994) which has been concentrated upon the south bank of the River Tyne and which has been partially documented in a paper by Moores *et al.*, (1998). A total of eight alluvial terrace assemblages, designated T1-8, have been differentiated at Snabdaugh on the basis of morphostratigraphic relationships, elevation above the current river and a variety of dating controls. In contrast to the site at Brownchesters (Redesdale), many units do not contain organic-rich palaeochannel fills and as a consequence many discrete terraces lack direct dating control. These have been classified on a provisional and relative basis, although some terraces remain unsurveyed and as a consequence have not been classified. In addition, exploratory coring of the palaeochannels on the north side of the Tyne has been undertaken, although these too have not proved fruitful in terms of the level of organic preservation for dating and pollen preservation for palaeoecological analyses. Correlation of terrace units upstream and downstream has been done principally upon the basis of relative height and is thus subject to alteration should further dates become available. The descriptions provided below focus upon data gathered from the floodplain immediately in front of the farm as documented in Passmore (1994), Passmore and Macklin (1997) and Moores *et al.*, (1998).

Figure 5.13: Geomorphological map of Pleistocene and Holocene river terraces and palaeochannels at Snabdaugh Farm showing cross profiles and core locations

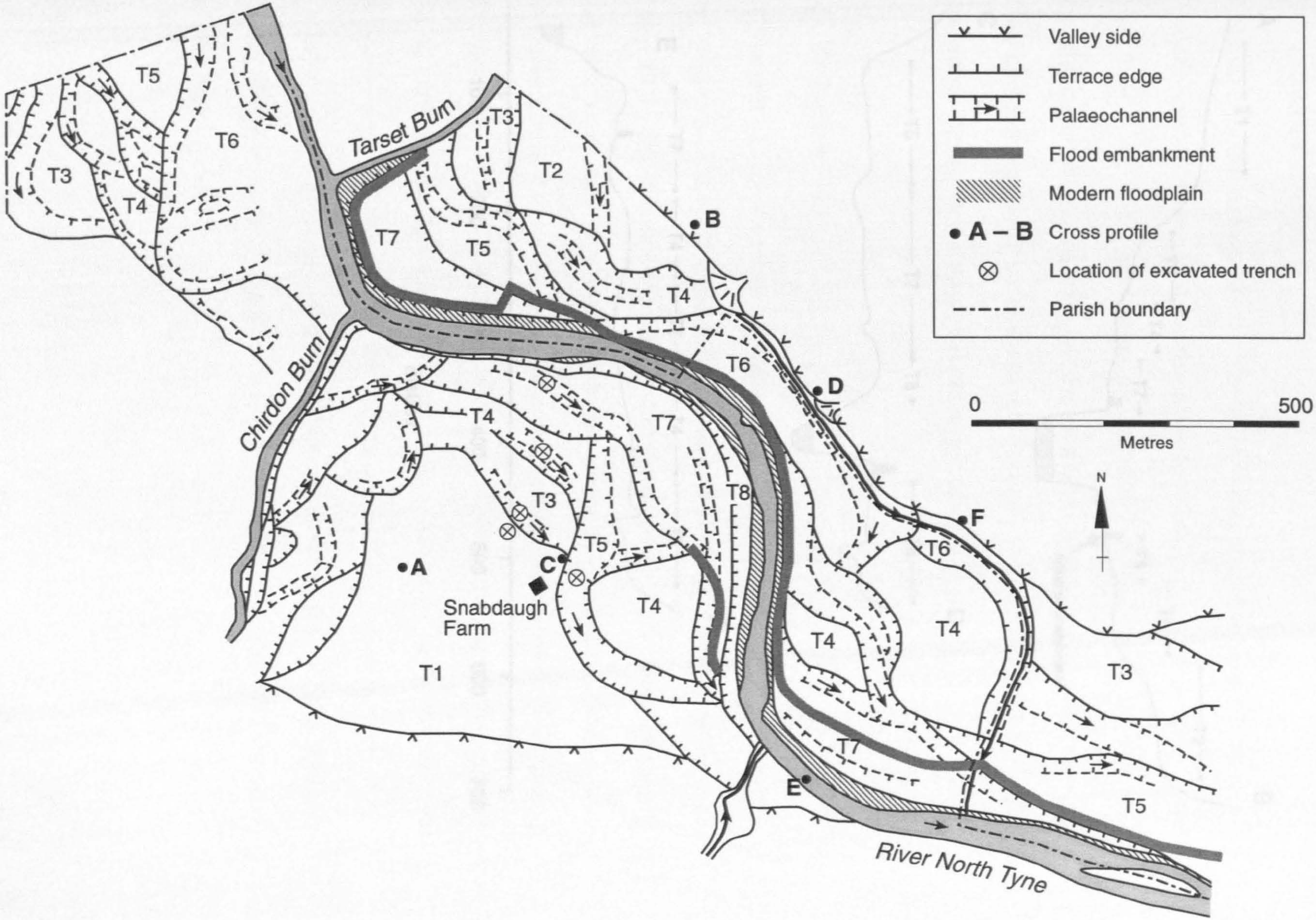
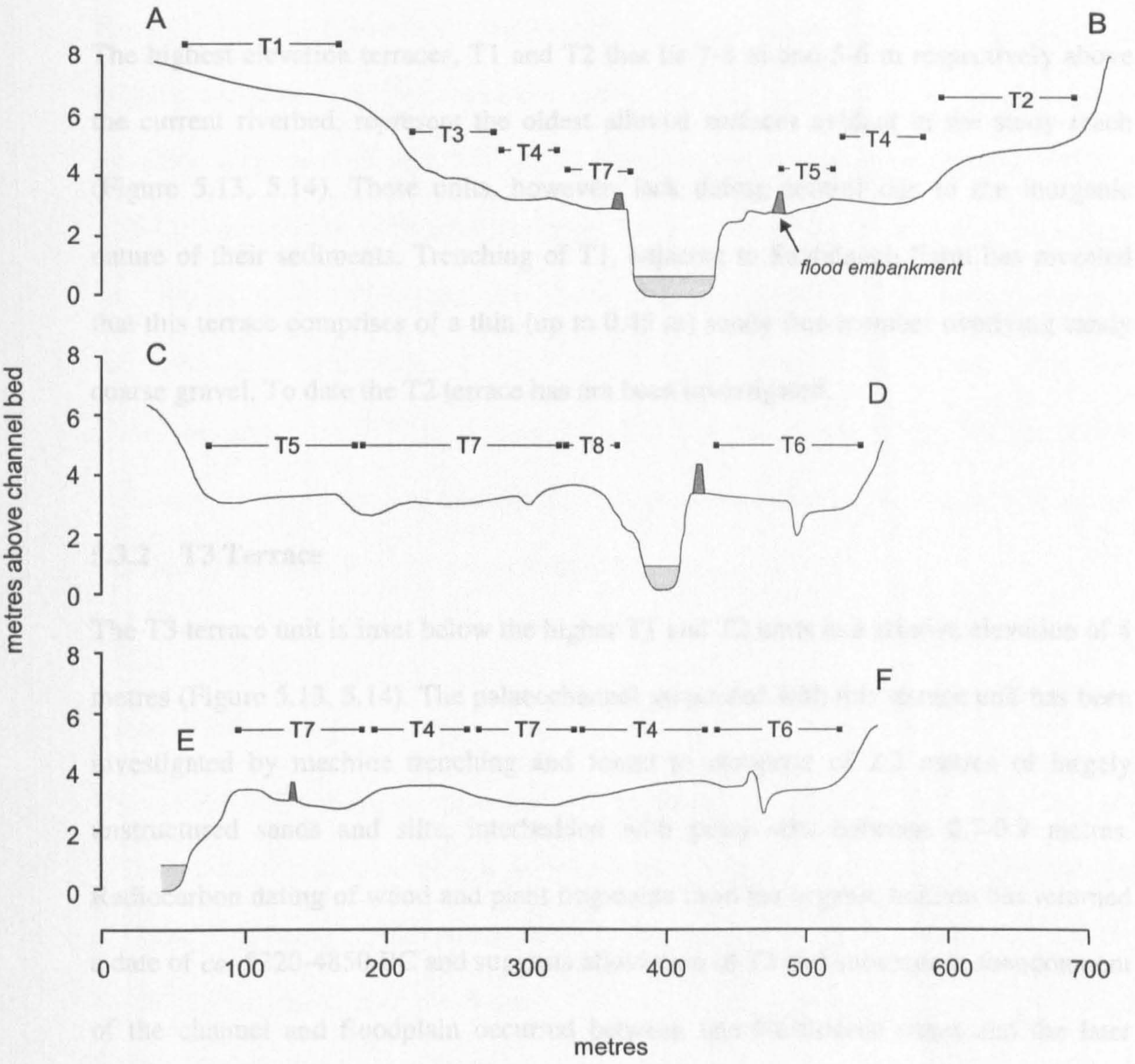


Figure 5.14: Surveyed cross-profiles of the valley floor at Snabdaugh Farm



5.3.1 T1 and T2 Terraces

The highest elevation terraces, T1 and T2 that lie 7-8 m and 5-6 m respectively above the current riverbed, represent the oldest alluvial surfaces evident in the study reach (Figure 5.13, 5.14). These units, however, lack dating control due to the inorganic nature of their sediments. Trenching of T1, adjacent to Snabdaugh Farm has revealed that this terrace comprises of a thin (up to 0.45 m) sandy fine member overlying sandy coarse gravel. To date the T2 terrace has not been investigated.

5.3.2 T3 Terrace

The T3 terrace unit is inset below the higher T1 and T2 units at a relative elevation of 4 metres (Figure 5.13, 5.14). The palaeochannel associated with this terrace unit has been investigated by machine trenching and found to comprise of 2.2 metres of largely unstructured sands and silts, interbedded with peaty silts between 0.7-0.9 metres. Radiocarbon dating of wood and plant fragments from the organic horizon has returned a date of *ca.* 5220-4850 BC and suggests alluviation of T3 and subsequent abandonment of the channel and floodplain occurred between late-Pleistocene times and the later Mesolithic period (Passmore, 1994). The shallow nature of the organic horizon within this palaeochannel was deemed to be insufficient to warrant palaeoecological analysis, given the extensive range of organic-rich fills within other palaeochannels elsewhere within the North Tyne basin.

5.3.3 T4 Terrace

The T4 terrace lies between 2.5 and 3 metres above the current riverbed, with sediments infilling the associated palaeochannel comprising of up to 1.5 m of poorly-bedded inorganic silty sands (Figure 5.13, 5.14). Palaeomagnetic dating of sediments between 0.56-1.15 m indicates infilling of the upper levels of this channel was occurring around *ca.* 1500 BC (Noel, 1991; Passmore, 1994), and suggests that incision of T3 sediments and subsequent alluviation of the T4 unit occurred sometime between the later Mesolithic and the mid-2nd millennium BC. This very broad chronological range within the surviving terrace units at Snabdaugh is in stark contrast to the number of episodes of alluviation visible at Brownchesters within the same period.

5.3.4 T5 Terrace

T5 alluvial units also lie between 2-3 m above the present river bed, but are differentiated from earlier T4 fills by well-defined terrace scarps and, immediately east of Snabdaugh Farm, a dated palaeochannel fill sequence up to 2.7 m thick (Figure 5.13, 5.14). Infilling the base of the channel is 0.3 m of fining-upward grey sandy silty clays that grade up-profile into 0.25 m of peaty sandy silt. A large piece of timber, clearly bearing toolmarks and resembling a truncated plank, was recovered lying at the transition between these fills and has been ^{14}C dated to *ca.* 800-150 BC (Passmore, 1994; Moores *et al.*, 1998). This date indicates local abandonment of the T5 channel occurred sometime during the late Bronze Age and Iron Age periods. Overlying these sediments are 0.75 m of silty peat with frequent wood and plant inclusions and interbedded fine silty lenses. Radiocarbon assays on wood and plant fragments extracted from the base (depth 2.2 m) and top (1.4 m) of the peat bracket this period of organic-rich sedimentation to between *ca.* 210-440 AD and *ca.* 1000-1270 AD respectively. Overlying sediments largely comprise up to 1.3 m of inorganic coarse-fine sands and silts (Figure 5.15).

Palynology (Figure 5.16)

The organic-rich sediments within this palaeochannel fill have provided the primary opportunity for palaeoecological analyses from within the Snabdaugh study reach. Pollen preservation within this fill is adequate for counting only between a depth of approximately 1.3 and 2.7 metres where sediments are organic in nature. The pollen diagram shows a largely treeless environment throughout the period, with peaks in *Alnus* and *Salix* almost certainly relating to extremely local stands of these taxa. There is an almost constant, if low, presence of cultivated taxa through the diagram, with levels of anthropogenic indicator species very high particularly in the lower portion of the diagram covering the Late Bronze Age, Iron Age and Romano-British periods. The peak in alder of over 60% (which is likely to reflect *in situ* vegetation succession as suggested by pollen concentration values) distorts the diagram, as quantities of grass are depressed from what appears to be stable percentages of around 25%. The Cyperaceae curve also demonstrates some large fluctuations, which are related to local water table conditions, which appear in part to be determined by alder levels within the palaeochannel.

Figure 5.15: Simplified lithostratigraphy and 14c dates for palaeochannel sediment core T5 at Snabdaugh Farm

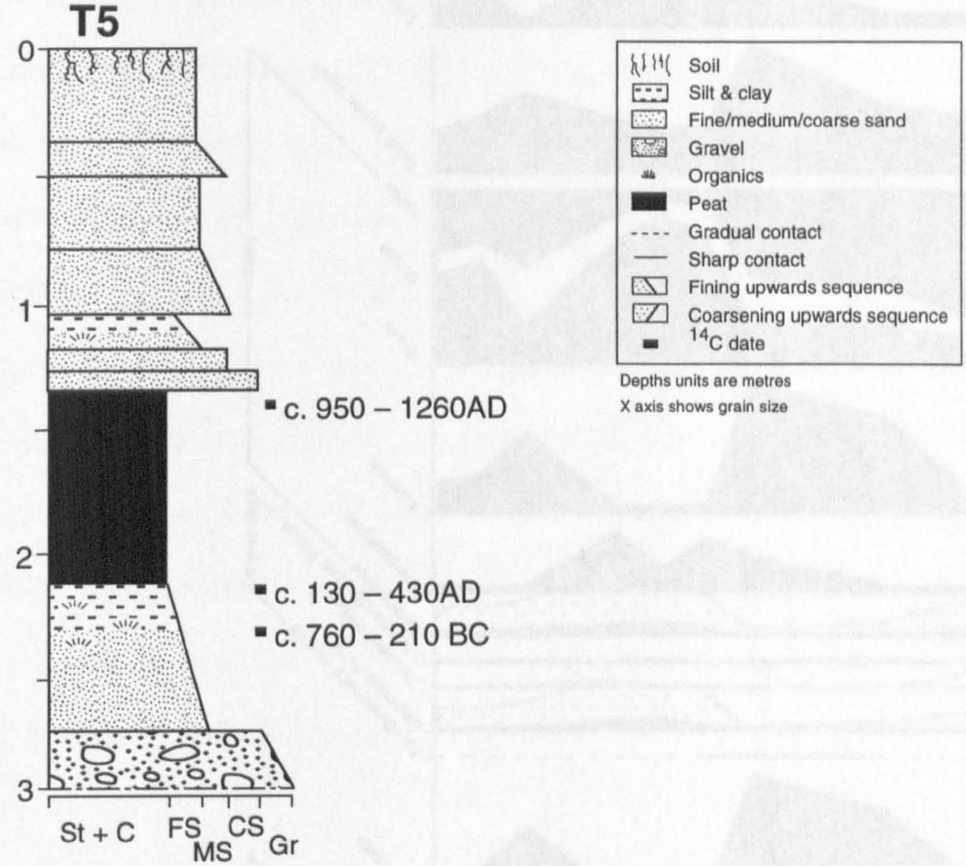
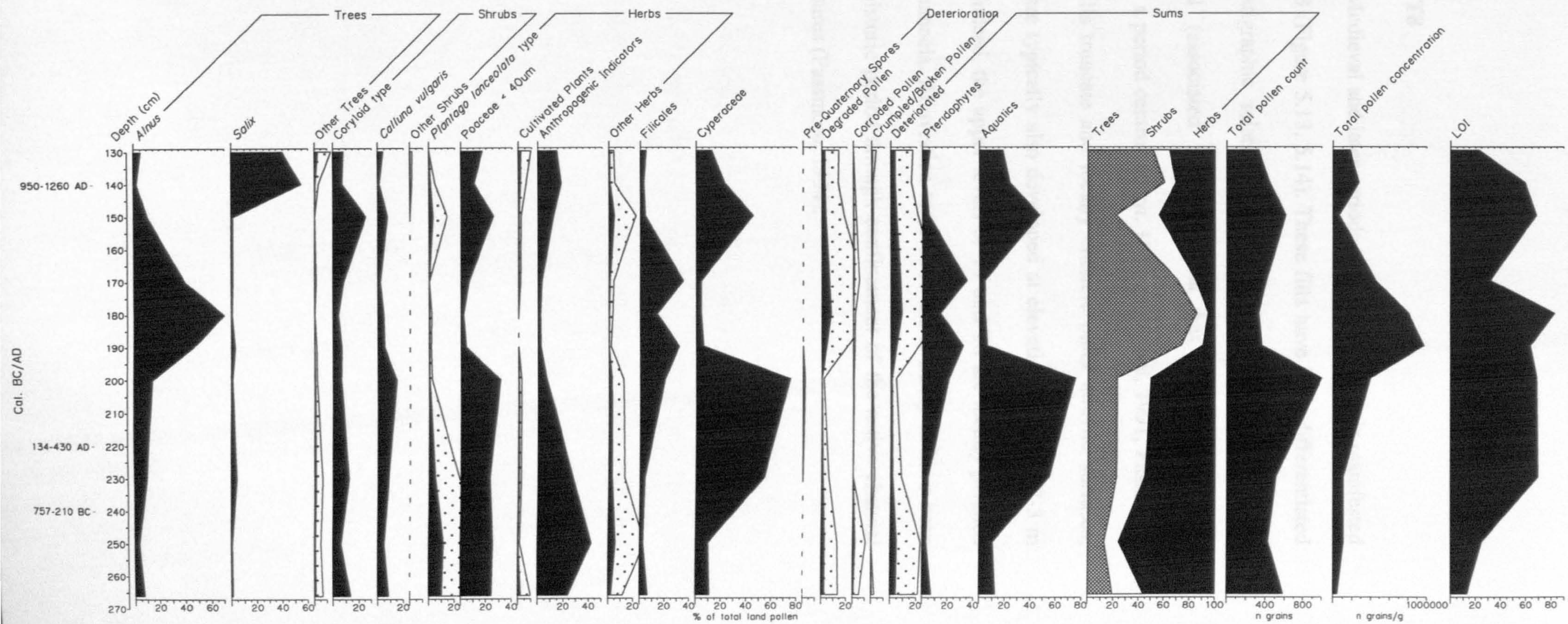


Figure 5.16: Snabdaugh Farm Palaeochannel T5
Summary percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

5.3.5 Terraces T6, T7 and T8

Fluvial activity dating to the Medieval and later periods in the study reach is manifested by terrace assemblages T6-T8 (Figure 5.13, 5.14). These fills have been differentiated on the basis of morphostratigraphic relationships, cartographic evidence and an inorganic palaeochannel fill (associated with T7) that has been dated using palaeomagnetic techniques to a period centred on *ca.* 1350 AD (Noel, 1991, Passmore, 1994). Medieval and later fills truncate and locally encircle older alluvial surfaces, although associated terraces are typically also developed at elevations between 2-3 m above the present river bed. Indeed, the upper levels of T7 and T8 are locally perched up to 1 m above T5 palaeochannels. Alluviation to these levels is likely to have been promoted during the recent historic period through confinement of the active channel zone by flood protection measures (Passmore, 1994).

5.4 Analysis of Pollen Deterioration

5.4.1 Summary Statistics

Analysis of the deterioration state (*sensu* Cushing, 1964, 1967) of pollen grains derived from alluvial contexts was carried out in an attempt to assess whether individual grains could be identified as being reworked from their original depositional context. This was done on the premise that grains that exhibit degradation-type deterioration are more likely to have undergone fluvial transport and may therefore be non-contemporaneous and distinct in a spatial sense from the local valley floor vegetation represented within the palaeochannel sediments from which the pollen was derived (Cushing, 1964,1967; Birks, 1970). This differentiation between allochthonous and autochthonous pollen has been thoroughly reviewed within Chapter 2.

The principal findings of the application of deterioration state analysis upon alluvial pollen samples was that relatively few of the pollen grains exhibited any form of deterioration (*ca.* 7 % of total pollen sum), the majority of pollen being well-preserved (Figure 5.17).

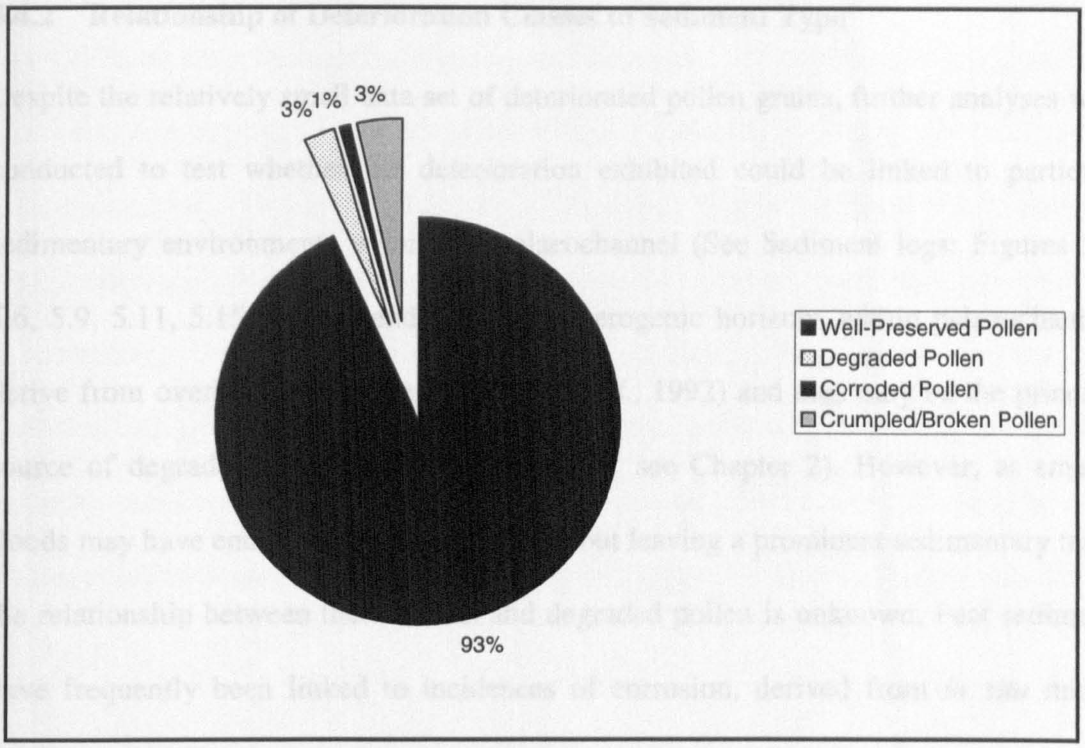


Figure 5.17: Pie Chart showing percentages of preservation state of pollen grains from valley floor alluvial sites.

5.4.2 Relationship of Deterioration Classes to Sediment Type

Despite the relatively small data set of deteriorated pollen grains, further analyses were conducted to test whether the deterioration exhibited could be linked to particular sedimentary environments within the palaeochannel (See Sediment logs: Figures 5.3, 5.6, 5.9, 5.11, 5.15 and Appendix 10.6). Minerogenic horizons within palaeochannels derive from overbank floodwaters (Erskine *et al.*, 1992) and thus may be the principal source of degraded pollen grains (Birks, 1970; see Chapter 2). However, as smaller floods may have encroached the channel without leaving a prominent sedimentary trace, the relationship between these events and degraded pollen is unknown. Peat sediments have frequently been linked to incidences of corrosion, derived from *in situ* micro-organism activity and periodic exposure to the air (Lowe, 1982; Delcourt and Delcourt, 1980; see Chapter 2).

Analyses of the deterioration state of pollen grains in comparison with the sedimentary context in which they are deposited are restricted by the original sampling strategy employed in the field. Cores were sub-sampled into 2-cm slices and although major stratigraphic divisions were taken into consideration in this strategy, minor alterations in the sediment were largely ignored. This has important implications for the results of any analyses, as sedimentary laminae between 1-20 mm existed within 2-cm sections of core. Recently, fine-resolution sub-sampling and analysis of palaeochannel infills at Brownchesters has revealed a detailed history of sedimentation at mm-scale resolution (Hildon, *pers. comm.*). The analyses described here, which are derived from pollen samples, may contain a range of sediment types and thus potentially important inaccuracies may exist within the data used for statistics.

In order to conduct statistical analysis upon these results it was necessary to quantify the grain size and organic content of sediment logs of palaeochannel fills taken in the field (Appendix 10.6). Two proxy measures of sediment type were employed to facilitate this. Firstly, sedimentary logs from the palaeochannel-derived cores were converted into a subjective 10-point hierarchical classification, grading from wholly organic peat sediments to gravel. It should be noted that this is a discrete classification, divisions between categories are non-scalar. Secondly, Loss-on-Ignition values were used as an approximate measure of the level of minerogenic material within individual samples.

Sedimentary Index	Sediment Description
1	Peat
2	Silty-Peat
3	Peaty-Clay
4	Peaty-Silt
5	Clayey-Silt
6	Sandy-Silt
7	Silty-Sand
8	Fine Sand
9	Medium / Coarse Sand
10	Gravel

Table 5.1: Outline of Sedimentary Index used for analyses of deterioration data

Data for correlation analyses with Sediment Index were ranked due to the non-continuous nature of this variable. To examine the relationship between LOI and

Sediment Index a Spearman's Rank correlation was carried out, which produced a coefficient of –0.785, significant at in excess of 99%. This shows that Loss on Ignition is inversely related to the sediment index (See Figure 5.18) and that the categories as described in the field are an accurate reflection of the nature of the sediment.

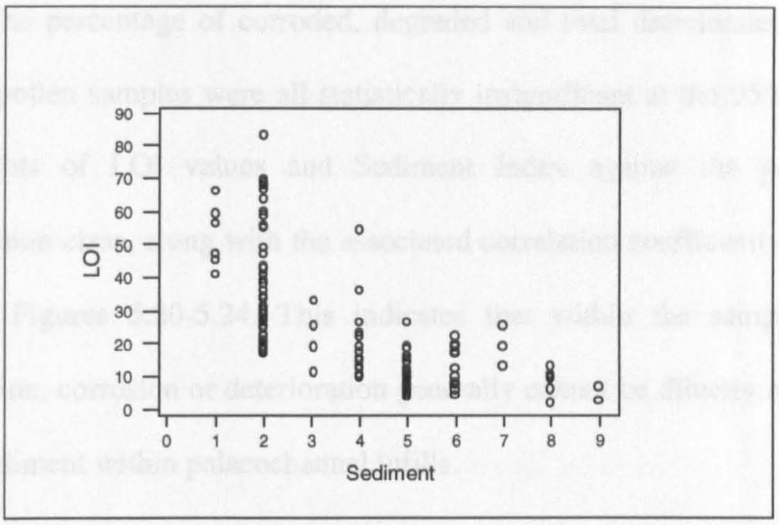


Figure 5.18: Plot of Sediment Index against % Loss-on-Ignition.

Correlation analyses of Loss-on-Ignition values and ranked analyses of Sediment Index against the percentage of corroded, degraded and total deteriorated pollen within the alluvial pollen samples were all statistically insignificant at the 95% level (Table 5.2). Scatterplots of LOI values and Sediment Index against the percentage of each deterioration class, along with the associated correlation coefficient are shown in Table 5.2 and Figures 5.20-5.24. This indicates that within the samples analysed here, degradation, corrosion or deterioration generally cannot be directly related to the nature of the sediment within palaeochannel infills.

Preservation State	**Loss-on-Ignition** (Correlation coefficient)	**Sediment Index** (Spearman Rank Correlation)
Corrosion	0.090	0.057
Degradation	-0.034	0.132
Deterioration	-0.051	0.163

Table 5.2: Correlation coefficients for preservation state with Loss-on-Ignition and Sediment Index.

5.4.3 Implications of Preservation State Analysis for Alluvial Pollen Taphonomy

The apparent inability of the techniques employed here to attribute a mechanism to the incidences of deteriorated pollen could be seen as evidence that alluvial sediments contain reworked pollen and that it is impossible to accurately identify. However, while floodwaters have clearly encroached upon the palaeochannels under analysis, and the increased concentrations of pollen in high-stage events has been well-documented (see

Chapter 2), the contribution of short-lived flood events to the total pollen rain received by these environments over any given season, or indeed the entire period during which palaeochannel sediments are accumulating, is likely to be minimal. Although there is an element of circular reasoning within this argument, the overall, well-preserved nature of pollen grains recovered from these palaeochannel sediments is testament to this. A programme of deterioration state pollen analyses upon modern fluvial samples during a range of river stages would be extremely useful in this respect to test whether transport processes are having a detrimental effect upon pollen exines.

The inability of these statistics to correlate specific elements of deterioration (corrosion and degradation) with the various sediment types may also be function of the resolution of the raw data; the sub-samples for palynological analysis having been taken from 2-cm sediment slices and thus possibly containing a variety of sediment types. There of course may be no correlation between sediment type and deterioration state, in which case processes for the development of degradation and corrosion of pollen exines require re-appraising.

In conclusion, it would appear that alluvial pollen samples derived from these organic-rich palaeochannel sediments are not unduly affected by secondary pollen deposition. Pollen spectra derived from these contexts are believed to accurately reflect local vegetation, with pollen derived principally from airborne sources. These alluvial contexts therefore offer unique opportunities for the reconstruction of coherent pollen diagrams (*cf.* Brown, 1996) from the valley floors of upland Britain.

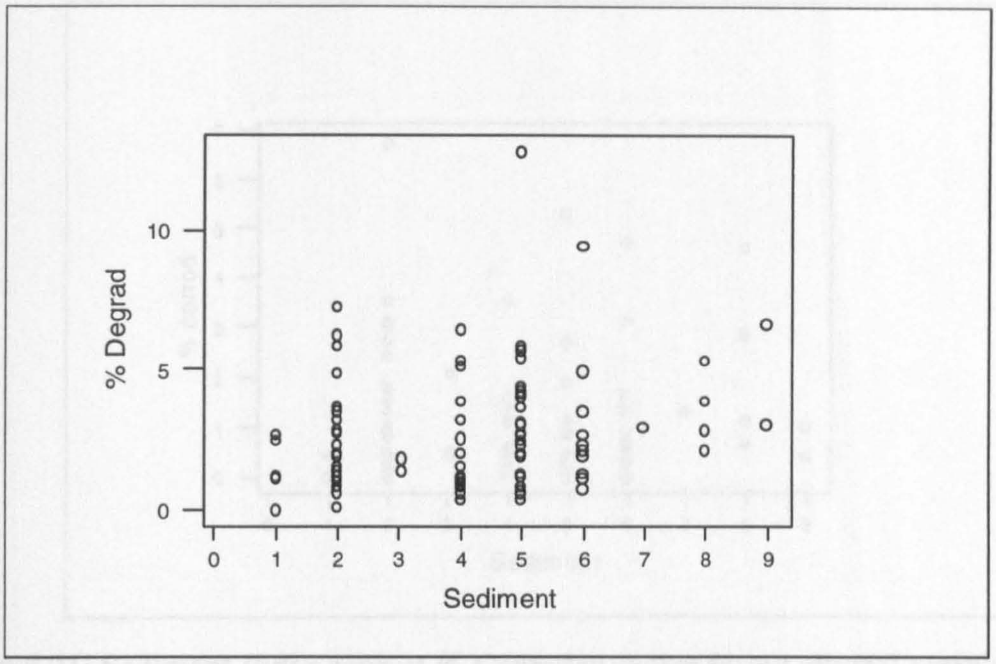


Figure 5.19: Sediment Index against % Degraded Pollen for all alluvial samples.

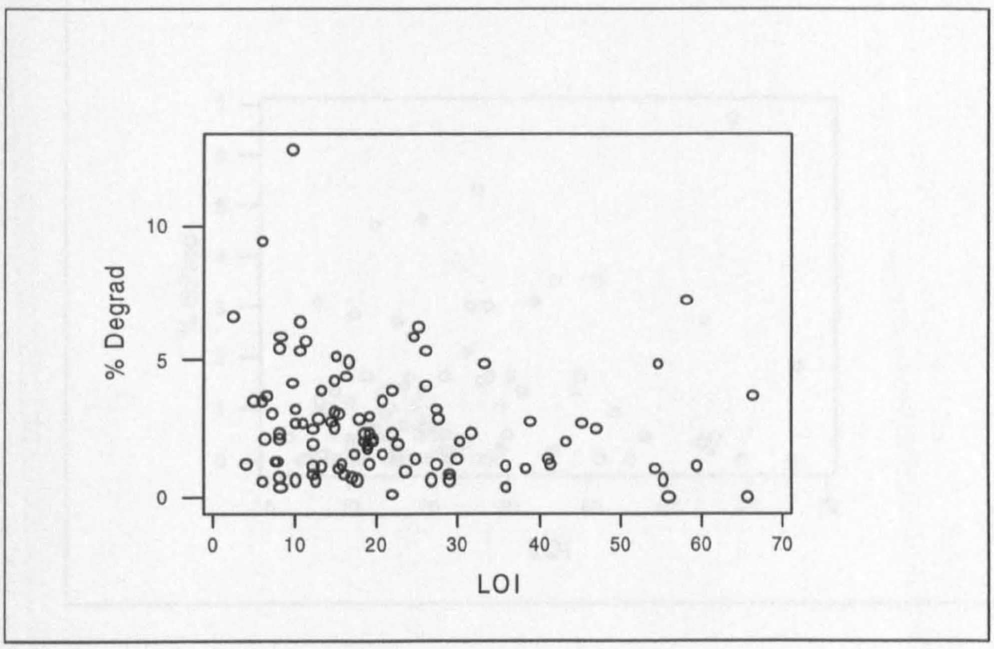


Figure 5.20: % Loss-on-Ignition against % Degraded Pollen for all alluvial samples. Correlation coefficient = -0.034

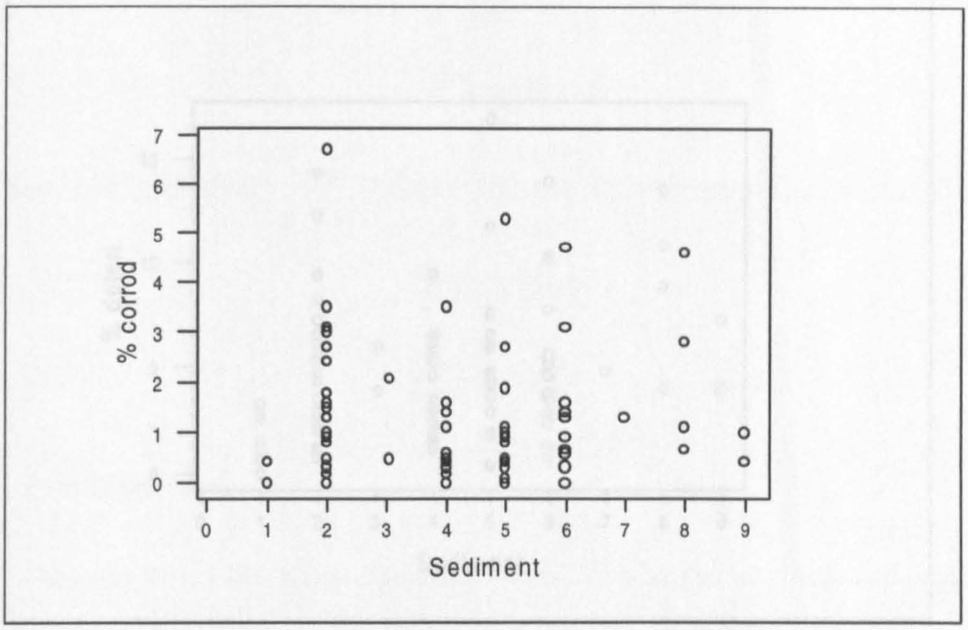


Figure 5.21: Sediment Index against % Corroded Pollen for all alluvial samples.

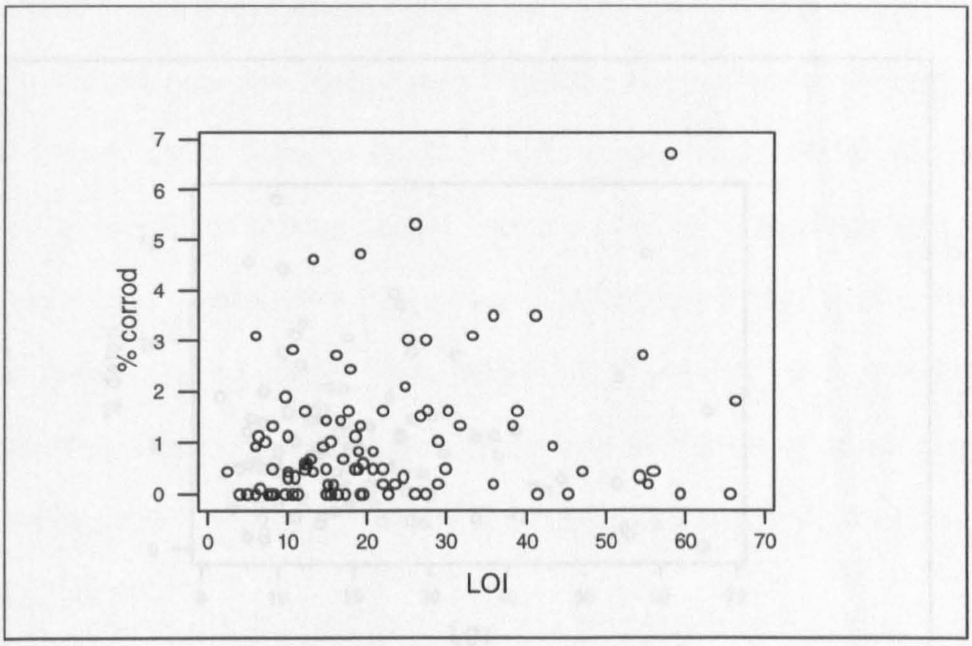


Figure 5.22: Loss-on-Ignition against % Corroded Pollen for all alluvial samples. Correlation coefficient = 0.090

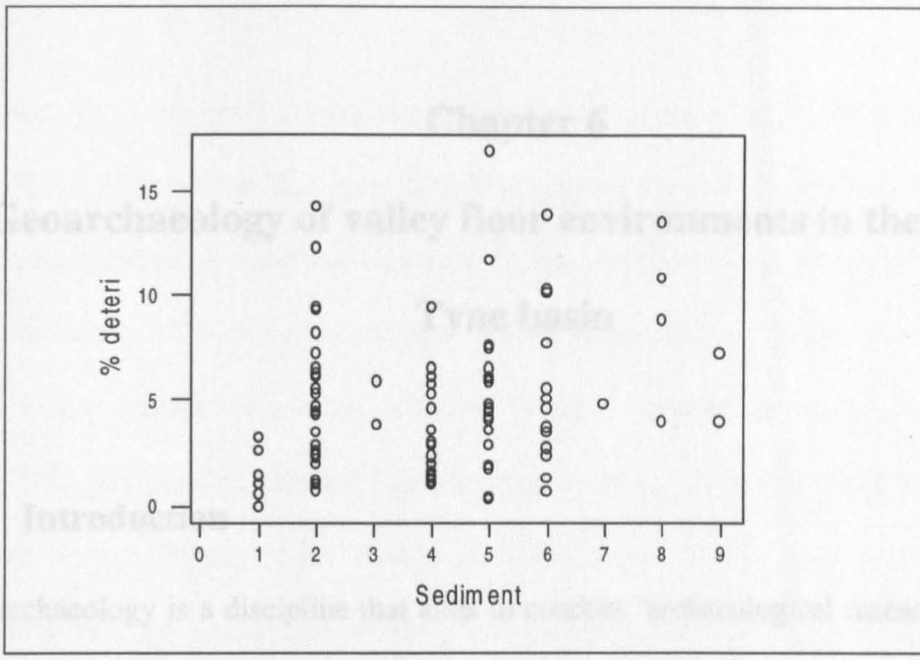


Figure 5.23: Sediment Index against % Deteriorated Pollen for all alluvial samples.

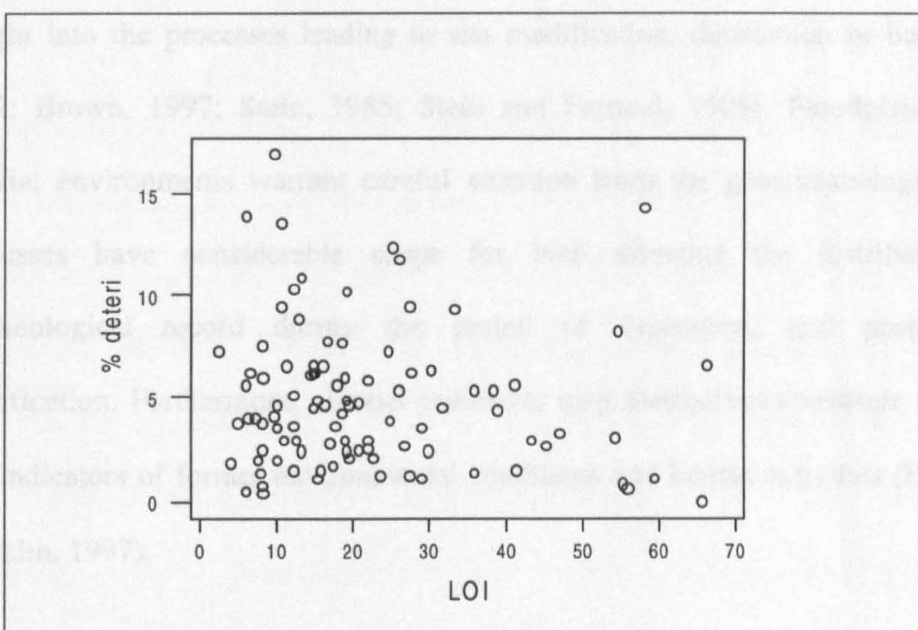


Figure 5.24: %Loss-on-Ignition against % Deteriorated Pollen for all alluvial samples. Correlation coefficient = -0.051

Chapter 6

Geoarchaeology of valley floor environments in the North Tyne basin

6.1 Introduction

Geoarchaeology is a discipline that aims to conduct 'archaeological research using the concepts and methods of the earth sciences' (Butzer, 1982: p.35). Geoarchaeology has its application not only in identifying site characteristics associated with particular archaeological features, but also in providing a physical environmental context and an insight into the processes leading to site modification, destruction or burial (Waters, 1992; Brown, 1997; Stein, 1985; Stein and Farrand, 1985). Floodplains and other alluvial environments warrant careful attention from the geoarchaeologist as fluvial processes have considerable scope for both affecting the distribution of the archaeological record during the period of deposition, and post-depositional modification. Furthermore, alluvial sediments may themselves constitute valuable off-site indicators of former environmental conditions and human activities (Passmore and Macklin, 1997).

6.2 Geoarchaeological evaluation of valley floors in the North Tyne Basin

A geoarchaeological approach to valley floor environments and human activity facilitates the extension of models of landform, sedimentary and archaeological associations in regional alluvial environments (Macklin *et al.*, 1992a; Passmore and Macklin, 1997). As is the case throughout many upland British river valleys, the typically fragmentary nature of Holocene fluvial terrace survival will have led to partial or complete erosion of prehistoric and historic archaeological landscapes in the North Tyne basin. Indeed, the number and chronological range of the terrace fragments that have been described in Chapter 5 demonstrate the dynamic nature of the valley floor at Brownchesters (Figure 6.1). However, fluvial activity has been characterised by comparatively restricted rates of lateral reworking in this area of the valley floor and a tendency towards net aggradation of floodplains. This is the reason for the excellent survival of multiple terraces and also points to the greater likelihood of older Holocene surfaces remaining at least partially intact.

The waterlogged and seasonally flooded nature of the Brownchesters site has probably precluded settlement upon the Holocene valley floor. However, settlement upon adjacent high gravel terraces has been demonstrated within other valley floors in the region (*e.g.* Milfield: Waddington, 1998a) and similar scenarios can be envisaged within North Tynedale. Areas of Holocene alluvium supporting floodplain woodland would have offered opportunities for hunting fowl and game, whilst rivers themselves are likely to have been fished, thereby provided rich resources for prehistoric communities (Zvelibil, 1994). Cleared land within the valley floor probably provided lush pasture for cattle and good quality soils for seasonal crop growth. Former human communities may also have built riverine structures, which may be particularly well-preserved within former channels and overbank alluvium (Passmore and Macklin, 1997). For instance, Neolithic trackways have been found within the Somerset Levels (Coles and Coles, 1986) and Roman bridge abutments have been found within the region, with examples at Corbridge, Lower Tyne valley (Bidwell and Snape, 1996) and possibly at Elishaw, Redesdale (Bidwell and Holbrook, 1989). Furthermore, machine-trenching of the T5 palaeochannel sediments at Snabdaugh have revealed an Iron Age worked wooden plank (Passmore, 1994; Moores *et al.*, 1998).

Persistently anaerobic conditions present within peat-filled palaeochannels are also conducive to the long-term survival of organic archaeological materials such as wood and leather. However, the sediment coring techniques employed at Brownchesters provide little opportunity to analyse these environments for this type of feature while the high water tables at the site prevent this type of investigation without costly excavation techniques. Indeed, modern Ordnance Survey maps show the valley floor at Brownchesters to be marshy and as a consequence the high gravel terraces T1 and T2 are likely to have been the focus for activity and possibly settlement. Evidence of rig and furrow cultivation on the surface of T5 (almost certainly of Mediaeval or later origin), illustrates the usage of these Holocene alluvial terraces within valley floor contexts by past human communities (See Plate 6.1).

It can be demonstrated that at Brownchesters, pre-4000 BC (Mesolithic) material preserved *in situ* will be restricted to Terraces T1-T6 (although younger terraces may contain material reworked from upstream contexts, *cf.* Gladfelter, 1985). Likewise, all Neolithic and Bronze Age material will only be found upon T1-T8 and Iron Age and Roman period artefacts upon T1- T10. Thus, the importance of geomorphological techniques in interpreting and explaining archaeological distributions is critical. In areas where the higher T1 and T2 terraces have been eroded by subsequent fluvial activity there is little scope for discovery of early prehistoric artefacts within valley floor contexts, despite the fact that these areas may have provided a focus for human activity. Additionally, many of the earliest Holocene terraces may have experienced subsequent phases of alluviation, thus burying former land surfaces beneath vertically-accreted, fine grained overbank alluvium. This is particularly true in alluvial basins such as Brownchesters, where vertical aggradation of the floodplain and levee surfaces may have rendered buried archaeological contexts invisible to surface survey.

Figure 6.1: Brownchesters Palaeochannel Infill Sequence and Flood History Diagram

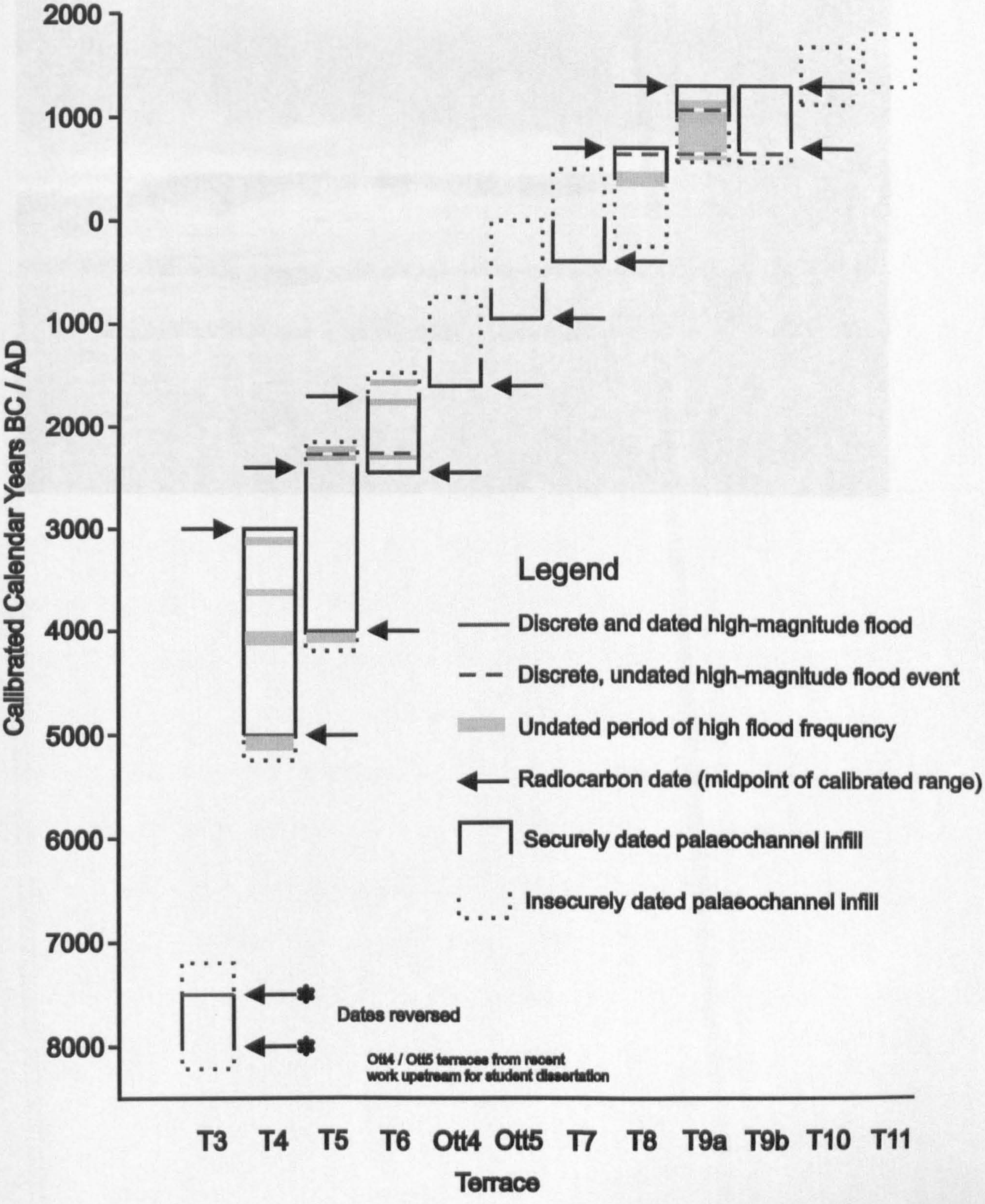


Plate 6.1: Palaeochannels at Brownchesters following flood, January 1995

6.3 Holocene valley floor development at Brownchesters, River Rede

The timing, dynamics and controls upon Holocene channel and floodplain development have been the focus of numerous geomorphological and geoarchaeological investigations (*e.g.* Harvey *et al.*, 1984; Robertson-Rintoul, 1986; Macklin and Lewin, 1986; Hooke *et al.*, 1990; Macklin *et al.*, 1992a and b; in press; Passmore and Macklin, 1994; Rumsby and Macklin, 1994; Tipping, 1994, 1995c, 1996; Taylor and Lewin, 1996; 1997). Within upland Northern Britain, however, these studies have typically been hampered by the tendency of older Holocene terrace and channel features to be partially or wholly eroded by subsequent fluvial activity, and also the lack of suitable organic deposits to provide chronological control via radiocarbon dating.

In the context of alluvial sedimentary sequences in previously documented upland British river valleys, palaeochannel environments at Brownchesters are unusual in that they exhibit thick deposits of peat and organic-rich clayey silt alluvium (Figures 5.3, 5.6, 5.9, 5.11). The benefits of these palaeochannels for palaeoenvironmental reconstructions arise from the interdigitated minerogenic alluvial deposits and organic rich horizons that facilitate ^{14}C dating. These units consist of finely laminated silt and fine sand lenses (*ca.*1-2 mm thick), with occasional thicker (>1 cm) fine-medium sand units with laminations of organic-rich sandy silts (Figures 5.3, 5.6, 5.9, 5.11). Organic-rich channel fills are also documented on a more limited scale at Snabdaugh Farm, (Passmore, 1994; Passmore and Macklin, 1997; Moores *et al.*, 1998). Discussion of the alluvial history of this site has been dealt with elsewhere (*op cit.*).

Investigations have focused on alluvial terraces developed between the present river and the west valley side, although further mapping and a programme of radiocarbon dating is planned from organic palaeochannel fills recently discovered on the eastern side of the River Rede. Details of ^{14}C ages, calibrations and depths are presented in the Results Chapter 5 and also Appendix 10.2. Detailed reconstruction of long-term fluvial sedimentation styles at Brownchesters are hindered by lithostratigraphic data that is restricted to single sediment cores from individual channel fills along with limited sedimentary logging from selected terrace units (Figures 5.3, 5.6, 5.9, 5.11). These single cores have been taken primarily for the purposes of palaeoecological analyses, however, some geomorphic inferences are possible. These are detailed in Moores *et al.*, (1998), and here only a brief summary is presented. All Holocene terraces, bar one, feature single-thread palaeochannels of moderate-high sinuosity and no evidence of ridge-and-swale topography diagnostic of migrating point bars (See Chapter 5). Holocene floodplain development has been dominated by overbank alluviation in the context of laterally stable meanders, reducing the problem of erosion of extant sequences. The overall pattern of Holocene valley floor development at Brownchesters has given rise to laterally stacked, low-relief alluvial fills that resemble 'row terraces' described by Becker and Schirmer (1977) in Southern Germany.

Relatively limited rates of lateral channel migration and a long-term tendency towards net aggradation of floodplain elevations contrasts with Holocene alluvial sequences described elsewhere in upper and middle reaches of northern British rivers. These are typically characterised by net incision of valley floors and development of younger terraces at progressively lower elevations (*e.g.* Harvey, 1985; Macklin *et al.* 1992a, 1992b; Passmore, 1994; Passmore and Macklin, 1994; Tipping 1995c; Passmore and

Macklin, 1997). Fluvial activity at Brownchesters has parallels with alluvial histories elsewhere in middle reaches of the North Tyne at Snabdaugh (Passmore, 1994; Moores *et al.*, 1998).

The fragmentary nature of terraces and their restricted range of elevations at Brownchesters preclude long-distance correlation of discrete alluvial units throughout the study reach on the basis of relative height. However, abundant *in-situ* peat deposits within palaeochannels have been dated by radiometric techniques. To date, a combination of fifteen ^{14}C assays and morphostratigraphic relationships for adjacent alluvial surfaces has established a terrace sequence comprising the nine Holocene alluvial fills, designated T3-T11, that are described in Chapter 5. In combination, sedimentary infills from these palaeochannels at Brownchesters provide a near-continuous record of Holocene fluvial activity from *ca.* 5000 BC – 1300 AD. In addition, a single channel dating to *ca.* 7500 BC offers an insight into early Holocene river evolution.

6.4 Periods of Holocene alluviation at Brownchesters

Phases of Holocene alluviation at Brownchesters can be bracketed via reference to radiocarbon dates obtained from organic sediments and / or wood remains preserved within palaeochannel sequences (Appendix 10.2). Radiocarbon assays from palaeochannel sediments post-date phases of floodplain formation represented by their associated terraces, thereby providing a *post-terminum* (Macklin and Needham, 1992; Brown and Keough, 1992) for the timing of fluvial activity. In some instances, where dates have been obtained within or close to the basal sediments of palaeochannel fills, the chronology for alluviation episodes is likely to be relatively accurate. Where dates close to the base of sedimentary sequences have not been obtained, chronologies for terrace sequences become less definite, although the rapidity of sedimentation within these contexts (Lewis and Lewin, 1983; Erskine *et al.*, 1992) means that error margins are significantly reduced. It is noted, however, that the upper levels of each terrace may have been subject to overbank alluviation associated with later periods of fluvial activity.

	Commencement of Palaeochannel Sedimentation			Cessation of Palaeochannel Sedimentation	
Terrace	**Years BP**	**Cal BC / AD**		**Years BP**	**Cal BC / AD**
T3	Early Holocene?	Early Holocene?	→	8510 ± 70	*ca.* 7500 BC
T4	8510 ± 70	*ca.* 7500 BC	→	6110 ± 80	*ca.* 5030 BC
T5	6110 ± 80	*ca.* 5030 BC	→	5110 ± 80	*ca.* 3950 BC
T6	5110 ± 80	*ca.* 3950 BC	→	3910 ± 80	*ca.* 2440 BC
T7	3910 ± 80	*ca.* 2440 BC	→	2350 ± 60	*ca.* 395 BC
T8	2350 ± 60	*ca.* 395 BC	→	1320 ± 60	pre 685 AD?
T9	1320 ± 60	pre 685 AD?	→	1370 ± 60	*ca.* 665 AD
T10	1370 ± 60	*ca.* 665 AD	→	Unknown	Unknown
T11	Unknown (LIA?)	Unknown (LIA?)	→	Unknown (LIA?)	Unknown (LIA?)

Table 6.1: Periods of alluviation at Brownchesters

Nationwide reviews of Holocene river activity have suggested that the period between *ca.* 9000-5000 BP (Macklin and Lewin, 1993; Brown, 1996) is characterised by relative floodplain stability, particularly in upland British rivers. The results presented here, however, provide some of the first dated evidence for Early-Mid Holocene fluvial activity, which Macklin and Lewin (1986) and Harvey (1985) suspect may be present, but hitherto have proved difficult to identify and / or date in fragmented and largely inorganic UK sequences. These early discontinuities in the alluvial record are apparent at *ca.* 7500 BC and 5000 BC (*ca.* 8500 and 6100 BP).

Comparisons of these 'new' periods of fluvial activity within the UK alluvial record with documented changes in river systems further afield has highlighted some interesting and potentially important similarities. The earliest dated phase of fluvial activity, *ca.* 7500 BC (*ca.* 8510 BP), identified at Brownchesters correlates with both a major environmental discontinuity at 8490 BP (Wendland and Bryson, 1974) and also the onset of flood phases (*ca.* 8500 BP) in the Vistula River, Poland (Starkel *et al.*, 1996). It is interesting that this date also coincides with one obtained from a palaeochannel close to Thirlings in the Milfield Basin, north Northumberland (Passmore *et al.*, 1998) of 8470 ± 70 BP (*ca* 7500 BC), supporting the possibility of climatic controlling mechanisms of Holocene flood frequency and / or magnitude. A major climatic discontinuity has been discovered within the GISP2 ice core from Greenland at around *ca.* 8200 cal BP (Meese *et al.*, 1994; von Grafenstein *et al.*, 1998) although this date is significantly later and cannot be considered contemporaneous with the signals from alluvial sequences within northern England.

The second period of fluvial activity within this previously recognised hiatus in the UK alluvial record occurs at *ca.* 5000 BC (6100 BP). This phase does not correspond to any of the major discontinuities identified by Wendland and Bryson (1974), but does occur concomitant with fluvial activity both in central European rivers (Becker and Schirmer, 1977; Starkel *et al.*, 1996) and in the USA (Knox, 1983). This date is also precisely matched by another from the T3 palaeochannel at Snabdaugh Farm (Passmore, 1994; Moores *et al.*, 1998), possibly demonstrating that controls upon this phase of alluviation are consistent over at least the basin-scale. Macklin and Needham (1993) also highlight an alluvial unit dated to shortly after 6270 BP from the Derwent catchment in the North York Moors, representing until now the oldest dated alluvial unit in upland Britain. Tipping (1995c) has also recently dated channel abandonment upon a terrace at Kirkpatrick Fleming to 5755 ± 40 BP (4727-4510 BC). Recent evidence suggests that the controlling mechanism responsible for this may be a global climatic deterioration and neo-glacial phase identified from the GISP2 ice core (Meese *et al.*, 1994) and also independent precipitation records from the Cairngorms (Dubois and Ferguson, 1985).

In their review of UK alluvial histories, Macklin and Lewin (1993) correlate previously documented (post-5000 BP) fluvial activity with these environmental discontinuities identified by Wendland and Bryson (1974) along with climatic shifts such as increases in precipitation (Birks, 1988) and the Little Ice Age (Lamb, 1995). They identify 6 discrete phases of fluvial activity that they attribute to changing large-scale (hemispheric) atmospheric circulation patterns. Some periods of alluviation at Brownchesters do appear to fit within the phases, such as a shift to a wetter climate identified from blanket bog stratigraphy (Blackford and Chambers, 1991) at around 600 AD, appears to coincide with the abandonment of the two T9 palaeochannels at

Brownchesters. In addition, although undated, the character and topographic position of the T11 terrace at Brownchesters suggests a Little Ice Age origin. However, other units at Brownchesters appear to correlate better with the flood phase history of the Vistula River (Starkel *et al.*, 1996).

Other authors, particularly those working in southern England have highlighted the influence of anthropogenic activity in at least partially controlling post-5000 BP (*ca.* 4000 BC) fluvial activity. The influence of human communities upon upland British rivers, has to some extent been a secondary consideration, with the exception of the last *ca.* 2500 years (Passmore and Macklin, 1997). This is principally because archaeological evidence has frequently been underestimated in importance and possibly also the fact that valley floor archaeology may have been buried beneath alluvium. However, the enhanced spatial resolution palynological studies presented here suggests a revaluation of the impact of prehistoric peoples upon the landscape of the region, and consequently the controlling mechanisms behind Holocene river activity, may be appropriate.

As a result of the early phases of fluvial activity, the site at Brownchesters has prompted a refinement of models of upland river valley development within Northern Britain and has again highlighted the inherent dangers in generalising basin-wide models from a sample of individual study reaches (Passmore, 1994). Despite the dynamic nature of the River Rede over Holocene timescales, the relatively low gradient and low relief nature of this alluvial basin has preserved an unusually large number of discrete, although fragmentary, terrace units of different ages. Recent work in extending the Brownchesters study reach both upstream and downstream is continuing to identify well-preserved terrace fragments of differing ages, thereby complementing existing knowledge of river activity in this reach of the River Rede.

Early indications also suggest that these low lying alluvial basins within middle reaches of upland rivers may hold the key to refining existing knowledge of Holocene alluvial histories in northern Britain. The sites at Brownchesters, Snabdaugh and now Thirlings (Passmore *et al.*, 1998) all appear to have recorded multiple generations of post-glacial fluvial activity and more importantly subsequently preserved organic sediments with which to date these features and undertake palaeoenvironmental analyses.

6.5 Flood records from palaeochannel sediments

The potential of palaeochannel sediments to yield detailed and dateable records of Holocene flood histories has been detailed in Chapter 2. Within palaeochannels at Brownchesters, thick deposits of interbedded and often finely-laminated peats, organic-rich silts and inorganic sands and silts potentially offer high resolution flood frequency records for the River Rede for a large proportion of the Holocene period. The discrete inorganic silt and sand horizons throughout these sequences are interpreted as representing deposits of moderate-large floods post-dating channel abandonment (Erskine *et al.*, 1992; Malik and Khadkikar, 1996). To date, quantitative estimates of flood magnitude are not possible owing to difficulties in elucidating the position and morphology of the active river channel that is contemporary with the flood unit within a given palaeochannel. However, these investigations do offer an insight into Holocene flood frequencies.

Given the limitations of working from individual sediment cores, and hence the limited knowledge upon the lateral variations of individual horizons, only limited inferences concerning flood magnitudes can be made. Coarser grain sizes may be broadly equated with higher magnitude events, but this inference rests on two assumptions. Firstly, it is assumed that the contemporaneous active river channel remains in the same location and is not subject to avulsion, incision, aggradation or extensive lateral reworking during the period palaeochannel sediments are accumulating. Secondly, progressive accumulation of sediment within the palaeochannel will render the local environment as progressively less likely to receive floodwaters from smaller-scale events.

Several periods of flooding can however be identified, although the precise timing of some of the events is vague due to currently limited dating control. Interpolation of dates between radiocarbon dated horizons in these alluvial contexts is extremely tenuous owing to the likelihood of highly variable rates of sediment accumulation. Periods of increased flood frequency may be manifested within the sedimentary record of these palaeochannels as successions of minerogenic laminae, whilst coarser, more discrete sandy lenses may be interpreted as individual flood events of mid-high magnitude. Flood horizons are summarised below and also in Figure 6.1, major coarse lenses are also plotted on the sediment logs for individual channels in Figures 5.3, 5.6, 5.9, 5.11.

Terrace T3 (Figure 5.3)

The T3 palaeochannel contains two notable flood horizons at a depth of 240-243 cm (*ca.* 7500 BC), where there are a couple of distinct grey sand-silt laminae each approximately 5mm in thickness.

Terrace T4 (Figure 5.3)

The T4 palaeochannel sediment records what appears to be evidence of several minor flood events between a depth of 306-520 cm in the form of thin sandy laminae within generally fine members. An additional larger and more discrete flood unit occurs between 365-370 cm where there is a lens of grey, well-sorted medium-coarse sand. All of these flood horizons occur sometime before *ca.* 5000BC.

Terrace T5 (Figure 5.6)

Within the T5 palaeochannel sediments flood laminae occur between 310-388cm, with a larger discrete grey silty-sand horizon between 340-342 cm, dated to *ca.* 3950 BC. A second phase of multiple minor flood incursions into the T5 palaeochannel occurs between 226-278 cm dating to sometime between *ca.* 3950-2400 BC (Moores *et al.*, 1998).

Terrace T6 (Figure 5.6)

The T6 palaeochannel contains comparatively little evidence of flood laminae, possibly as a consequence of its rapid sedimentation rate. A single flood unit does exist at a depth of 268-271 cm (1690-2440 BC) consisting of coarse upward light grey silty-medium sand. Additionally fine sandy laminae are also present toward the top of the core at a depth of 62-82 cm (post-1690 BC).

Terrace T8 (Figure 5.9)

The T8 palaeochannel contains a number of coarse sand horizons that become progressively finer overlying the basal gravel between 239-278 cm, indicative of post-abandonment flood dating to sometime pre-AD 685. A further potential flood horizon occurs between 130-132 cm, but absence of radiocarbon dates prevents anything more precise than a pre-AD 685 timing for this event.

Terrace T9a (Figure 5.11)

This palaeochannel sequence contains a highly detailed record of flood histories, probably due to the core location at the upstream end of the palaeochannel cut-off. Between 83-310 cm the sediments are virtually continuously laminated with sub-2mm thickness horizons of minerogenic material. In addition, two very distinct, grey medium sand flood units are present at depths of 287-290 and 120-122 cm respectively. All these units date to pre-AD 1285, and if this channel is assumed contemporaneous with T9b can also be bracketed to post-AD 665.

Terrace T9b (Figure 5.11)

This palaeochannel contains little evidence of flood horizons, despite apparently being contemporaneous with T9a. The reason for this is likely to be the relative difference in core location, as this sequence was taken from the downstream end of the meander loop cut-off. These distal cores typically exhibit only thinly developed or even an absence of flood horizons as these areas are well-documented to not receive as much minerogenic material as parts of the palaeochannel proximal to the point of cut-off (Bridge, 1985; Erskine *et al.*, 1992). As a consequence of this, only the sediments between 141-159 cm (immediately pre-AD 1305) contain any evidence of minerogenic laminations indicative of floodwater encroachment into the palaeochannel.

Attention is drawn from this preliminary examination of the timing of flood events from the site at Brownchesters to the apparent correlation of phases of flood activity with episodes of channel abandonment (Figure 6.1). In particular, the abandonment phases of the palaeochannels associated with Terraces T5, T6, OTT5 (derived from undergraduate dissertation), T9a and T9b all appear to be preceded by flood events recorded within the sediments of previously abandoned adjacent palaeochannels. While this is a provisional observation that requires detailed further analysis (and dating), this has extremely important implications when considering the question of causality within the fluvial record, which will be discussed in the following section.

A further potential of the chronologically overlapping sediments at Brownchesters is the correlation of individual flood units. Once again this is limited by dating control, but it would appear that specific discrete high magnitude flood events, recorded by coarser-grained minerogenic sediment, may be evident in multiple cores from different palaeochannels. For instance, a flood event at the top of sediments from T5 appears to match with a similar unit from the middle of the T6 profile. Likewise, another event at the top of the T8 core appears to be within the same chronologically time frame as one at the base of the T9b sediments. Additional phases of multiple minerogenic laminae also appear to be correlated both with similar periods in adjacent channels and also with larger magnitude events. It should be remembered that sedimentary records of high magnitude flood events in one channel might only manifest themselves as small laminae within another palaeochannel due to differences in relative height and proximity to the active channel at the time. Examples of this type occur predominantly within Terraces T3, T4 and T5, principally because these palaeochannels are where there is the greatest chronologically confirmed overlap in the sedimentary sequences.

6.6 Evaluating fluvial response to vegetation changes

Evaluating the degree to which extensive, potentially catchment-wide anthropogenic activity may have controlled the pattern of Holocene valley floor development is an extremely contentious issue (Tipping, 1995a, 1995b, 1995c, 1998; Brown, 1997) and one which Passmore (1994) and Passmore and Macklin (1997) stress cannot be addressed simply by looking at isolated reaches within a large river catchment. The debate about causality within British Holocene alluvial records has, to some extent, been clouded by confusion regarding some fundamental issues, namely that fluvial activity occurs principally in response to flood events and that these are climatically controlled. Human activity in terms of vegetation manipulation cannot cause fluvial response only sensitise alluvial environments and catchments to the influence of climatic factors. This study does not incorporate an independent climatic record and thus discussion is limited to chronological similarities in the vegetation, fluvial and previously published climatic records.

However, previous studies have shown that few alluvial sedimentary sequences in upland Northern England are dateable via standard radiocarbon methods (see Chapter 2), and even fewer examples are of the antiquity encountered here (Macklin and Lewin, 1993; Brown, 1997). Palaeochannel sediments, particularly at Brownchesters, therefore offer a unique opportunity for comparing palynological and geomorphological records within a precisely dated radiocarbon framework. This study provides an opportunity to attempt to establish the degree of synchroneity between human and / or climate changes, allowing for potential chronological lags in the fluvial system.

Although channel abandonment can occur through a variety of either relatively gradual or catastrophic processes (Chapter 2), the majority of changes in river channel development occur during short time periods associated with major flood events (Knox, 1985, 1993; Rose *et al.*, 1980). The importance of vegetation cover in regulating flood events is well-documented and there are numerous modern examples of humans significantly altering flood regimes through their actions (*e.g.* forest removal in the Himalayan foothills). Thus, the removal of trees in parts of the upper North Tyne catchment may have resulted in an increase of both the quantity of run-off and sediment supply, resulting in changes to sensitive alluvial environments in downstream areas. Human activity upon valley floor environments within the immediate environs of the channel may have also aided and facilitated the process of channel abandonment by destabilising the riparian vegetation, to an extent that alluvial sediments become sensitised to what may have been relatively minor changes in climate (Brown, 1997). This study appears to demonstrate that selected middle reaches of upland rivers have not only been sensitive to these changes but have also recorded multiple generations of Holocene fluvial activity.

The principal instance where possible connections may be involved between vegetation change and geomorphic response at Brownchesters is dated to *ca.* 4000 BC. A large, possibly multi-loop or avulsion type, channel abandonment upon the T5 terrace occurs and has been dated immediately prior to *ca.* 4000 BC. Pollen records derived from the sediment which has infilled this palaeochannel indicate that human activity was occurring within the valley floor environment at this time. Additionally, in two of the upland pollen diagrams from the region, peat formation was initiated at around this time (*ca.* 3975 BC at Sells Burn, *ca.* 3700 BC at Bloody Moss: See Chapter 4, Appendix 10.1). The precise mechanisms for this change are unknown, however, human activity and declining tree cover has frequently been cited in literature concerning the controls of prehistoric peat formation (Moore, 1988; Simmons, 1996). The third upland pollen diagram, from Drowning Flow, also records a decrease in tree cover at this date (Figure 4.1, Appendix 10.7), supporting the hypothesis of anthropogenic forest removal in the uplands. This alteration in upland vegetation cover may have had important consequences for fluvial processes in valley floor areas further downstream and led to changes in channel planform within downstream alluvial basins. An undated, but possibly contemporaneous period of increased fluvial activity is registered within the sediments of the adjacent T4 palaeochannel. This shift to a more minerogenic fluvial sedimentation style is likely to reflect an increase in flood magnitude and / or frequency and possibly sediment supply that again could be a consequence of upland vegetation change. Although circumstantial, recent archaeological evidence also adds credence to this proposed scenario. Interpretations of the role of a recently excavated and important hengiform monument in the Milfield Basin (Waddington, 1997a) have lent weight to the idea of widespread usage of upland areas for pastoral agriculture, particularly in areas of Fell Sandstone, at around 4000 BC. This usage would inevitably necessitate at least some degree of forest removal and subsequent alteration in hydrological regimes.

At a date of *ca.* 2500 BC, there is a further phase of fluvial activity associated with the abandonment of the T6 palaeochannel at Brownchesters. Upland pollen diagrams from the region at this time show a progressive and sustained rise in heathland cover, but with no major changes that would suggest a dramatic alteration of hydrological patterns (Figures 4.1-4.3). However, the valley floor pollen diagram from the T5 palaeochannel at Brownchesters shows a marked increase in herbs and grass species at this time, consistent with increased usage of the valley floors by human communities (Figure 5.7; Moores *et al.*, 1998). It is possible that this manipulation of valley floor vegetation sensitised and destabilised previously deposited alluvium making them more susceptible to changes in fluvial activity.

In summary, therefore, it can be seen that early phases (7500 and 5000 BC) of fluvial activity at Brownchesters appear to be consistent with hypotheses of global climatic controls (*sensu* Macklin and Lewin, 1993). Synchrony of the timing of alluvial discontinuities over basin, regional and international scales is testament to this. Later phases of alluviation at Brownchesters, however, appear to be related more closely to local factors associated with anthropogenic activity, similar findings to those of Tipping (1995c). It is these human-induced factors which appear to facilitate, if not control, most periods of fluvial activity post-4000 BC.

Chapter 7

Discussion

7.1 Introduction

The results from this study are discussed and analysed within an overarching chronological framework. Specific questions related to archaeological issues within the region are examined with respect to the palynological record derived from both the upland and valley floor sites. Instances where local-scale vegetation records have demonstrated the presence of human activity where archaeological evidence is absent or scarce are highlighted. In addition, evidence of local-scale activity which is absent from pollen records reflecting a predominantly regional vegetation signal, both already published and presented here, is also emphasised.

A number of the specific questions derived from regional archaeological results have been outlined within the introduction. These include:

- Existing archaeological and palynological records yield little evidence of Mesolithic communities in North Tynedale and Redesdale, despite a riverine distribution of existing sites elsewhere in the region. Is this a result of the insensitivity of regional pollen diagrams to small-localised vegetation fluctuations that may represent the first evidence of human activity or a genuine absence?
- Existing pollen records suggest that there had been little vegetation disturbance pre-third millenium BC outside the area of the Milfield basin, north Northumberland. Is

this the case, given the scarcity of pollen records in the region between the Hadrianic Frontier and the Cheviots?

- Pollen records suggest that cereal cultivation was a relatively late phenomenon in central Northumberland, with agricultural activity beginning earlier in the north-east and south-east of the region. Is this the case? Have fertile valley floors and associated river terraces provided a focus for early farming for Late Mesolithic / Early Neolithic farmers?
- Fluctuations in upland / lowland settlement patterns during the Bronze Age have been inferred on the basis of some regional archaeological evidence. Can the palynological evidence provide further insights into this pattern?
- Debates surround the relative impact of the Romans upon the vegetation of the region. These include the timing of major landscape-scale deforestation and the extent of existing Iron Age agriculture, which recent archaeological evidence suggests may have been more widespread than previously believed. Can carefully targeted palynological investigation resolve these issues?

7.2 Small-scale upland clearance and the onset of peat formation

This study has not been designed to examine the earliest date of the inception of peat development within the North Tyne basin. Indeed, in contrast to other parts of the country, little targeted work has been carried out upon elucidating the timing of the onset of peat formation within northern England. However, the onset of peat formation and the development of moorland has been unequivocally linked to anthropogenic interference with the vegetation in other areas of upland Britain (Simmons, 1996; Moore and Wilmott, 1976) and may therefore represent the best way of discerning early human activity within the North Tyne basin.

Radiocarbon dates from close to the base of cores obtained from the upland peat bog sites analysed in this study reveal that the inception of peat development occurs within the Late Mesolithic period (*ca.* 6000-3500 BC; Darvill, 1987). The timing of this process varies between sites, with a chronological variation of approximately 1000 years and while reflecting local topographic and hydrologic conditions; anthropogenic and climatic causal mechanisms must also be considered.

The processes that lead to peat formation have been extensively reviewed by Moore (1973, 1975, 1987a, 1987b, 1988, 1989). Peat formation is the result of an excess of local plant productivity in relation to the rate of organic decomposition. This is usually caused by the inhibition of microbial decay rates rather than an increase in plant productivity and is frequently associated with the development of localised waterlogging. This creates an anaerobic environment and impairs the breakdown of plant material, allowing the accumulation of peat. Waterlogging is thus an important pre-requisite for the onset of peat development and can arise due to the combination of the following factors (from Moore, 1988);

- Climatic change
- Anthropogenic forest removal
- Use of fire
- Grazing
- Edaphic changes

Each of the upland sites cored for this study lies at an altitude in excess of 250 metres and occupies flatter ground either on or adjacent to major interfluves (see Chapter 3: Section 3.1.1). Thinner, nutrient-poor soils combined with higher precipitation, reduced temperatures and potentially greater exposure make these areas highly susceptible to small perturbations in climate or alterations in either the intensity or nature of anthropogenic activity. Records of these fluctuations have registered in a variety of ways within the palaeoenvironmental record.

Of the peat cores analysed in this study, the earliest date for the onset of peat formation in North Tynedale is around 4925 BC obtained from the Drowning Flow core. Since this time peat has constantly accumulated at the site, reaching in excess of 7 metres depth within localised areas. The basal sediments at Drowning Flow indicate peat development occurred on an already organic-rich silty, sandy soil, which supported a diverse woodland flora consisting predominantly of hazel scrub with some alder, oak and to a lesser extent, birch and pine (see Troels-Smith log, Appendix 10.3).

The percentages of open ground taxa within these sediments are relatively high and extremely significant, with small peaks in the levels of Poaceae, Caryophyllaceae, *Rumex* and *Succisa*. This is indicative of a degree of local woodland clearance and is a regular feature of pollen diagrams from upland Great Britain covering the early stages of peat development. Indeed, Moore (1988) has demonstrated that removal of upland forests by anthropogenic activities has been one of the principal causes of the development of peat deposits. It is likely that selective removal of tree species from the area around Drowning Flow has resulted in an alteration of local hydrological conditions, deterioration of soils and subsequent peat development. Forest clearance was probably carried out for a specific purpose and may constitute the first attempts by prehistoric groups to manipulate the environment in which they lived (Simmons 1975, 1996; Simmons *et al.*, 1975).

The early onset of peat formation at Drowning Flow is, in part, also likely to have been due to both its higher altitude and interfluve location. At higher altitudes, the density of forest cover would have been reduced and many of the (particularly thermophilous) trees would not have grown as vigorously, making clearance by fire or manual methods far easier. The slightly lower temperatures and increased annual precipitation associated with the higher altitude would also have aided peat formation once forest cover was removed. Flatter ground associated with the interfluve would also have enabled waterlogging to occur and the treeless environment of the area would have afforded the site with commanding views of both the Tarset Burn, flowing into North Tynedale, and also Redesdale. Speculatively, this may have had spiritual significance to the Mesolithic communities, as prominent natural locations are often considered to be 'special places' by hunter-gatherer societies (Tilley, 1994).

Work aimed at elucidating the fluctuations in Holocene tree limits has demonstrated the importance of altitude in determining the species composition and vigour of growth in upland environments. Macroscopic wood remains from the north Pennines have revealed that trees grew to 760m in the region and Turner (1984) has argued on the basis of palynological work on Cross Fell that tree lines extended beyond this during the post-glacial climatic optimum *ca.* 5000 BC (Lamb, 1995). Indeed, the base of some of the cores taken for this study (and other trial cores within the North Tyne basin) have contained fragments of wood at the boundary between the more minerogenic substrate and the overlying peat (Appendix 10.3). *Pinus sylvestris* stumps have also been observed in exposed sections at the base of peat deposits at Caudhole Moss, close to Lordenshaws hill-fort in the Simonside hills at an altitude of *ca.* 290m (Manning, 1996). These fossil tree remains have been dated to *ca.* 5000 BC and although climatic (Bennett, 1984) and volcanic (Gear and Huntley, 1991) mechanisms have been linked to fluctuations in *Pinus* woodland elsewhere in Great Britain it is likely that these specimens were either deliberately cleared by humans or were wiped out by worsening edaphic conditions associated with hydrological changes caused by the anthropogenic removal of surrounding woodland.

Peat formation dated to *ca.* 3700 BC at Bloody Moss begins *ca.*1200 years later than at Drowning Flow. The pollen recovered from the basal deposits suggests vegetation composed predominantly of hazel scrub with some alder, birch, oak and pine. Levels of *Calluna* and other heath species are, however, much higher, suggesting that the surrounding landscape was already relatively open, possibly having already been cleared of forest by earlier human communities. Bloody Moss (Section 3.1.1) is a saddle / spur mire, occupying sloping ground just outside the North Tyne basin. It is likely that peat development occurred later at this site due to the slightly freer-draining nature caused by the slope-angle, when compared to Drowning Flow that occupies a flatter, interfluve location. The dating variation for the onset of peat development is, interpreted therefore, as reflecting local topographic factors.

A further reason for the later development of peat at Bloody Moss may be the site's geographical location. Redesdale provides one of the most direct and easiest routes over the western side of the Cheviot massif, thereby forming an important line of communication between Northumberland and Scotland. Bloody Moss is several kilometres further away from the valley floor of Redesdale in comparison to Drowning Flow and is therefore likely to have been a less attractive location for Mesolithic human activity. Bloody Moss is closer to the Coquet valley, which itself contains a wealth of prehistoric archaeological evidence. However, Coquetdale is likely to have been less favourable for settlement due to its steeper profile, narrower valley floor and poorer potential as a communication route. The importance of river systems for providing easier communication routes ought not to be underestimated, particularly when woodland cover was far more extensive than at present. Just as Redesdale can be viewed as important in a north-south direction, so the Tyne-Solway corridor provides opportunities for east-west communication routes.

The date for the onset of peat formation at Sells Burn is *ca.* 3975 BC, obtained from wood fragments found between the overlying peat deposits and more minerogenic substrate close to the base of the core. This gives an intermediate date for the onset of peat formation at this site in comparison with Drowning Flow and Bloody Moss. Sells Burn is at a lower altitude (260m) than either of the previous sites and as a result the primary woodland coverage was far denser, containing a higher proportion of birch and alder pollen, with fewer indications of open ground taxa than the other upland sites discussed above. Topographically, the site lies within a small basin (Chapter 3) and thus waterlogging of the site may have occurred relatively rapidly, allowing peat to develop.

Archaeological evidence of Mesolithic activity, in the form flint finds is far more concentrated in the lower reaches of the North Tyne catchment in the vicinity of Sells

Burn (Figure 7.1). This would seem to indicate the likelihood of a higher degree of interference with the vegetation around this site and may have assisted in the relatively early date for peat initiation at Sells Burn.

However, despite the early initiation of peat development, the palynological record from Sells Burn is somewhat different to the sites discussed above. In contrast to the other sites, arboreal cover persists in the landscape surrounding Sells Burn for several centuries after peat had begun forming in the basin. This suggests that vegetation disturbance in the area was, contrary to the archaeological evidence, relatively minimal, or that the palynological record is locally biased by the presence of local forest stands adjacent to the basin. Additionally, the vegetation record is somewhat distorted, owing to poor pollen preservation in the basal minerogenic deposits, indicated by a reduction in the pollen concentration and relatively high percentages of post-depositionally resistant *Filicales* and *Polypodium* spores (Burrin and Scaife, 1984; Lewis and Wiltshire, 1992) (see Chapter 2).

From the evidence presented here the development of peat has not been synchronous across the entire North Tyne basin and thus cannot be attributed to climatic factors alone. Inter-site differences in altitude, topography, underlying geology, soil type and aspect, although important, are deemed here to be insufficient to account for the chronological differences in the onset of peat formation alone. Palynological records of these sites are comparable to those found elsewhere in Britain (*e.g.* Moore, 1975, 1983; Moore and Wilmott, 1976), suggesting that there was human involvement in the process of localised deforestation which altered hydrological regimes and led to paludification.

Thus, in certain localities, peat inception may represent the earliest discernible impact of human populations on the environment.

7.3 Mesolithic activity in valley floor locations

The palynological results from the valley floor sites examined in this study are, by their very nature, chronologically fragmented (see Chapter 5) and only one of the analysed cores from Brownchesters covers a substantial portion of the Mesolithic period, with another covering the Late Mesolithic - Neolithic transition at its base. Significantly however, the core from Brownchesters Terrace T3 which spans the period *ca.* 8000-7500 BC contains incidences of anthropogenic indicator species, including pollen possibly belonging to the group *Avena / Triticum* along with other cultivated taxa (see Section 3.3.3 for discussion on identification of cereal pollen grains). The earliest occurrence of cereal pollen in this context is pre-7500 BC, far earlier than the commonly accepted date for the onset of cereal cultivation in Great Britain *ca.* 4000 BC. This is even significantly earlier than the pre-elm decline cereals highlighted by Edwards and Hirons (1984), Edwards (1988, 1989) and Edwards and McIntosh (1988), although Davies (1997) has recorded several cereal type grains from around Oban, Scotland at dates of *ca.* 9200 BP, *ca.* 8800 BP, *ca.* 8380 BP and *ca.* 7400 BP. These dates concur with those found within Redesdale and as they come from an area renowned as a Mesolithic type site (Obanian culture) could be regarded as significant indicators of Mesolithic activity. Davies (1997) errs on the side of caution in the interpretation of cereal pollen of this age, citing the likelihood that the pollen is of a natural, non-cultivated origin, although tentatively suggesting that cereals could have been grown as a dietary supplement during periods of otherwise poor food supply. A similar conclusion must be drawn in the case of the North Tyne basin, especially given the paucity of corroborating archaeological evidence and the possibility that the pollen may be derived from a non-indicator species such as *Glyceria* spp. which may thrive within palaeochannel conditions. However, some authors are beginning to question the validity of assumptions made concerning the initiation of arable agriculture within Northern Europe. For instance, Zvelibil (1994) outlines a number of scenarios which could explain the discovery of cereal pollen within these contexts, highlighting the cultivation of indigenous wild grasses in mainland Europe from *ca.* 6000 BC.

Development of peat-filled palaeochannels within the North Tyne basin has occurred independently, or at least not as direct consequence, of anthropogenic interference with the vegetation. At both Snabdaugh and Brownchesters, peat development has been initiated due to locally high water tables within episodically alluviating palaeochannels (Brown, 1997) (see Chapter 2 for full discussion of palaeochannels as sources of palaeoenvironmental archives).

The importance of proximity to water is a well-documented facet of Mesolithic settlement patterns (Simmons, 1996) and the apparent concentrations of activity in coastal areas have already been discussed. However, there is no doubt that coastal, lakeside and riverine environments provided a rich resource base for prehistoric peoples which have been exploited since long before the Mesolithic (*cf.* Darvill, 1987, p29). Excavated Mesolithic sites such as Star Carr and Seamer Carr, North Yorkshire (Schadla-Hall, 1989), which occupies a former lake edge and Noyen-sur-Seine, northern France (Mordant and Mordant, 1992), are testament to this. Inland waterways act in the same way as cleared forest within the uplands by attracting grazing animals and wildfowl. Fish (Simmons, 1980) and shellfish (Bonsall, 1981, 1996; Bonsall *et al.*, 1986) were an important component of the diet for Mesolithic people and a number of edible aquatic plants such as water chestnuts and waterlilies have also been found within Mesolithic contexts across Northern Europe (Zvelibil, 1994). Additionally, woodland that grows in proximity to lakes and rivers would have contained a number of useful species for the construction and tool making activities of Mesolithic communities.

Within Northern England existing Mesolithic sites are distributed predominantly around the coast, with 26% of inland sites located within 2 km of a major river and below 244m (Higham, 1986; Davies, 1983) (See Figure 7.1). Weyman (1984) has also noted this distribution, highlighting the fact that many sites are concentrated on sloping ground close to rivers between 45 and 300 metres above Ordnance Datum. She also states that where there are apparent spatial gaps in the record, this may be a consequence of the lack of ploughing (which is critical for exposing buried lithic material) within a given area, and thus modern day agricultural practices have a large bearing upon our knowledge of Mesolithic and later communities. Targeted fieldwalking has aided the recovery of artefacts, for example, Fell and Hildyard (1953) discovered Mesolithic material in Upper Weardale after specifically searching along the route of a pipeline and within ploughed fields. Darvill (1987) has highlighted the prevalence of Mesolithic and earlier sites localised at the confluence of rivers, a pattern still evident in settlement today. He also highlights the usage of sheltered spots within valleys penetrating the uplands and it is likely that then, as now, Redesdale and North Tynedale offered similarly hospitable conditions as the Northern Pennines, where there is to-date more evidence for the active presence of Mesolithic peoples (Young, 1987; Fell and Hildyard (1953).

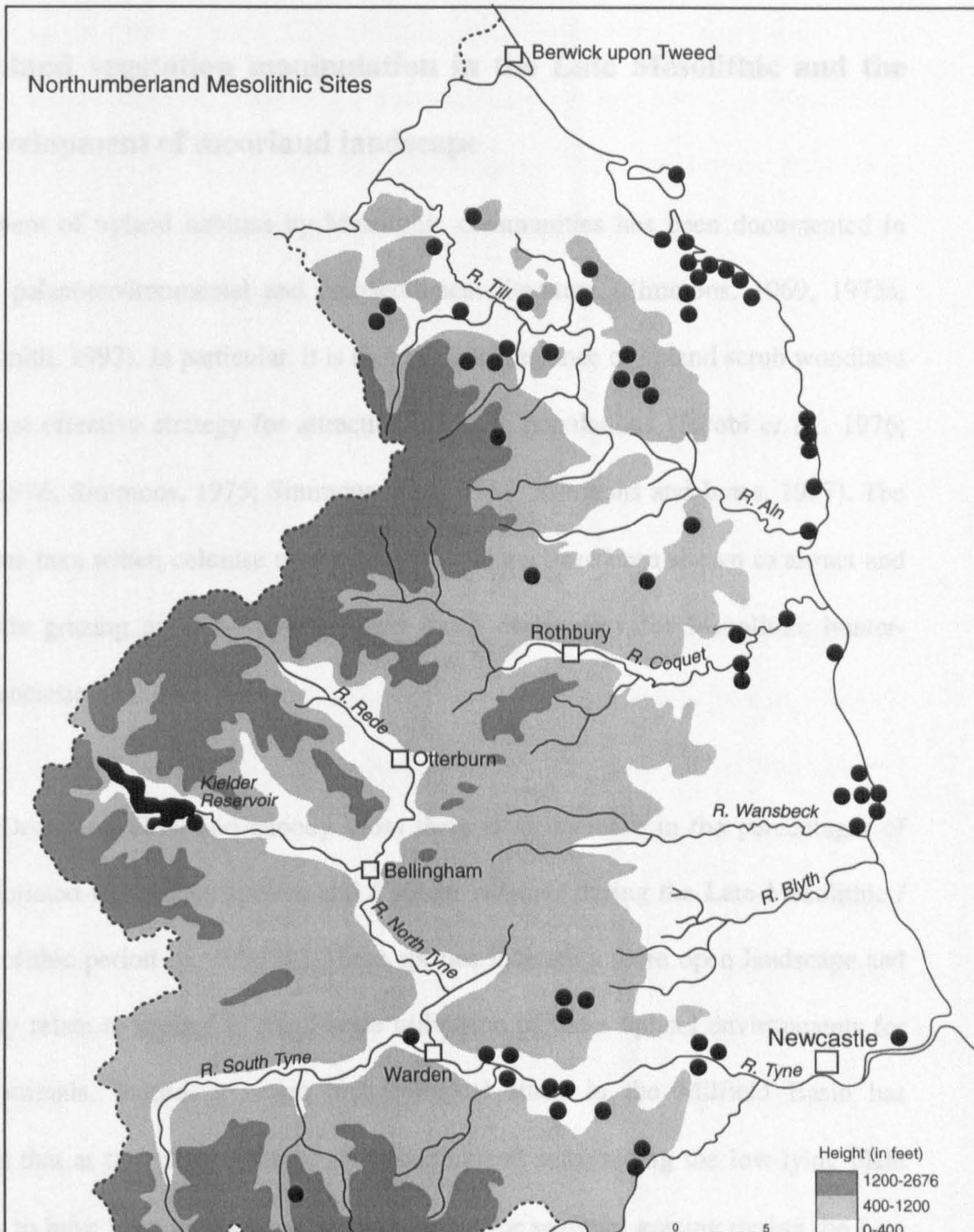
It is well known that in the east of Great Britain many Mesolithic sites have been inundated by rising sea levels associated with the melting of the Late Devensian ice sheets and also eustatic response of the continents (Lamb, 1995). Many sites now lie under the North Sea and a number of estuarine and low-lying settlements have also suffered the same fate. In the west of the country sites are concentrated around former coastlines which have been raised above modern sea level and are therefore more visible, such as at Eskmeals, Cumbria (Bonsall *et al.*, 1986) and Oban, western Scotland (Bonsall, 1996; Davies, 1997). Within inland Britain major river valleys are likely to offer the best opportunities for the discovery of new sites, with Woodman (1989) highlighting that existing indications of Scottish riverine and lakeside Mesolithic distribution patterns are both underestimates and not viewed as significant. Indeed, Davies (1983) specifically cites the Rivers Blyth, Wansbeck, Aln and Coquet as particularly warranting systematic fieldwalking. However, even a brief inspection of the map of Mesolithic sites in Northumberland (Figure 7.1) demonstrates that this statement can equally be applied to the Rivers North Tyne and Rede.

Seasonal use of riverine sites in inland Britain has been postulated by Evans (1975) who envisaged a pattern of hunting determined by the summer migration of animals into the upland areas. He believes that this movement can simply explain the distribution of flint flakes and also highlights the role of river valleys in providing communication routes between regions, an important factor when considering North Tynedale and Redesdale. Similar coastal-inland relations have been discovered in southern Norway (Bang-Andersen, 1996), although a lack of radiocarbon dates at Norwegian coastal sites and lack of evidence within the intermediate zones, makes it difficult to specify regional patterns of seasonality. Recent indications from Milfield (Waddington, in press) suggest that this coastal-upland seasonal migration may have been dramatically overestimated in Northern England, at least for the Late-Mesolithic period. Lithic material used for tool making at Milfield originates both from local non-flint sources, particularly agates, and imported flint derived largely from north-east Yorkshire. This is despite the coast being only 15 km away and where flint, albeit of poorer quality, occurs within the glacial drift. This suggests that seasonal migration between coast and upland was not a major component of the annual cycle of activity in this vicinity, and that distinct cultural groups may have occupied these areas.

Existing evidence of Mesolithic activity within the North Tyne basin is scarce, but what there is appears to conform to the general models of riverine distribution (Davies, 1983) (see Section 7.1) outlined above. Weyman (1984) has reported flint scatters found upon a glacial gravel terrace at High Warden adjacent to the confluence of the North and South Tyne and Waddington and Beckensall (Waddington, pers comm) have made additional finds around Warden Hill. The typology of some of these flints from this area suggests an Early Mesolithic phase of activity within Tynedale (Tolan-Smith, 1996) and the discovery of a Late Upper-Palaeolithic artefact at Prudhoe (Cousins and Tolan-Smith, 1995) is indicative of an even earlier phase of human activity, although as yet this remains an isolated find. Weyman (1984) details further flint finds which have occurred on both banks of the River Tyne around Corbridge and Bywell and more recent work by Tolan-Smith (1996, 1997) has demonstrated the presence of flint scatters on the valley sides of the Lower Tyne.

In mid-upper reaches of the North Tyne catchment, Mesolithic flints have been discovered during the excavation of a later Iron Age and Romano-British farmstead at Kennel Hall Knowe (Jobey, 1978). Likewise, recent excavations (by Lancaster University Archaeological Unit and the Archaeological Practice, Newcastle University, 1997) close to Potts Durtrees on the Otterburn Military Range has revealed a small struck flint spall, indicating flint has been worked in this locality. However, any patterns of archaeological activity must be viewed with an element of caution as survey bias can have a significant influence over the derivation of distribution maps (Hamond 1980, Young 1994). In addition, alluvial and colluvial processes may have masked the archaeological record on valley floors and sides (Passmore and Macklin, 1997).

Figure 7.1: Mesolithic sites in Northumberland



From Davis (1983)

7.4 Upland vegetation manipulation in the Late Mesolithic and the development of moorland landscape

Management of upland habitats by Mesolithic communities has been documented in both the palaeoenvironmental and archaeological literature (Simmons, 1969, 1975a, 1975b; Smith, 1992). In particular, it is thought that clearance of upland scrub woodland is the most effective strategy for attracting ungulate populations (Jacobi *et al.*, 1976; Mellars 1976; Simmons, 1975; Simmons *et al.*, 1989; Simmons and Innes, 1987). The herbaceous taxa which colonise regenerating woodland have been shown to attract and concentrate grazing animals, making them much easier prey for Mesolithic hunter-gatherer societies (Mellars, 1978).

At both Drowning Flow and Bloody Moss there is an increase in the percentages of undifferentiated Ericaceous species and *Calluna vulgaris* during the Late Mesolithic / Early Neolithic period *ca.* 4000BC. These species indicate a more open landscape and commonly relate to an initial, small-scale utilisation of these upland environments for grazing animals. Indeed, a recent archaeological study in the Milfield Basin has suggested that at this time, areas of sandstone upland surrounding the low-lying plain are likely to have been used and actively managed for seasonal grazing during the Late Mesolithic (Waddington, 1996). Excavations upon the 'Coupland Henge', which is on the raised gravel terraces of the basin adjacent to Milfield village, has revealed that this Late Mesolithic / Early Neolithic enclosure was probably used for corralling stock, as well as social gatherings and ceremonial activities. Trackways leading from this enclosure connect to areas of adjacent Fell-Sandstone upland an the east side of the River Till, where areas of outcropping rock are decorated with numerous examples of cup and ring marked rocks (Beckensall 1983, 1991, 1992, 1995; Waddington, 1995, 1996). These are thought to be contemporaneous features, dating to the Late Mesolithic / Early Neolithic period around 4000 BC (Waddington, 1996, 1998a) and have been interpreted as (amongst other things) early indicators of grazing rights over a particular portion of the landscape (Waddington, 1996).

The concentration of monuments and early dates associated with the Milfield area of north Northumberland is testament to the relative importance of the region during this period of prehistory. The density of archaeological remains and monuments of this Late Mesolithic / Early Neolithic period within North Tynedale and Redesdale does not approach that present at Milfield, but this, at least in part, is likely to reflect also the lack of systematic survey within the area. However, a few cup and ring marked rocks are also known on the sandstone fells around Redesdale, such as those at Todlaw Crag (Beckensall, 1983), Dour Hill (Beckensall, 1995) and additional unconfirmed examples in the vicinity of Snabdaugh Farm (Charles Allgood, pers. comm.). Thus, a similar, smaller scale scenario can be envisaged within the North Tyne basin, where the cleared Fell-Sandstone uplands would have provided ample seasonal grazing for animals and the opportunity for foraging fruits, nuts and berries.

Heathland expansion occurs later at Sells Burn, *ca.* 3000 BC, possibly as a result of grazing being initiated later in the vicinity of the site or indeed the lower altitude not being as conducive to heath development. It seems unlikely that grazing or other anthropogenically-induced impacts would be lessened at this site, which has already been demonstrated to be proximal to apparent concentrations of human activity. However, there is a marked lack of other shrub and herbaceous species characteristic of open ground grazed environments. This may imply that the pollen represented in the diagram is of a relatively local origin due to the small basin location and therefore less reflective of the wider landscape that is sensed by the other sites examined in this study. Given that palynological indications show a significant proportion of forest within the area, this effect is likely to be exacerbated by the sheltering of local trees in the area and is hence dominated by *Betula*, *Alnus* and Coryloid type that may have been growing nearby.

In addition to aiding hunting strategies, upland woodland clearance may have assisted gathering practices and facilitated pastoral agriculture. At Drowning Flow, fluctuations of hazel and grass percentages may be suggestive of woodland management for the production of hazelnuts (Simmons, 1996), which is a well-documented component of the diet of Mesolithic peoples (Zvelibil, 1994; Morrison, 1980). Hazelnut remains have been found at numerous excavations, such as Star Carr (Clark, 1972), Derravaragh, Ireland (Mitchell, 1972) and within more local upland contexts, such as in the Tweed valley (Mulholland, 1970). Dates from hazelnut and other edible plant remains throughout Britain and Ireland during the Mesolithic and Early Neolithic period have been collated by Zvelibil (1994) and vary between approximately 7600 and 3000 BC. Palynological support for this hypothesis comes from occurrences of *Rumex*, *Potentilla* and Ranunculaceae, which have been found to be colonising species following vegetation disturbance in the North York Moors (Simmons, 1996). Resolution of the diagram is insufficient to relate results to temporary local vegetation cycles in the manner of Simmons and co-workers. However, this evidence of woodland manipulation at Drowning Flow begins around 5000 BC and continues up to and beyond the elm decline at approximately 3500 BC which has been a common feature of diagrams from the North York Moors (Simmons, 1996).

Material records of hunting practices or Mesolithic settlement, in the form of either stone tools or animal bone remains within the North Tyne basin and indeed upland Great Britain generally, are extremely scarce. This is because Mesolithic dwellings tended to be either cave sites (*e.g.* Victoria Cave, near Settle - from Darvill, 1987) or were constructed of bio-degradable materials and were temporary rather than permanent residences. In addition, hunting above 300m is likely to have been a summer or autumn activity (Smith, 1992) and of an extremely transitory nature. Archaeological records thus do not tend to be concentrated within discrete sites. The actions of Mesolithic groups within the uplands may also have acted to cover their own traces, by initiating the peat formation processes which subsequently buried stone tools and destroyed bone material due to the low pH of the overlying substrate. This is undoubtedly one of the major factors for the apparent invisibility of Mesolithic populations within the archaeological record of the uplands of the UK and the apparent concentration of sites in coastal locations (Smith, 1992).

However, recently Edwards *et al.*, (1983) have indicated the presence of Mesolithic human communities in inland south-west Scotland, despite a previous absence of surficial archaeological remains. Here, flint flakes and tools have been found around the margins of a number of lochs and streams where peat is being actively eroded and also in peat upcast of forestry drains. Detailed survey of the South Pennines has revealed clusters of Mesolithic activity, despite an extensive peat cover (Stonehouse, 1987/88). In the north-east, flint artefacts have increasingly been found inland, concentrated around major river valleys such as the Tweed (Mulholland, 1970), Till (Waddington, 1995, 1997b, in press), Tyne (Tolan-Smith, 1997) and Wear (Young, 1987). It seems likely that a similar scenario can be envisaged in the Tyne basin, where worked flints have been discovered within upland contexts eroding from below blanket peat deposits at Birkside Fell (Tolan-Smith, 1998) and from soil ploughed for afforestation (Spikins, 1996). Recently, Waddington (pers. comm) has identified Mesolithic material during field-walking of exposed peat around Black Stitchel, a cairn in the centre of the impact area of the Otterburn ranges, Redesdale, at an altitude of *ca.* 300m OD. This demonstrates that inland penetration of Mesolithic peoples was fairly widespread in this area of northern Britain and the paucity of further evidence is likely to be due to a combination of lack of survey, modern commercial afforestation and the lack of available ploughed soil for field walking. Indeed, Weyman (1984) cites the lack of systematic survey of much of Northern England as being one of the principal reasons for the relative absence of Mesolithic remains in the region. Palynological techniques, however, offer the opportunity for tracing the activities of Mesolithic communities despite the absence of archaeological evidence.

7.5 Late Mesolithic / Early Neolithic Agriculture in Valley Floor Locations

Palynological evidence for Late Mesolithic agriculture comes from the reach of the River Rede at Brownchesters. The early part of the Brownchesters Terrace T5 core (Figure 5.7) analysed covers the Late Mesolithic / Early Neolithic period and shows peaks in grass pollen, allied with incidences of anthropogenic indicator species and cultivated taxa as defined by Behre (1981) and Birks (1990) (see Chapter 3, Section

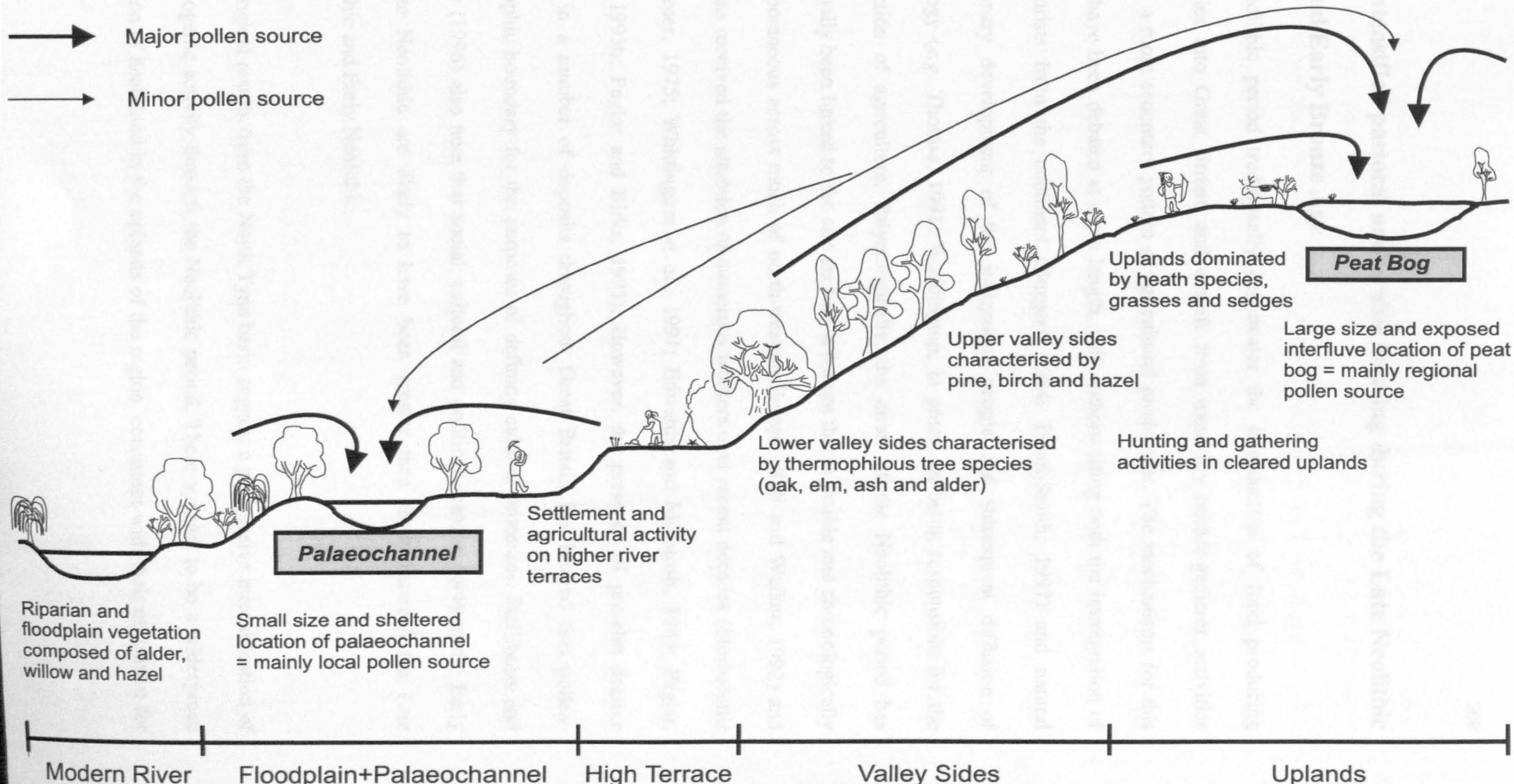
3.3.3). More specifically, these pollen grains of *Hordeum* (barley), *Avena / Triticum* (oats / wheat) along with grains which could not be accurately ascribed to a particular species, demonstrate that cereal cultivation was occurring extremely proximal to this valley floor location. This can be interpreted as evidence for the presence of agricultural human activity in this part of the valley floor during this period and is of particular significance given the lack of Late Mesolithic / Early Neolithic archaeological remains in the area (Moores *et al.*, 1998). Furthermore, relatively large percentages of Coryloid type pollen also add credence to the hypothesis of a combination of agriculture and continued reliance upon more traditional gathering form of subsistence. High alder levels may also be a consequence of the management of this tree for wood production, as Coles and Coles (1986) have found evidence of coppiced alder forest within the Somerset Levels (See Plate 7.1, for example of floodplain alder woodland).

Recent archaeobotanical work by Jacqui Huntley upon contexts derived from excavations at the Coupland Enclosure, Milfield, has lent weight to the palynological results from Redesdale by suggesting this valley floor arable agricultural activity was widespread within the region at this time. These analyses have revealed grains and glumes of emmer wheat and barley dating to *ca.* 3800-3900 BC along with an abundance of charred hazelnuts (Waddington, pers comm.). This suggests that valley floors played a critical role in the agricultural activities of human communities in Northumberland during the Late Mesolithic / Early Neolithic and that their diet depended upon a combination of subsistence strategies (Waddington, 1998b). The extension of this model of valley floor land utilisation into the late 3rd Millennium BC to other areas of Northern Britain, and indeed further afield, may be possible if suitable sites for palaeoenvironmental analyses can be found. The disturbance indicated by the palynological evidence is by no means extensive, with arboreal taxa, particularly *Alnus*, *Quercus* and Coryloid type dominating the diagram during this period. However, the small-scale utilisation of drier areas of valley floor, such as the Late Glacial gravel terraces, is a likely scenario, with areas of Holocene alluvium remaining vegetated by alder woodland and other species with a preference for the damp floodplain conditions (Brown 1988: Tallantire, 1992; Chambers and Price, 1985; Chambers and Elliot, 1989). It is easy to envisage how this relatively small-scale, yet extremely important, occurrence of agricultural practice is absent from pollen diagrams reflecting a predominantly regional vegetation record (Figure 7.2).

As outlined, Zvelibil (1994) has called for a re-examination of these early incidences of cereal cultivation as they provide grounds for a reinterpretation of the activities of Late Mesolithic communities. The results outlined here add further to the debate concerning early agriculture, demonstrating conclusively that cereal cultivation began prior to the elm decline and that previous diagrams, with an emphasis upon a regional pollen signal, may have underestimated the extent of Late Mesolithic agriculture in northern England. This can be extended to existing models of human development, the majority of which currently suggest that arable agricultural practices did not commence until permanent settlement was established and seasonal movement had ceased (Simmons, 1996). Palynological and archaeological results from northern England appear to suggest 'advanced' Late Mesolithic cultures, who incorporate stock rearing and cereal cultivation into an otherwise nomadic lifestyle. The expansion of heathland in the region, as detected by regional pollen diagrams, may as a consequence be an extremely important indicator of the activities of Late Mesolithic cultures (Simmons, 1996).

Plate 7.1: Alder floodplain woodland, showing abandoned palaeochannel, River Ohre, near Libocovice, Czech Republic

Figure7.2: Schematic Diagram showing Late Mesolithic / Early Neolithic Vegetation in the North Tyne Basin



7.6 Intensified pastoral and arable farming during the Late Neolithic and Early Bronze Age

The Neolithic period traditionally demarcates the introduction of food producing economies into Great Britain and a shift from transitory hunter-gatherer activities towards a more sedentary pattern of agricultural production. The mechanisms for this change have been debated at some length, with authors citing both the immigration of agriculturists from the continent (Burgess, 1984; Tolan-Smith, 1997) and natural evolutionary development of the indigenous people and subsequent diffusion of technology (*e.g.* Thomas, 1991; Waddington, in press) as being responsible for the introduction of agriculture. Palynologically, the onset of the Neolithic period has traditionally been linked to the elm decline, a feature that is visible and chronologically contemporaneous across much of north-western Europe (Bell and Walker, 1992) and which has received the attention of numerous workers over recent decades (Sturludottir and Turner, 1975; Whittington *et al.*, 1991; Edwards and McIntosh, 1988; Peglar, 1993a, 1993b; Peglar and Birks, 1993). However, the presence of pre-elm decline cereals in a number of deposits throughout Great Britain has blurred this pollen-stratigraphic boundary for the purposes of defining cultural processes. Stallibrass and Huntley (1996) also note that social, cultural and political changes between the Early and Late Neolithic are likely to have been greater than those between the Late Mesolithic and Early Neolithic.

Palynological results from the North Tyne basin suggest a progressive intensification of anthropogenic activity through the Neolithic period. There appears to be a widespread expansion of heathland in the uplands of the region, consistent with their utilisation for grazing purposes. At both Drowning Flow and Bloody Moss this occurs in a progressive manner between a date of approximately 4000 and 2500 BC and is concomitant with a continued reduction in arboreal pollen percentages. However, Drowning Flow also records a decrease in heathland cover, associated with a regeneration of hazel scrub woodland at a date of approximately 3000 BC, that may reflect a temporary cessation of local grazing activity. At Sells Burn the first indications of any heathland cover in the area occurs during the Later Neolithic period and here the expansion of heath species is relatively steady. In all of the diagrams the incidence of anthropogenic indicator species also becomes more frequent, with some taxa demonstrating a more continuous presence through the diagram. This is testament to an increased level of activity in the uplands of the North Tyne basin during the Late Neolithic, moving away from small-scale temporary usage towards a more sustained and extensive pattern of pastoralism.

The pollen diagrams presented here all demonstrate a general transition from a forested environment to one dominated by heathland taxa. However, in comparison with many other published pollen diagrams from the region, it should be noted that this expansion occurred within an environment that was already relatively sparse in tree cover. The reasons for this are as yet unclear, but may be attributable to earlier Mesolithic groups leaving their legacy upon the vegetation of the area or processes of edaphic development.

Evidence of Neolithic activity from the valley floor site at Brownchesters comes principally from palynological results obtained from the palaeochannel associated with terrace T5. This covers the period dated to between pre-4000 BC and approximately 2000 BC, thus representing virtually the whole of the Neolithic, bar the transition to the

Bronze Age. There is a constant presence of anthropogenic indicators with sustained levels of cultivated taxa, principally cereal-type pollen including *Hordeum* type and *Avena* / *Triticum*. The quantities of these cereals are significantly greater than equivalent values for the same period in the upland cores. From a date of approximately 2300 BC there is a large increase in percentage values of grass pollen, broken only by a massive influx of birch pollen which is almost certainly due to extremely local, *in situ* sources. This occurs concomitantly with a decrease in the percentage of tree cover, noticeably alder, oak and to a lesser extent and slightly earlier willow. Pine percentages are also reduced, but at the levels recorded here the pine pollen is probably of regional origin. Wetland pollen taxa found within the sediment cores are testament to the patchy nature of valley floor vegetation as damp conditions prevailed within parts of the floodplain. Overall, pollen records indicate a clearance of the valley floor floodplain woodland and the replacement by herbaceous taxa demonstrative of human activity on the valley floor.

A second palaeochannel at Brownchesters provides support for this interpretation. Pollen records from the sedimentary infill of the former channel associated with terrace T6, which have accumulated rapidly over just 600 years between approximately 2300 and 1700 BC, overlap the uppermost section of the diagram from T5 described above (Chapter 5). The curves for non-cultivated grasses, oak and indeed undifferentiated ferns can be seen to correspond well, thereby allowing more confidence to be placed upon the chronological framework provided by the radiocarbon dating. Again, there is a relatively high level of anthropogenic indicator species and cultivated taxa, which is at odds with some previous assumptions that regard human impact to be fairly minimal during this period (Davies and Turner, 1979; Dumayne, 1993a, 1993b). However, this does correspond well with palynological results from within the uplands of the Cheviot Hills, where significant human impact has been found to be broadly synchronous around 4650-4200 cal BP (*ca.* 2300 BC) (Tipping, 1992).

Indeed, these palaeochannels contradict existing palynological evidence which has suggested that there has been little disturbance of regional vegetation before the third millennium BC outside of the Milfield basin (Higham, 1986). On the basis of archaeological evidence, the Milfield plain is believed to be the heartland of Neolithic occupation in northern Britain (Higham, 1986) and recent excavations have demonstrated that its relative importance may have been underestimated on a national scale (Waddington, 1997a). The evidence presented here suggests that Neolithic populations in North Tynedale may also have been greater than previously envisaged.

Archaeological records of Neolithic populations in North Tynedale are more extensive and tangible than those of the Mesolithic period, but are still relatively limited. However, no known settlement sites have been found within the basin, although Neolithic sites discovered elsewhere in the Borders have been found whilst excavating Early Medieval remains (*e.g.* Thirlings, Yeavering, Doon Hill, Dunbar and the Hirsel, Coldstream). Burgess (1984) highlights that these chronologically distinct communities appear to have chosen the same sites and built similar timber buildings.

A number of long cairns form documented monumental evidence of the Neolithic in the area. These features are burial monuments and take the form of large, elongate constructions, now covered by loose stone. The best known and largest of these long cairns is that at Bellshiel Law, on the northern side of the valley in Redesdale (Masters, 1984) which measures approximately 114m in length. This has been partially excavated by Newbigin (1936), who found a single rock cut grave, surrounded by an edging of well-laid kerbstones at its eastern end. Although this cairn was excavated prior to the advent of radiocarbon dating techniques, dates from other long cairns suggest that these monuments date broadly from 3500-2500 BC. There are further possible long cairns in the area, as outlined by Masters (1984), although the example at Dour Hill, has recently been surveyed by Waddington *et al.*, (in press) and contains corbelled chambers. The potential long cairn named on Birks Moor (Masters, 1984), is particularly relevant to this study as it overlooks the study reach at Snabdaugh, on the North Tyne, where there are numerous palaeochannel features on the valley floor. Archaeological evaluation carried out as part of the proposed development of the Otterburn Training Area has highlighted that Hare Cairn, 5 km north of Otterburn village, is possibly a Neolithic feature, owing to its similarity to 'great barrows' from other areas of Northern England (LUAU & NUAP, 1997). The presence of these sepulchral remains implies fairly significant population levels and on this basis Upper Redesdale can be considered an important area to Neolithic communities despite the fact there is relatively little supporting artefactual evidence for their presence. However, the presence of an upland Neolithic enclosure on Harehaugh Hill, situated in-between different valley communities (*i.e.* Redesdale and Coquetdale) dating to *ca.* 3000 BC (Waddington *et al.*, 1998), indicates that archaeological features of this period are frequently found at the margins of settlement, rather than centrally on the valley floors.

The area of Milfield, in north Northumberland, contains more evidence of Neolithic occupation than North Tynedale throughout the whole period. There are a large number of henge monuments, stone circles, pit alignments and settlement sites in the area of the Milfield basin (Harding, 1981), coupled with a tradition of cup and ring marked rocks

(Beckensall, 1983, 1991, 1992, 1995; Waddington, 1995, 1996). The Eden valley west of the Pennines also contains considerable evidence for Neolithic activity in the form of 'Long Meg' a stone circle on the east bank of the River Eden (Burl, 1976), plus a number of cursus monuments, long cairns and the Penrith henges (Higham, 1986). Burgess (1984) has mapped Neolithic activity in the Northumberland region on the basis of finds of stone and flint axe heads, concluding that Neolithic settlement was widespread and focused upon the lowlands and river valleys. In the Ingram valley, a tributary of the Till, ongoing excavations by Adams (1996) are analysing a rough stone revetment enclosing a lynchet, that is believed to date to *ca.* 4000 BC. This provides a tentative indication that early agricultural practices were taking place in this region of Northumberland.

The records of flint and other Neolithic tools and artefacts from the North Tyne basin are very rare, primarily due to a lack of survey and the availability of ploughed soil. A 'dark coloured arrow head' has been found at Shittleheugh, just a few kilometres upstream of Brownchesters and a barbed and tanged arrow head has been found within the Otterburn Military Training area at South Yardhope, which lies just outside the Rede catchment (Charlton, 1996). Lower down in the Tyne basin at Riding Mill, an extensive flint chipping sites has been found (Weyman, 1980). Here, a range of Late Mesolithic microliths and Neolithic arrowheads have been discovered, demonstrative of an active population over many years. Indeed, the re-use of specific sites by successive Mesolithic and Neolithic communities is extremely high in northern Britain and can be seen not only in the Lower Tyne, but also in Weardale, Walney Island and in the Milfield basin.

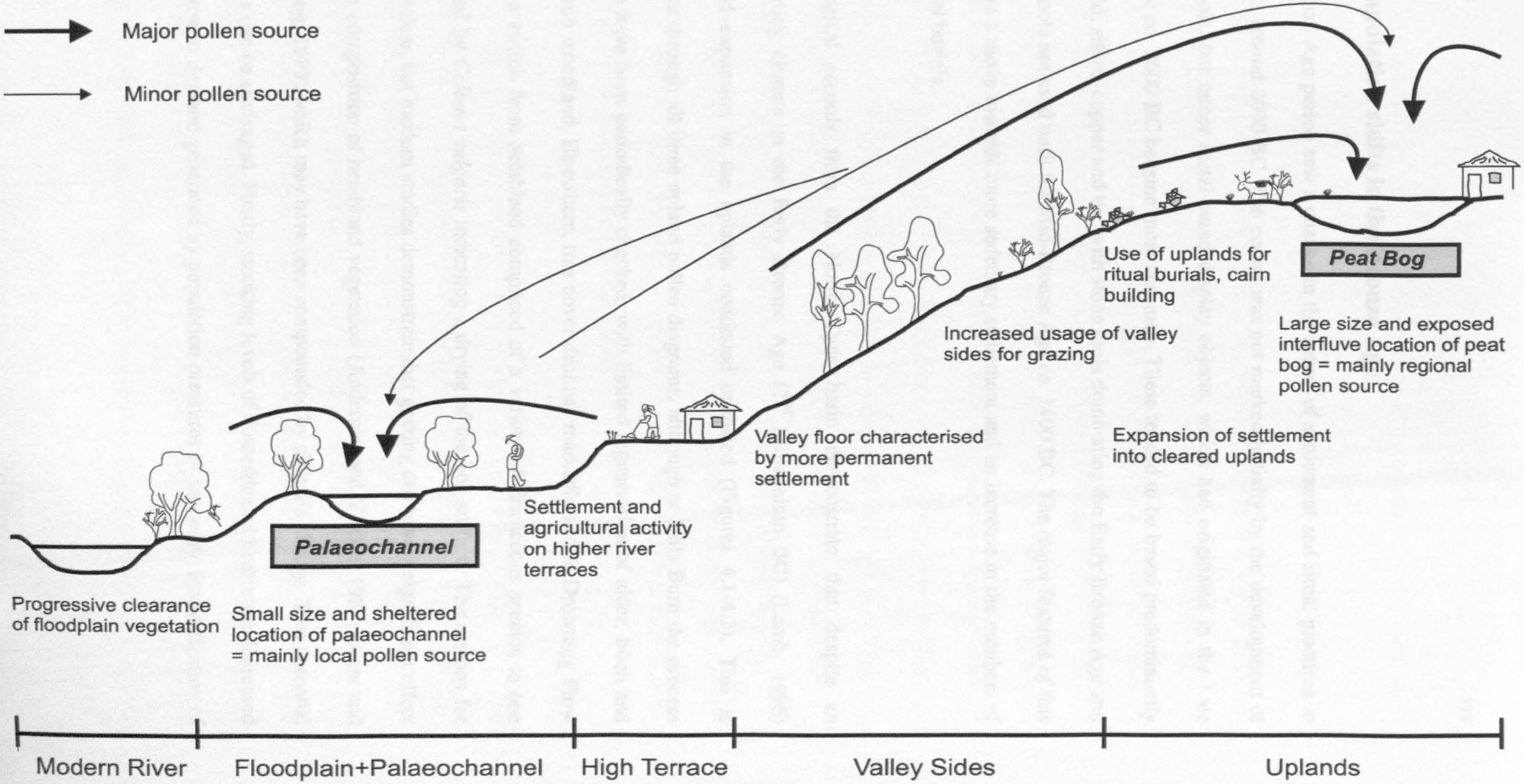
Stone axe technology has been implicated in the clearance of lowland woodlands throughout Britain in the Neolithic. East of the Pennines finds of these tools are rare, although notably the distribution is characteristically lowland and riverine (below 150m OD) (Higham, 1986). Charlton and Day (1976) have discovered, during a detailed survey, three such examples of polished stone axes in Redesdale. Of these, one was discovered at Otterburn, adjacent to the site at Brownchesters, providing unequivocal evidence for the presence of Early Neolithic populations in this area of the North Tyne basin. A further example was also found within a valley floor context at Elishaw, approximately three kilometres upstream of Otterburn (adjacent to Shittleheugh mentioned above) and the third at Potts Durtees around three km north of Elishaw adjacent to the Durtees Burn which flows into the River Rede. On the southern valley sides of Redesdale, three celts (stone axes) have been discovered on Troughend Common, which overlooks the area around Otterburn. Further afield, in the Lake District and north Northumberland more examples of stone axes have been found, with their source commonly acknowledged to be the 'Langdale axe factories' (Smith, 1992), where volcanic tuffs provided the raw materials for production.

Pottery remains are also scarce from the North Tyne basin during this period. A single piece of Neolithic pottery (Peterborough ware: see Burgess, 1984) has been recovered from very close to the site at Brownchesters, approximately 1 km downstream at Heatherwick. This was excavated from a circle of stones that has subsequently been destroyed (Charlton and Day, 1976). Again, the area around Milfield contains a more complete record, with Early Neolithic pottery discovered at Thirlings dating to *ca*. 3280 BC (Miket, 1976, 1987) and similar material also found at nearby Ford (McInnes, 1969). The excavation by Greenwell of an Early Neolithic long cairn on nearby

Broomridge has also produced a large amount of pottery sherds (from Waddington, 1996). Grimston Ware pottery (*cf.* Miket 1987) has also been excavated from the 'Coupland Henge'. This came from a context dating to 3800 BC, making it the earliest pottery discovered in Northumberland (Waddington, 1997, pers. comm.).

Despite the relative scarcity of Neolithic (particularly Early Neolithic) archaeological evidence in the area, both the regional upland and local valley floor pollen diagrams have demonstrated a continuous human presence throughout this period. The upland diagrams (Figures 4.1-4.3) demonstrate a continuation of Late Mesolithic grazing practices associated with a progressive expansion of heathland vegetation in what appears to be an already fairly open environment. Valley floor pollen diagrams indicate a more sedentary form of agriculture based at least partially upon pastoralism, but including the cultivation of cereal crops. Woodland cover remains a significant component of the vegetation of the floodplains and valley sides and it is likely that small-scale arable agriculture took place within clearings in drier areas of the valley floor, such as upstanding late glacial gravel terraces. The discovery of a number of stone axes, worked flint and pottery in the vicinity of the valley floor at Brownchesters adds credence to this hypothesis. The pollen diagrams presented here support the indications of a relatively large Neolithic population, as suggested by the presence of long cairns in the area. The palynological results thus support the notion that the paucity of archaeological finds in the area is due to both a lack of systematic survey (Weyman, 1984) and potential post-depositional geomorphological processes obscuring the evidence (Passmore and Macklin, 1997).

Figure7.3: Schematic Diagram showing Late Neolithic / Bronze Age Vegetation in the North Tyne Basin



7.7 Population shifts in the Bronze Age

The Bronze Age period saw a change in the nature of settlement and ritual practices in Britain at around 2000 BC. The period was not marked initially by the development of metal tools, but rather metal-based display objects, which had originated in the Late Neolithic *ca.* 2600 BC became more common. These tended to be based predominantly upon gold, silver, copper and tin, with stone tools dominating the Early Bronze Age and bronze tools not used until the Mid-Bronze Age *ca.* 1400 BC. The major features of this time were a move towards more sedentary settlement and an increase in the numbers of individual burials.

Palynological records from the North Tyne basin demonstrate that despite an ameliorating climate in the Early Bronze Age (2nd Millennium BC) (Lamb, 1995) heathland expansion in the uplands continued unabated (Figures 4.1-4.3). This is consistent through all three upland pollen diagrams, although at Sells Burn the process seems to have been periodically checked, with limited regeneration of alder, birch and hazel scrub woodland. Elsewhere, tree cover declines markedly and at Drowning Flow there is a switch from heathland comprised of a variety of Ericaceous species to one dominated by *Calluna vulgaris* indicating a drying of the bog surface. The reasons for this is unclear, but modern studies demonstrate that grazing can have a significant effect upon the composition of heathland vegetation (Anderson and Yalden, 1981; Grant and Armstrong, 1993) which may have been compounded by climatic change. Two potential scenarios can be envisaged. Firstly, stocking levels of domesticated herbivores increased in response to demand generated by population pressures or secondly, intensification of grazing occurred through year round usage associated with the improved and more stable climatic conditions.

The first occurrence of taxa directly associated with cultivation also appear at around 1000 BC in the diagrams from Drowning Flow and Bloody Moss, albeit at relatively low percentages. This rise is concomitant with a slight increase in the percentage of grasses and thus demonstrates an intensification of land utilisation within the uplands. This appearance of cereal-type pollen is not particularly unusual for this Late Bronze Age date. Indeed Davies and Turner (1979) found the first incidence of cereal pollen at precisely this date in the diagram from Steng Moss and also the inferred Bronze Age levels from the undated diagram from Broad Moss in the Cheviots. Likewise, Dumayne (1992) has found small scale cultivation occurring in the vicinity of Fozy Moss between *ca.* 1575 BC and 835 BC, and also further north at both Fannyside Muir between 1775 BC and 1180 BC and also Cranley Moss between approximately 1650 BC and 1285 BC. Dumayne (1992) has attributed this to cultivation occurring within semi-permanent clearings over time periods of *ca.* 400-700 years.

Pollen records from the valley floor study reaches are somewhat limited from this period, owing to a lack of palaeochannel fills dating to this time. The upper portion of the palaeochannel associated with terrace T6 at Brownchesters covers the early Bronze Age. Here there is a sharp rise in the quantity of anthropogenic indicator species, with the incidence of cultivated cereal taxa also increasing and becoming a constant presence in the diagram. It can be envisaged that the few cereal-type grains recorded within the upland cores represent small-scale cultivation of suitable environments in what would have been relatively marginal terrain. Cultivation appears to have been focused upon the valley floors and lower valley sides, such as around the Brownchesters study reach, which would have been more conducive to arable agriculture.

During this Early Bronze Age period, tree cover in the vicinity of the valley floors was relatively limited. Indeed, the presence of very high alder percentages are reflecting virtually *in situ* growth as indicated by the presence of clumps of alder pollen encountered on the slides during counting (Davis, 1989). The decline in alder percentages reflects, in part, the natural terrestrialisation of the palaeochannel, but the large increase in herbaceous taxa, particularly grasses, lends support to the notion that this reduction in alder percentages was abetted by human clearance. Of the other arboreal taxa only hazel is present in any significant quantities and this almost certainly coexisted as scrub within the areas of alder woodland. The valley floor and immediate valley sides can be seen to be a mix of woodland within damper areas, surrounded by pastoral and arable cultivation in the drier areas of the floodplain.

The pollen diagram from this palaeochannel ends at a date of approximately 1600 BC, therefore not allowing any further insights into the vegetation of the later Bronze Age. However, the results from this Early-Mid Bronze Age context demonstrate that not only was there significant woodland removal in valley floor areas, but also that production of cereals was occurring on a greater scale than previously envisaged. Previous published diagrams from the area have suggested that these events occurred slightly later, either in the Iron Age or during Romano–British times (Dumayne, 1993a, 1993b; Davies and Turner, 1979). The combination of regional upland diagrams and local valley floor diagrams suggest that this is not the case and that deforestation and cereal production have been occurring at least locally, for many millennia prior to conventionally accepted dates.

In many respects this new palynological evidence supports the existing archaeological evidence of cultivation (Gates, 1982). Topping (1989) has mapped incidences of cord rig and cultivation terraces throughout Northumberland and the Borders, with a noticeable concentration in the vicinity of Redesdale. These agricultural archaeological remains tend to survive primarily in the uplands of the region, where disturbance in subsequent periods has been minimal. As a result of this, cord rig remains are likely to be a gross under-representation of the area formerly under plough (Topping, 1989). Although the dating of these prehistoric agricultural features is frequently difficult and they are commonly ascribed to the Late Bronze Age / Iron Age period, there is some evidence from Perthshire (Barclay, 1983) to suggest that narrow ridged cultivation was taking place in the Early Bronze Age. Indeed, Mercer and Tipping (1994) have identified a phase of soil erosion from the Cheviot Hills dating to the Early Bronze Age, consistent with the advent of extensive farming practices and Macklin *et al.*, (1991) have also identified evidence of Late Neolithic to Bronze Age activity from sediments on Callaly Moor, near Rothbury, Northumberland.

The cessation of sediment accumulation within this palaeochannel, and the absence of any immediate succeeding examples, prevents the direct comparison of this environment of the Early-Mid Bronze Age with that of the later Bronze Age and Early Iron Age. This is critical, as it would provide an indication of the environmental conditions associated with the worsening climate of this period and would demonstrate the influence of climatic fluctuations upon agricultural practices within these relatively marginal areas. Although this is highly conjectural, it may well be that the reason for the absence of palaeochannels within this study reach is precisely the fact that climatic conditions did deteriorate. This may have led to an enhanced level of fluvial activity within these valley floor areas and as a result the reworking of channel and terrace forms during this period.

Archaeological evidence of Bronze Age activity within Tynedale and indeed Northumberland more generally is far more extensive than that of the preceding periods of prehistory. Conclusive evidence of Bronze Age activity exists in Redesdale with the extensive settlement at Todlaw Pike, on the Otterburn Training Area. This site consists of 2 / 3 timber round houses, a small cremation cemetery, burial and field clearance cairns and a broken cup-marked stone (Charlton, 1996). Further Bronze Age huts can be found on Hillock, Wholehope Knowe and near Barrow Cleugh, all within the Otterburn ranges (*op cit.*). Excavations at Hallshill (Gates, 1983), close to East Woodburn and overlooking the River Rede, have revealed a Late Bronze Age / Early Iron Age timber roundhouse which has been the focus of a substantial volume of work, including detailed archaeobotanical analysis (van der Veen, 1992). These unenclosed settlements date from the mid-second millennium BC, if not the Early Bronze Age (Burgess, 1984) to just after the mid-first millennium BC (Jobey, 1985) (Figure 7.3). They are often associated with field plots and extensive cairnfields, such as those at Todlaw Pike and Black Stitchel on the Otterburn Training Area (Charlton, 1996).

Extant monumental remains of the Bronze Age period in Redesdale include the 'Three Kings' stone circle on the valley side above Cottonshopeburnfoot. This feature, dating to the Early Bronze Age, actually consists of four standing stones (one having collapsed) and is of a type consistent with 'four posters' more regularly found in Perthshire, Scotland (Burl, 1971). In addition, The Goatstones, lower down the North Tyne valley is a similar feature, dating to the same Early Bronze Age period. Bronze Age pottery, in the form of food vessels and urns, in this part of Northumberland are relatively scarce (Gibson, 1978). Examples are mainly associated with burial practices and funerary monuments (Higham, 1986) containing either cremated remains or perishable grave-goods.

7.7.1 Upland / Lowland Population shifts in the Bronze Age

Burgess (1984, 1985) has used an apparent hiatus in the dates of late-Neolithic / Early Bronze Age settlement on the Milfield plain to suggest that this period saw a huge social and spiritual upheaval in Northumberland. He suggests that rising populations were creating adverse effects on the productivity of fragile soils and that as a consequence lowland settlement was abandoned and Early Bronze Age communities lived predominantly in the uplands. A more favourable climate at this time (Lamb, 1981) is argued to have facilitated a longer growing season and hence 'making it possible to cultivate cereals at over 400 metres' (Burgess, 1985; p. 200). Waddington (pers comm) has questioned this hypothesis on the basis of recent evidence for Early Bronze Age occupation in the Milfield plain, provided by the Lookout Plantation settlement (Monaghan, 1994) and re-use of the Coupland Enclosure also dated to this period. A further argument is that the apparent concentration of Bronze Age settlement in the uplands is purely a result of preservation bias between upland and lowland environments. Additionally, Tipping (1996) has suggested estimates of the extent of Neolithic settlement in the Cheviot uplands have been under-represented by the archaeological record. Therefore, the apparent Bronze Age exodus to the uplands as they apparently became much more attractive to human communities is not necessarily a genuine distribution, but an artefact of archaeological survey, preservation bias and theoretical standpoint (Tipping, 1996; Mercer and Tipping, 1994).

The palynological results presented here, whilst not resolving debates surrounding settlement, suggest that the lower-lying river valleys continued, and increasingly, became the focus of arable cultivation and were not, as Burgess suggests, non-productive as a consequence of preceding Neolithic farming practice. Similar results have been found at Burnfoothill Moss by Tipping (1995b) who suggests that although farmers moved into the uplands, this was an expansion from, rather than an abandonment of the lowlands. In addition, Burgess' (1984) premise that this Bronze Age activity represented the first incursion by human populations into the uplands of the Cheviots also seems in doubt. The upland diagrams presented here suggest that clearance of forests and expansion of heathlands began far earlier than the Bronze Age, although it must be conceded that the process was accelerated during this period. Other pollen diagrams in the region, as Young and Simmonds (1995) have already pointed out, do not manifest this apparent translocation of population. Steng Moss (Davies and Turner, 1979) does not register the hypothesised sudden influx of people into the area, with pollen curves all demonstrating a smooth profile and Dumayne (1992) has found no evidence of large-scale changes in the vegetation associated with this apparent shift in settlement.

A second facet to Burgess' (1984) upland-lowland hypothesis is the subsequent abandonment of the uplands at the beginning of the first millennium BC, associated with a climatic downturn. This climatic event is manifested in proxy climatic records from Bolton Fell Moss, Cumbria (Barber *et al.*, 1994) where macrofossil evidence indicates a shift from *Sphagnum* section *Acutifolia* to *S. imbricatum* indicating a wet period. Evidence for this event is also somewhat fragmentary, although the Hallshill unenclosed settlement site in Redesdale, excavated by Gates (1983), provides some of the most securely dated contradictory evidence (Young and Simmonds, 1995). This site spans a wide-range of dates (*ca.* 1200-600 BC), which have been attained from charcoal from post-holes and hearth deposits (Gates, 1983). Recently, van der Veen (1992) has obtained further dates from carbonised seeds from the Hallshill site which calibrate to 1200 BC and has also demonstrated the presence of cereals at the beginning of the first millennium BC. This demonstrates that this site was not abandoned and as Gates (1983), has suggested, there is no archaeological evidence to indicate that upland desertion occurred early in the first millennium as a consequence of climatic change. Indeed, Jones (1981, 1984) has suggested that during the first half of the first millennium BC there was an increase in the scale of arable production, caused by rising populations and a reduction in soil fertility.

The pollen records in this study all have the benefit of radiocarbon dates which lie at and around the first millennium BC, although a minor calibration plateau means the dates have a relatively wide range (Appendix 10.1). At this time, both Sells Burn and Bloody Moss show an increase in Poaceae accompanied by notable rises in *Plantago lanceolata* and other anthropogenic indicator taxa such as Ranunculaceae and *Rumex* spp. Both diagrams also begin to record significant quantities of Cyperaceae pollen, indicating changing surface moisture conditions. This is associated with a general trend of increased cover of heathland, although in both cases this is periodically interrupted by small regeneration phases of Coryloid type vegetation. At Drowning Flow minor regeneration of hazel also occurs, but this is concomitant with the first indications of upland cereal cultivation and the appearance of small percentages of a number of herbaceous taxa. In summary, the three upland diagrams do show significant changes in vegetation composition at around this time but not, as Burgess (1984) has suggested, an abandonment of these higher altitudes. In all instances the alterations in vegetation suggest an increased level of anthropogenic impact in the uplands during this Late Bronze Age period and this is a pattern which continues into the Iron Age.

7.8 The Pre-Roman Iron Age in the North Tyne basin

The early part of the Iron Age period is believed to have had witnessed immediate impact upon the societies living in Northern Britain, who remained rooted in Bronze Age traditions (Cunliffe, 1974). Iron Age archaeology is abundant within the North Tyne basin and includes a number of unenclosed settlements (Jobey, 1985), palisaded enclosures (Burgess, 1985; Jobey, 1965) and hillforts (Jobey, 1965, 1966). These settlement types are frequently stated to belong to successive generations and although the chronological definition of this model has become somewhat blurred and overlapping with the advent of radiocarbon dates, the general pattern of development does still hold true (Figure 7.3).

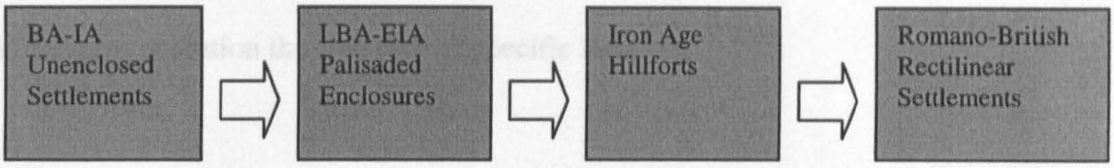


Figure 7.4: Generalised Model of Bronze Age - Iron Age Settlement Development

This evolution of settlement type from the Late Bronze Age through the Early Iron Age period has been attributed to increased population pressures brought about by climatic deterioration, increased clearance and need for more defensive situations (Jobey, 1985). Unenclosed settlements, such as that at Hallshill (Gates, 1983) have already been discussed with respect to Bronze Age communities in the North Tyne basin. This form of settlement has been recognised principally through the advent of radiocarbon dating and have been found to range between approximately 1200-600 BC. The discovery of these settlements has supported and helped account for the numerous examples of Late Bronze Age burial cairns that are present in the upland areas of the region (Gates, 1983).

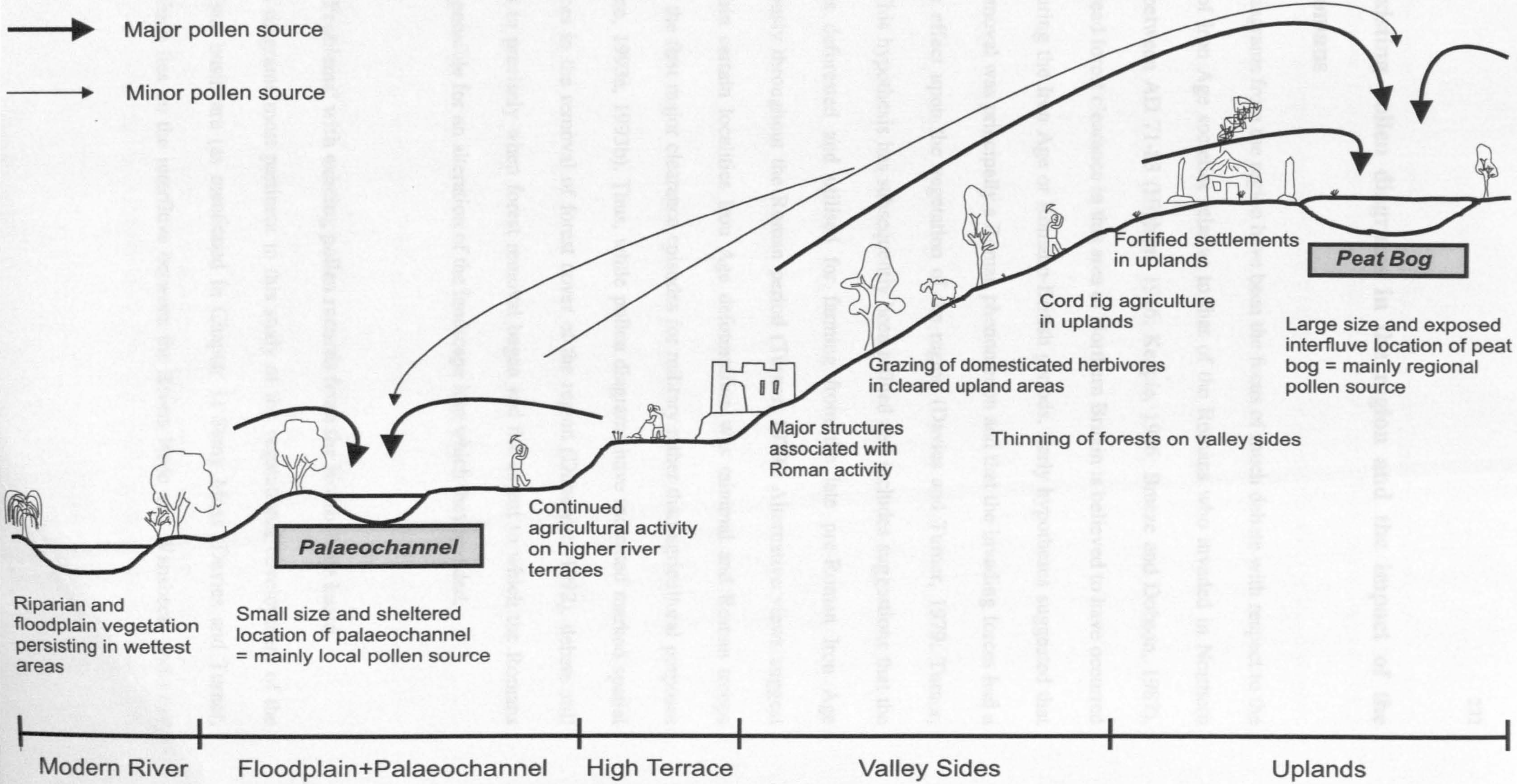
Subsequent palisaded enclosures date from approximately 900 BC onwards and can be found in a variety of locations. Several palisaded enclosures have been excavated in North Tynedale prior to the construction of Kielder Water (Jobey, 1973, 1977, 1978; Jobey and Jobey, 1988). These settlements, particularly at Gowanburn which is located on an upstanding river terrace (Jobey and Jobey, 1988) and that at Belling Law which is on a riverine spur (Jobey, 1977), illustrate the importance of riverside settlements to prehistoric groups. The Iron Age / Romano-British site at Kennel Hall Knowe has also produced one of the few examples of Mesolithic flint from the area, again emphasising the usage of certain sites for many millennia. Significant proportions of palisaded enclosures in Northumberland underlie later hillfort structures, indicating a direct line of settlement evolution through time at specific localities.

The distinction between hillforts and settlements is frequently slight, due to both being used for habitation while not all hillforts occupy positions of outstanding natural defence (Jobey, 1965). There are two small adjacent defended enclosures / hillforts overlooking Redesdale at Fawdon Hill and Colwellhill immediately northwest of Otterburn village (Jobey, 1965). Whilst these examples are extremely proximal to the sites in this study, some of the best examples of these defensive structures lie a little further afield. Lordenshaws hillfort (Topping, 1991) is strategically located on a locally prominent spur of the Simonside Hills looking out over Coquetdale and east towards the coast. Adjacent to this site there are a number of examples of prehistoric rock art carved into the outcropping Fell Sandstones (Beckensall, 1983), demonstrating the importance of these areas for multiple periods of human occupation. Harehaugh hillfort is nearer to the North Tyne basin, lying at the foot of Upper Coquetdale adjacent to the confluence with Grasslees Burn. Another site, Warden Law, overlooks the confluence between the North and South Tyne Rivers, illustrating the importance of strategic location. One of the largest examples of a hillfort in Northumberland can be found at Yeavering Bell, overlooking the Milfield plain. This earthwork, which contains some 130 hut circles (Jobey, 1965), along with further forts located some 16-22km apart (Jobey, 1965) illustrates the level of population within Northumberland during this period. Indeed, the density of hillforts in the region is far greater than most other areas of Britain (Clack and Gosling, 1976), indicating not only the necessity of these protected settlements but also the possibility that they were occupied for extended periods of time. The relative paucity of such settlements south of the River Tyne suggests that this landscape boundary also formed a significant cultural divide in the later prehistoric period (Clack and Gosling, 1976).

The Iron Age is generally assumed to be a period when population levels were rising rapidly and consequently utilisation of the landscape for agriculture was intensified (Topping, 1989). Evidence of extensive Iron Age agricultural practice is witnessed by cord rig field systems throughout the uplands of the North Tyne Basin, particularly in Redesdale (Topping, 1989). Further examples of this form of cultivation are being discovered as more areas are surveyed and excavated, such as at the scooped settlement of Barracker Rigg (Charlton, 1996) within the Otterburn Military Range (LUAU / NUAP, 1997). Direct evidence for pastoralism is less plentiful, with relatively few faunal remains precluding the reconstruction of livestock populations (Higham, 1986). Of the remains found, cattle, goat, pig, ox, horse and sheep are the most common, although differences in assemblage are apparent between sites in the region (*cf.* Jobey, 1973, 1978, 1982, Heslop, 1983). These faunal remains do, however, suggest that grazing levels are likely to have intensified during this period. Indeed, all the upland pollen diagrams from this study appear to reflect an increased utilisation of the landscape for grazing purposes at this time, a pattern that originates in the Late Bronze Age (Figures 4.1-4.4). At Drowning Flow, intensified grazing activity appears to be manifested by a large increase in the number of *Pteridium* spores recorded within the core. This suggests that areas of upland *Calluna* heathland were either being overgrazed or overburnt (to facilitate new growth for grazing). Either of these processes would have given *Pteridium* a competitive advantage over *Calluna* due to its un-palatability for grazing animals and deep rhizome system allowing rapid re-growth following fire (Hobbs and Gimingham, 1984). At both Sells Burn and Bloody Moss, the impact of grazing is suggested by increases in grass species, allied with the occurrence of herbaceous taxa associated with pastoral agricultural practices, such as Ranunculaceae, *Rumex* spp., *Potentilla*, Chenopodiaceae, *Plantago lanceolata* (Behre, 1981).

There is an absence of Iron Age pollen records from the valley floor of Redesdale due to the lack of suitably dated palaeochannel infills. A date of *ca.* 395 BC has, however, been returned from wood eroding out of the base of a contemporary section of bank on the River Rede at Brownchesters (Terrace T7) thereby dating the onset of the terrace formation (Figure 5.9). In North Tynedale the only palaeochannel to have so far yielded suitable organic sediment for dating and palynological analyses has a chronological range covering the Iron Age dating to between *ca.* 757 BC and 1260 AD (Moores *et al.*, 1998; Passmore, 1994). This valley floor diagram indicates an almost complete absence of trees during this period, with uncharacteristic peaks in both alder and willow percentages at a later date reflecting *in situ* development of these tree taxa. From this it can be said with some confidence, that valley floor woodlands in this area of North Tynedale had been cleared prior to the Iron Age. In addition, the diagram shows an extremely high level of anthropogenic indicator taxa, attaining values in excess of 40% during the Iron Age. This, in combination with the occasional occurrence of cereal pollen, indicates that this valley floor and immediate valley-side environment was being managed for a combination of pastoral and arable agricultural practices (Moores *et al.*, 1998). Iron Age human activity is also attested by the recovery of a worked wooden plank, which has provided the date 757-210 BC from close to the base of this channel (Passmore, 1994).

Figure7.5: Schematic Diagram showing Iron Age / Romano-British Vegetation in the North Tyne Basin



7.9 Existing pollen diagrams in the region and the impact of the Romans

Pollen diagrams from the region have been the focus of much debate with respect to the impact of Iron Age societies relative to that of the Romans who invaded in Northern Britain between AD 71-83 (Higham, 1986; Keppie, 1986; Breeze and Dobson, 1987). Widespread forest clearance in this area of Northern Britain is believed to have occurred either during the Iron Age or Romano-British periods. Early hypotheses suggested that forest removal was principally a Roman phenomenon and that the invading forces had a dramatic effect upon the vegetation of the region (Davies and Turner, 1979; Turner, 1979). This hypothesis has subsequently been refined and includes suggestions that the area was deforested and utilised for farming from the late pre-Roman Iron Age continuously throughout the Roman period (Turner, 1979). Alternative views suggest that within certain localities Iron Age deforestation was minimal and Roman troops initiated the first major clearance episodes for military rather than agricultural purposes (Dumayne, 1993a, 1993b). Thus, while pollen diagrams have indicated marked spatial differences in the removal of forest cover of the region (Dumayne, 1992), debate still exists as to precisely when forest removal began and the extent to which the Romans were responsible for an alteration of the landscape into which they invaded.

7.9.1 'Problems' with existing pollen records from the North Tyne basin

The two diagrams most pertinent to this study of the vegetational development of the North Tyne basin are (as mentioned in Chapter 1) Steng Moss (Davies and Turner, 1979) which lies on the interfluve between the Rivers Rede and Wansbeck, and Fozy

Moss (Dumayne, 1992; 1993a, 1993b; Dumayne and Barber, 1994) outside the North Tyne catchment close to Hadrian's Wall (see Figure 1.1). Both these diagrams have primarily focused upon the issue of the impact of the Roman troops on the vegetation and the Iron Age landscape into which they invaded. Both diagrams have limitations associated with their interpretation and the manner in which the data is displayed. A third paper (Manning *et al.*, 1997) has also attempted to address this debate and will also be discussed.

7.9.1.1 Steng Moss

The pollen diagram from Steng Moss (Davies and Turner, 1979) has been generated from a 7.35m peat core which covers the period from just prior to the elm decline up to the present day, with most samples spanning Late Bronze Age to Early Anglian times. The diagram has a total of 7 radiocarbon dates and a proxy date at elm decline levels. This diagram is, however, somewhat misleading, due to the manner in which pollen percentages have been calculated, four key interconnected points can be identified.

1. The herbaceous taxa have been calculated as percentages of the total tree pollen, as opposed to the now conventional way of expressing their quantity as a percentage of the total terrestrial pollen. This has meant that individual herbaceous taxa are relatively over-represented with species such as grasses showing peaks of over 300% and individual tree pollen types reaching far greater levels than they would if the diagram had been calculated as is now standard practice.

2. In addition, *Calluna* has been included as a 'bog species' and as a result is excluded from the percentage calculations along with the aquatic species. The reasoning that

Davies and Turner (1979) provide is that this species was growing upon the bog surface along with assorted sedges and *Sphagnum* species. This is undoubtedly true, however, the ecological requirements of *Calluna* are such that it also extremely likely to have occupied other areas of the surrounding landscape from which the arboreal pollen grains are also derived. This has important implications for the interpretation of the diagram. For instance, *Calluna* values at levels dating to *ca.* 1200 BC reach almost 100% of the arboreal pollen sum, and would, therefore, if calculated using the methods employed in this study represent approximately 50% *Calluna* coverage and a significant degree of open heathland landscape. Likewise, peaks in *Calluna* at a date *ca.* AD 100 would not be so pronounced and would only represent in the order of 70-80% on one of the diagrams presented here.

3. This calculation is further amplified by the fact that Coryloid type is also excluded from the tree pollen sum. This, however, is fairly standard practice as this species can frequently occur as an understory scrub (Huntley and Birks, 1983) and is thus grouped with shrub taxa. However, the exclusion of Coryloid type from the total upon which all other percentages are based has the effect of further exaggerating tree pollen curves. This occurs at the expense of species that are more likely to have persisted within an open landscape and thus provide a very different picture of the prehistoric landscape than the one that is advocated here.

4. A further potential problem with the diagram is the estimated rates of peat formation, which increase dramatically at a date around 800 BC to levels in excess of six times the average for the sedimentary sequence as a whole. Davies and Turner (1979: p793) cite 'the widespread climatic deterioration that is thought to have

culminated at this time' for the increase in peat accumulation rates. However, this figure is far in excess of any other measures of ombrotrophic peat development from elsewhere in the region (which are on average just 14 years cm $^{-1}$: Barber *et al.*, 1993). Other diagrams which Davies and Turner (1979) present from Northumberland within the same paper do not show this marked increase, which may be expected if it were a climatically driven phenomenon. Also the sedimentary log associated with the core does not show any signs of an increase in rate at this point, which would perhaps be indicated by the peat mass becoming less humified (Barber, 1985). There is also no apparent increase for other periods of climatic deterioration within the core, although it could be argued dating of these periods is not at sufficient resolution to determine this. It seems more likely that there is the possibility of erroneous radiocarbon dates within this sequence, although the reasons for this remain difficult to elucidate.

It can therefore be seen that the Steng Moss diagram relatively under-represents possible impacts of early human cultures upon their environment which may be manifested by heathland expansion. Widespread clearances are also over-represented due to herb pollen calculations which emphasise later prehistoric forest removal during the Roman period.

7.9.1.2 Fozy Moss

The diagram from Fozy Moss has been generated from a three-metre peat core covering the period from the Early Neolithic to the present, with the Roman period being the focus of the study. The diagram contains three radiocarbon dates, and it is partially this factor which is critical to the adequate interpretation of the pollen sequence. Dumayne

(1992) has carried out high-resolution palynological analysis of the period around the time when Roman troops invaded northern Britain. However, chronological control of this portion of the diagram is provided by a radiocarbon date of AD 185, with a linear interpolation between the other two dates in the core. These dates are 900 cal. years and 1390 cal. years respectively away from this Roman date and thus the assumption of a constant sediment accumulation rate over this period is somewhat doubtful. Whilst this is a perennial problem for palynologists, the unquestioning application of this technique over this period, where a plateau in the dendrochronological calibration curve exists and hence dating ranges are relatively large, complicates the refinement of the vegetation record. Dumayne *et al.*, (1995) acknowledge this inadequacy in their dating scheme from Fozy Moss and have used the presence of a minerogenic inwash layer which occurs concomitant with the decline in arboreal cover as evidence for the building of Hadrian's Wall and not as a result of deforestation *per se*. The palynological record that Dumayne and co-workers present is not in question, however, to suggest that this mineral layer is Roman because it relates to the building of the wall is circular reasoning. The mineral layer almost certainly relates to the deforestation of the area, although its origin within a raised mire system is also questionable, but this deforestation has not been adequately demonstrated to be Roman.

Dumayne *et al.* (1995; p119) also selectively use the archaeological evidence to 'suck the date to that event' citing 'the scarcity of archaeological evidence' (Dumayne and Barber, 1994, p167) from the Neolithic, Bronze Age and Early Iron Age in the area. This paucity of archaeological evidence from the early prehistoric is simply not the case, with multi-period features occurring within just a few kilometres of the site at Fozy Moss. Goatstones four-poster stone circle (Burl, 1971) lies just three kilometres north of

Fozy Moss and dates to the Early Bronze Age. The stones used also contain cup and ring marks, an example of the re-use of decorated rock outcrops from earlier periods that is a frequent phenomenon in stone monuments dating from this time (Higham, 1986). A second stone circle lies just 2 km west of Fozy Moss, dating to the same period, along with a number of Bronze Age cairns on the adjacent King's Crags and also a tumulus immediately to the south of the wall *ca.* 2 km from this site. There is also an example of a pre-Roman boundary which is cut by the ditch associated with the wall, a type of unlikely to be associated with a wholly forested environment (Waddington, pers comm). Another set of pre-Roman earthwork boundaries is known at Sycamore Gap, near Crag Lough (Crow, pers. comm.) that are overlain by the Roman Military Way and which are now buried at their southern end by peat bogs. This indicates division of the landscape for agricultural purposes and thus a cleared environment. Further evidence for agriculture within the corridor of Hadrian's Wall comes from cord rig agriculture that underlies the Roman camp adjacent to Greenlee Lough, this relationship has been established through excavation (Welfare, 1985) although it is difficult to establish the late Iron Age origin of these features. Further afield, to the east of Haltwhistle Burn fortlet more cord rig is overlain by a temporary Roman marching camp, suggesting Iron Age agriculture. Warden hillfort, is also relatively proximal and is a prime example of an Iron Age settlement in the vicinity. This all suggests that pre-Roman archaeology in the area is not as scarce as Dumayne and Barber (1994) highlight and that the Romans were faced with a relatively open landscape that was already being fairly intensively utilised for agricultural purposes. The evidence suggests that the area was, in fact, a place where activity was concentrated given that many examples of earlier prehistoric archaeology are likely to have been destroyed during wall construction due to stone robbing and increased activity in the area associated with the *vici*. Furthermore, if the area was entirely forested then why was the wall built in the location that it now occupies? The defensive benefits of the Whin Sill are obvious, but if the area were covered in dense woodland, the River Tyne itself would have surely afforded more protection from native tribes.

Similar criticisms to the ones voiced here have already been levelled at the conclusions of Dumayne and Barber (1994). Indeed, McCarthy (1995; 1997) has highlighted the pre-Roman archaeology of the area around Carlisle and the Lower Eden valley in the context of palynological results from Glasson Moss, Walton Moss and Bolton Fell Moss, which suggest a similar pattern of forest removal. The conclusions of Dumayne and Barber (1994) are thus, in some ways, symptomatic of the concentration upon Roman archaeology in the region (Higham, 1986, Young, 1994). The pollen evidence Dumayne (1992) and Dumayne and Barber (1994) presents are convincing, and there appears no doubt that major vegetation changes did occur around this time. However, to ascribe the impact purely to invading Roman forces, on the basis of an insecurely established radiocarbon chronology is misleading.

In common with Davies and Turner (1979), Dumayne (1992) has also excluded the pollen of Ericaceous species (including *Calluna*) from the total pollen sum, citing the *in situ* growth of the taxa as the reason for its exclusion. This leads to a percentage over-representation of the tree species, which gives an impression of the landscape being largely forested where it may have consisted of a significant proportion of heathland. Had the Ericaceous species been included in the pollen sum, conclusions drawn about the lack of impact that earlier prehistoric peoples had upon the landscape may have been significantly different, as heath species constitute approximately 20% of the total pollen for much of the pre-Roman period.

7.9.1.3 Vindolanda Ditch Fills

Manning *et al.*, (1997) have utilised two ditch fills at the Roman fort of Vindolanda, close to Hadrian's Wall to attempt to overcome the chronological problems of reconstructing vegetation histories during this period. These ditches have been precisely dated, on the basis of archaeological evidence, to *ca.* AD 85-92 and *ca.* AD 160-180 respectively. Manning *et al.*, (1997) have used pollen evidence to demonstrate that clearance in the vicinity of Vindolanda occurred prior to *ca.* AD 85 and this was likely to have been a native rather than Roman phenomenon. Whilst the conclusions that Manning *et al.*, (1997) present are convincing and appear to be supported by the results of this study, the manner in which they have been derived appears to be flawed. Three key points can be identified.

Firstly, ditch fills of this size are generally expected to receive a predominantly local pollen input (Tauber, 1965; Jacobsen and Bradshaw, 1981; Prentice, 1988), a fact which Manning *et al.* (1997) acknowledge and discuss. They cite the herb pollen present as being agrarian assemblages rather than ones that could be derived from close to buildings. This distinction is vague as many species indicate anthropogenic disturbance and cannot be accurately assigned to such specific land-use categories. Additionally, one would expect that sediments from within an occupation site would contain pollen indicative of clearance and anthropogenic activity. This would most likely be the case even if the ditch fill were receiving pollen from a greater source area. Finally, if the pollen were derived from a greater distance, species such as *Calluna*, indicative of the clearance of which Manning *et al.*, (1997) hypothesise, would be represented in greater quantities within the ditch.

Work by the author (Moores, unpublished; Crow, 1997) on organic ditch fills at High Rochester, Redesdale have revealed very similar pollen assemblages. These samples are characterised by very stable vegetation, with high pollen diversity indicating a combination of pastoral and arable agricultural practice in the vicinity of the fort. Dating, and indeed the resolution of these samples, is not as tightly constrained as the sedimentary sequence at Vindolanda that Manning *et al.*, (1997) present. However, the results indicate a local presence of *Calluna vulgaris*, demonstrating that this species is not exclusively a bog plant. Tree pollen percentages, particularly alder and birch, are fairly consistent with the regional diagrams and it could be interpreted that this is indicative of the small ditch fill being representative of the wider region, *sensu* Manning *et al.* (1997). However, these species are particularly prolific pollen producers (Anderson, 1970) and may simply originate from an isolated local stand of these species of trees.

7.9.2 Interpretation of data presented here

Having outlined the differences in interpretation between the existing pollen diagrams within the region, on the basis of the various ways percentage pollen diagrams can be calculated, it is necessary to appraise the methods used in this study. Of particular relevance to the interpretation, is the inclusion of *Calluna* and undifferentiated Ericaceous species in the total terrestrial pollen sum. As already discussed, the inclusion of these species is based upon the likelihood that they grew in more areas of the landscape than just the bog surface. This pattern is clearly visible today and is particularly prevalent within the Fell Sandstone areas of the region (Lunn, 1976). The fact that many of these species are likely to have been growing *in situ* means that they are undoubtedly over-represented in the pollen diagrams presented here. However, the *in situ* growth of a number of arboreal species within upland mire ecosystems is a common occurrence observable at many sites today. Davies and Turner (1979) cite the development of a birch dominated assemblage from one consisting primarily of alder as a consequence of changing mire surface conditions at Camp Hill Moss, Northumberland. Therefore, to selectively remove species that occupy far wider ecological niches than those present upon the bog surface is likely to lead to confusion. The over-representation of *Calluna* within the diagrams here is thus acknowledged, with the view that seeing the genuine vegetation pattern behind a single curve is far easier than attempting it for all arboreal species. Evans and Moore (1985) have examined the representation of *Calluna vulgaris* in modern surface samples, concluding that in areas where insect activity is minimal the plant produces far more pollen which is subsequently dispersed by the wind, meaning that *Calluna* pollen can be found far from its original source.

7.10 Major Forest Clearance: an Iron Age / Romano-British phenomenon?

The palynological records from the upland sites presented here can add little to the debate of the relative impact of the Romans versus the pre-existing native Iron Age communities. This is because they have not been counted to specifically elucidate the period in question, they too suffer from an inadequate number of radiocarbon assays and the dates that are present suffer the same calibration problems. However, the diagrams do, as already discussed, provide a different perspective upon the vegetation history of the North Tyne basin. They suggest that deforestation of the uplands began far earlier than the Iron Age or Romano-British periods and that it was a progressive, as opposed to rapid process.

In the diagrams from Bloody Moss and Drowning Flow the principle factor consistent with the hypothesis of forest clearance during this period is the onset of the decline in Coryloid type percentages. This species, which probably occupied the more marginal areas, may well have been cleared in response to increasing demand for pastoral agriculture to feed an expanding population and later the garrisons occupying the frontier zone around Hadrian's Wall. Indeed, the association with declining Coryloid type percentages and the increase in levels of grasses is notable and suggestive of manipulation of the landscape for grazing purposes. At Drowning Flow there is a marked rise in the level of *Plantago lanceolata* pollen from a date of *ca.* AD 45-245, which supports this hypothesis of grazing within the uplands during the Roman period. Alder pollen levels do also decrease, however, this is impossible to confidently ascribe to Roman influence and part of a much longer term downward trend in the relative coverage of these species.

The site at Sells Burn is just two kilometres to the northwest of Dumayne's (1992) site of Fozy Moss and demonstrates many of the same patterns of vegetation disturbance. At a depth of *ca.* 150 cm, likely to equate to either the Iron Age or Romano-British period, there is a marked decline in arboreal taxa. It could be postulated that this represents Roman impact upon the vegetation, but it should be noted that this sudden decline forms part of a much longer-term trend of forest removal. The clearance is associated with an increase in percentages of *Calluna*, this may partially reflect local *in situ* vegetation fluctuations. Grasses also increase but due to the vagaries of percentage calculations never attain the levels found by Dumayne and Barber (1994). The results from Sells Burn indicate that an increase in the rate of forest destruction did occur in the late first millennium BC or early first millennium AD. However, the invading Roman troops did not invade into an area that was bereft of indigenous Iron Age communities and nor did they encounter an almost entirely forested landscape. Evidence of clearance was present in the area for many millennia prior to the Roman invasion and is witnessed within both the archaeological and palaeoecological records from the region.

It should be noted that the Roman period did not appear to bring about any increase in the quantities of cereal pollen grains recorded within the upland cores. Indeed, the site at Sells Burn, which is the most proximal to the main area of Roman activity in the region, does not demonstrate any conclusive proof of cereal cultivation in the vicinity until after the Roman withdrawal. This suggests that Roman arable agriculture was no more extensive than that of the preceding indigenous Iron Age people. There is no doubt that cereal cultivation close to extant Roman structures was occurring, as witnessed by the presence of *Hordeum* pollen within the ditch fill at High Rochester. (Crow, 1997) However, this site is relative proximal to the valley floors and lower valley sides which would have been both more conducive to crop growth and easier to manage, given the volatile nature of the frontier zone.

7.11 Post-Roman Vegetation record

As debates surrounding the relative impact of the Romans upon the vegetation of the region, so too the effect on the landscape following the withdrawal of troops has attracted much attention (Finberg, 1972). Dumayne and Barber (1994) have found that at Fozy Moss and Glasson Moss, woodland regeneration occurred, although this is limited to elements of scrub vegetation, principally Coryloid type. They postulate that the local economic and political structures of the area collapsed and that settlement in the frontier zone was abandoned. Conversely, Turner (1979) has found, through palynological methods, that agricultural practices continued until at least the sixth century. This has been assumed to represent a measure of political and economic stability after the Romans withdrew from northern Britain and a continuation of the same forms of farming techniques. Indeed, of the sites that Dumayne and Barber (1994) have analysed, Bolton Fell Moss and Walton Moss do not show this woodland regeneration. Consequently, it can be seen that there are marked regional differences in the recovery of woodland in the Hadrianic frontier zone following Roman withdrawal.

The results presented here support this spatially variable hypothesis. Both Drowning Flow and Bloody Moss which are several kilometres north of the corridor of Hadrian's Wall do not show any forest regeneration in periods subsequent to those likely to represent Roman levels. However, these same diagrams never significantly registered Roman influence upon the landscape in the first instance and thus non-response to their departure is unsurprising. It is likely that these areas were covered by extensive heathland vegetation with some hazel scrub, the poor nature of the podsolised soils upon the sandstone uplands unsuited to the re-establishment of trees. Bloody Moss registers a small drop in levels of grasses during this period, although the dating resolution is insufficient to ascribe this event confidently to the Roman withdrawal. The proximity of this site to the arterial route of Dere Street, the major road running north-south connecting York and Edinburgh, along with the major outpost fort at High Rochester and several camps, such as at Bellshiel, Birdhope and Silloans (Charlton, 1996) indicates the presence of the Romans in Redesdale. However, occupation of High Rochester fort in the later 4th Century has been postulated on the basis of pottery finds dating to this period (Crow, 1997). This contradicts previous evidence from High Rochester, as many archaeologists believe that wholesale abandonment occurred with the departure of the Romans (Casey and Savage, 1980). However, any occupation of the fort during this period was likely to have been significantly less than during the Roman presence in the region and thus a decline in agricultural practices appear likely.

The site at Sells Burn, does register a small-scale and relatively short-lived phase of woodland expansion in what is presumably the period following Roman occupation. Coryloid type is the principal species that increases its coverage, although both *Betula* and *Alnus* also show small increases. This occurs at the expense of *Calluna* heathland, suggesting a revegetation of the better soils around Sells Burn. The fact that *Calluna* levels fall so sharply adds credence to the suggestion that this species occupied a far wider range of habitat than simply the bog surface itself. Admittedly arboreal taxa produce vast quantities of pollen, but this would not be expected to register so dramatically if the *in situ Calluna* were 'filtering' the signal.

One of the most striking features of the pollen diagrams from the valley floor palaeochannel infills at Brownchesters is the presence of a prominent peak in the presence of *Avena-Triticum* at a date of pre-*ca.* AD 685. The low pollen productivity (Anderson, 1970) and poor dispersal capabilities of this group of cereal crops has been the topic of much discussion with respect to discerning early prehistoric agriculture. Therefore, this abnormally high presence demonstrates the cultivation of oats / wheat at a large scale within the immediate valley floor. It is also likely to represent a marked shift away from previous regimes of subsistence strategy towards a more intensive form of agricultural production. Indeed, terrace surfaces adjacent to this and other palaeochannels contain evidence of broad rig agriculture which may be contemporaneous to the sedimentary infill. The association between this archaeology and the pollen record is by no means assured, as these features are notoriously difficult to date.

Further pollen records from the valley floor sites are limited to the single diagram from Snabdaugh. Resolution, both in terms of pollen counting frequency and sediment accumulation rate at this time is poor. However, a decrease in the numbers of anthropogenic indicator taxa from approximately the Late Bronze Age continues throughout the Roman and Post-Roman period. This is associated with minimal levels of tree taxa, with the exception of those that are likely to have been growing *in situ*, namely *Alnus* and *Salix*.

The interpretation of pollen records from this time must also consider changing climate patterns within the British Isles. Abandonment of agriculture within upland Britain may not have been driven by purely cultural forces and may have had a physical origin. Blackford and Chambers (1991) have found a shift towards a wetter climate, indicated by blanket mire stratigraphic records, dating to *ca.* 600 AD. It may be this pattern which has forced the shift and concentration of agriculture within suitable areas of valley floor.

Archaeology from this period is limited due to a paucity of diagnostic artefactual evidence (Charlton, 1996) and has resulted in records from this time being heavily dependent upon documentary sources for which interpretation is frequently difficult (Higham, 1986). A series of plagues are documented to have spread following Roman withdrawal, with outbreaks occurring in the mid-sixth and the late seventh / early eighth centuries (Higham, 1986). Evidence for habitation is minimal throughout this period in much of Northumberland, with the exception of Edwin's Palace at Gefrin (Yeavering) or the Grubenhausen (huts with sunken floors) in the Till valley (Charlton, 1996). Undoubtedly, this is once again most likely a consequence of a lack of survey and a concentration upon Roman archaeology within the region (Young, 1994). It is likely that many Romano-British settlements continued in existence long after withdrawal and Charlton (1996) highlights that only excavation can resolve this apparent archaeological hiatus.

7.12 Early Anglian, Viking and Scandinavian Settlement in the North Tyne Basin

Documentary sources suggest that these were turbulent times in the history of Northumberland and palynological analyses can do little to elucidate the economic and social processes at this time. Small fluctuations in the intensity of anthropogenic impact by this time become increasingly difficult to distinguish within the regional pollen record. The following discussion is thus somewhat speculative, particularly where archaeological records are scarce and reliance is placed largely upon documentary evidence.

Bloody Moss demonstrates a renewed increase in the levels of grasses at a date immediately prior to *ca.* AD 575-990. This is concomitant with an increase in cereal type pollen, which for the first time achieves a sustained, although small, presence throughout the remainder of the core. Sells Burn demonstrates a very similar pattern at approximately the same date, with a peak in Poaceae pollen and the first signs of any cereal cultivation from this site. This may represent the cessation of the area as a military zone and the establishment of more extensive farming practice in the vicinity. Any evidence of cereal cultivation at Drowning Flow ceases subsequent to the Roman period and cereal type pollen is not registered again within this profile.

Valley floor sediments from this period are limited to infills from two contemporaneous channels at Brownchesters and the uppermost levels of the diagram from Snabdaugh Farm. The Brownchesters channels have been correlated on the basis of their morphology, relative height, sedimentary sequence and radiocarbon dating. One of the channels has not had palynological analyses carried out upon it due to time constraints; it is likely that this channel would also show the same general pattern of species. The analysed channel shows a fairly constant level of anthropogenic activity within the valley floor areas throughout the period to approximately AD 1250. Percentages of arboreal taxa are fairly constant along with levels of Poaceae, anthropogenic indicator species and indeed cereals within the period dated *ca.* AD 665-1285. At Snabdaugh, levels of anthropogenic indicator species and cultivated taxa appear to progressively rise through this period, following a reduction in percentages in immediate post-Roman times. This, however, is partially a consequence of the ontogeny of the palaeochannel system, as alder levels peak as the immediate environs become slightly drier. This has had a masking effect upon the levels attained by all other species within the diagram and thus this apparent reduction in anthropogenic activity may not be a genuine decline.

It is difficult from this to build an accurate picture of the nature of the vegetation, but it would appear that agriculture continued to be concentrated in the lower altitude areas of the North Tyne basin. Anthropogenic interference with the natural vegetation seems to have remained at similar levels throughout this period with there being no indication that forest regeneration occurred either in upland or lowland areas. The resolution of the diagrams is possibly insufficient to register small, temporary changes that may have occurred as a result of the changing fortunes of the Northumbrian kings and Viking and Scandinavian settlers during this period, as summarised by Higham (1986).

7.13 Mediaeval and later vegetation history

Vegetation patterns within the North Tyne basin from this period are limited to results from upland pollen sites as no palaeochannel fills have been dated to this time. These suggest a continuation of earlier practices, with the uplands utilised primarily for grazing purposes and some limited arable agriculture presumably focused in valley floor and valley side areas. Documentary and archaeological records from North Tynedale also suggest that by 1300 AD much of the upper part of the valley had been developed for farming purposes (Charlton, 1987), with a similar pattern of exploitation envisaged for Redesdale.

Further archaeological evidence for this pattern of agriculture comes from the presence of shielings, which are widely distributed throughout North Tynedale and Redesdale. These temporary settlements housed herdsmen, whilst they were tending flocks in the upland summer pastures of the region. This suggests a similar agricultural scheme as proposed for the preceding post-Roman periods, where the uplands were utilised as seasonal pasture and the valley floors and lower valley sides were the location for crop husbandry.

Settlement evidence during this period consists of numerous stone-built castles, such as at Otterburn, Elsdon, Troughend and Hesleyside (Charlton, 1987). There was thus a fairly high level of population within the area, concentrated upon the valley floors and lower valley sides. The evidence of cereal cultivation found at Brownchesters may thus relate directly to the occupation of Troughend and Otterburn castles, whose residents no doubt exercised considerable power over Redesdale.

Later, in mid 16th Century Tynedale and Redesdale, fortified farmhouses (known as bastles) were built in response to the activities of the Border Reivers (Charlton, 1987). These legendary people were lawless groups who would raid and pillage property and livestock either side of the Scottish border. Due to a collapse of local administration, local populations became vigilantes in the fight against criminals and anarchy reigned, with individuals responsible for meting out justice. This regime lasted for many years and resulted in the defensive nature of these individual settlements. Many of these are still standing, such as at Hole near Bellingham, Black Middings near Shipley Shiels and two at Gatehouse (Charlton, 1987) and were once widely distributed in the upper North Tyne and Rede valleys.

In common with results from elsewhere in northern Britain, the upland sites presented here all demonstrate a marked decline in *Corylus* percentages at the top of the pollen sequence. This phenomenon has been dated to commence at *ca.* 1700 AD elsewhere in the region with an almost complete removal by *ca.* 1800 AD (Barber, pers. comm.). Here, interpolated dates from Sells Burn and Drowning Flow can be considered roughly parallel to this chronology, but the decline at Bloody Moss begins much earlier at *ca.* 1200 AD. The reasons for the virtual disappearance of this species from the uplands of the region are not known, but may be related to climatic factors such as the Little Ice Age or intensified land-use within the uplands.

7.14 Summary

The palynological analyses from a variety of sedimentary contexts within the North Tyne basin, representing vegetation records over a range of spatial scales have provided new insights into the Holocene landscape dynamics of this area. The upland diagrams have provided regional vegetation records that have previously been absent for this area and have demonstrated patterns of land utilisation and human activity that contrast with previously published studies. The pollen diagrams derived from palaeochannel contexts have provided additional detail of local scale and potentially important valley floor environments over both over extended Holocene periods and also at relatively high chronological resolutions. They have highlighted the preferential use of lowland floodplain environments by generations of societies, but have in particular emphasised human activity during the Late Mesolithic and Early Neolithic periods.

Chapter 8

Conclusions and recommendations for future research

8.1 Conclusions

Holocene land-use and vegetation landscapes in the North Tyne basin revealed by this study have been shown to contrast with previously published palynological results from the region. The combination of pollen diagrams from upland sites, which reflect predominantly regional-scale vegetation patterns, and alluvial valley floor sites with a mainly local pollen source, has facilitated detailed analyses of environmental changes and the assessment of a wider range of temporal and spatial scales than has hitherto been possible within North Tynedale, Redesdale and northern England. This combination of scales has also allowed the integration of Holocene vegetation patterns with archaeological evidence from the region, providing both the environmental context of former human cultures and an off-site perspective upon questions posed by the existing archaeological record of the area.

Local-scale palynological records have been obtained from a series of organic-rich, relatively rapidly accumulating palaeochannel fills within an alluvial basin of the River Rede and an individual channel in North Tynedale. These newly identified sedimentary resources offer opportunities for providing little exploited records of valley floor environments within upland northern Britain. Therefore, these environments are likely to prove as valuable as those in southern Britain, in terms of reconstructing patterns of Holocene vegetation. These local-scale off-site palaeoecological records represent the most effective means of evaluating former valley floor land-use and human activity and offer considerable potential for future research. Despite concerns, it has been demonstrated that coherent (*cf.* Brown, 1996) pollen records can be produced from this type of sedimentary environment and that the benefits of this approach for future palynological studies outweigh problems of pollen taphonomy which are not fully understood.

8.1.1 Early anthropogenic impact upon the landscape of the North Tyne basin

Existing palynological studies have recorded minimal anthropogenic vegetation disturbance in northern England pre-*ca.* 2500 BC, whereas the sites analysed here in the North Tyne basin, indicate interference began much earlier. It is believed that this is principally a function of site selection and the scale at which the vegetation record has been reconstructed, as opposed to the North Tyne basin having a unique landscape history. Upland sites reflecting regional vegetation demonstrate progressive woodland removal and replacement by heath from the Late Mesolithic onwards. Local-scale palynological analyses, meanwhile, have revealed convincing evidence of anthropogenic activity, particularly in low-lying valley floor areas, also since the Late Mesolithic period. This includes evidence of cereal cultivation upon drier alluvial terraces at a date of *ca.* 4000BC and which continues throughout the Neolithic period. This onset of arable agricultural practices is much earlier than regional diagrams have suggested and emphasises the importance of local-scale analyses for discerning small, temporary periods of human activity. These palynological results support recent archaeological evidence that is emerging from the region, particularly in north Northumberland, which suggests that the impact of human activity in the Late

Mesolithic / Early Neolithic period has been underestimated. Both the palynological work and archaeological evidence from the region support findings from elsewhere in Europe which indicate that openings within forested floodplain environments may have provided foci for the earliest farmers (van Andel and Runnels, 1995). The palynological results also suggest that systematic, carefully targeted geoarchaeological survey of the North Tyne basin may yield further corroborating evidence of the presence former human societies and their activities.

8.1.2 Bronze Age settlement patterns

Although to an extent archaeological evidence has already challenged hypotheses of shifts in upland-lowland settlement patterns during the Bronze Age in northern England (Gates, 1983; Young and Simmonds, 1995), palynological results presented here add weight to arguments against these altitudunal migrations. Upland pollen records dating to this period show a continuation of patterns of heathland expansion throughout the North Tyne basin, without the major alterations in vegetation composition that might be expected if there were movements of people to and from the area. Additionally, lowland diagrams suggest an intensification of valley floor human activity during the period when abandonment was supposed to have occurred. The postulated alterations in settlement location are thus believed to be a function of a fragmentary and frequently poorly dated archaeological record in the region.

8.1.3 Roman impact upon the landscape of the North Tyne basin

The impact of the Romans upon regional vegetation is a topic that has been the focus for considerable debate (Dumayne, 1992, 1993a, 1993b; Dumayne and Barber, 1994;

Manning *et al.*, 1997; McCarthy, 1995). This study has demonstrated that forest clearance was a phenomenon that had its origins far earlier than the Iron Age or Romano-British period. Although the Romans inevitably had an impact upon the environment of the region, it would appear that they certainly did not encounter an entirely forested landscape and had only the effect of expanding the range of clearance. It is postulated, from upland pollen evidence, that this was undertaken to increase the range of grazing land. Pollen evidence from Sells Burn, which is the most proximal site to the Hadrian's Wall corridor, in contrast to results from Fozy Moss (Dumayne, 1992, 1993a, 1993b) demonstrates no presence of cereal cultivation until after Roman withdrawal. Comparison of these results with published accounts in relatively close proximity, demonstrating how pollen records that represent different spatial scales may contain contradictory evidence of vegetation histories.

8.1.4 Post-Roman vegetation dynamics

Post-Roman vegetation records presented here are in accordance with previously published work which have suggested a spatially variable pattern of vegetation following Roman withdrawal. At Sells Burn limited and short-lived woodland regeneration does occur, whilst at other sites forest remains largely cleared. Later human activity within the North Tyne basin appears to remain focused upon the areas of valley floor. For instance, palynological records from palaeochannel sediments dating to the Dark Ages show large peaks in cereal cultivation that are consistent with fairly intensive agricultural practices. This suggests that wholesale abandonment of the region did not occur following the end of Roman rule and indicates native settlement remained relatively stable for several centuries.

8.1.5 Summary

This study has contributed to filling spatial and temporal gaps in the existing knowledge of Holocene landscape evolution and vegetation dynamics. Whilst, this has been by no means exhaustive, data presented here has helped to address a number of pertinent archaeological issues. Many of these issues have to some extent been overlooked in published palynological records from the region, due principally to an overt spatial and temporal focus upon the Roman period. This study has demonstrated that palynological evidence exists for early human activity within the North Tyne basin, and, in some respects has placed the onus upon archaeologists to conduct landscape scale surveys of the nature of that carried out by Waddington (1998) in the Milfield basin. However, geoarchaeological methods may also prove instrumental in discerning human activity due to the complications of post-depositional alterations of archaeological assemblages, particularly within valley floor environments. With the continued refinement of this multi-disciplinary approach to the reconstruction of former landscapes, the post-glacial history of the North Tyne basin may be better understood and appreciated.

8.2 Future Research

This study has utilised the potential of organic-rich palaeochannel sediments to yield high-resolution, locally detailed palynological records. The importance of these results in terms of their application and contribution towards providing relevant contextual environmental information for archaeological evidence has been demonstrated. Further, prospection of likely alluvial environments is necessary to extend existing knowledge of valley floor environments into areas where palynological records of this scale do not exist. Using these techniques it may be possible to identify individual areas, which have an absence of local archaeology, but for which the pollen record provides indications of past human activity.

These environments have also indicated that, due to the interdigitating of peat and coarse minerogenic sediment, records of Holocene flooding may also be discernible and more importantly dateable. Early indications suggest that these periods of flooding can be linked to documented alterations in global climate and also possibly to local anthropogenic interference with the vegetation. Multiple core studies using recently developed Stitz coring methods and an increased programme of radiocarbon dating may also facilitate the reconstruction of the frequency and magnitude of flood events. Results to date, however, have already prompted a re-examination of models concerning the timing and controls over periods of Holocene alluviation. Previous studies have suggested that the early-mid Holocene was a period of stability within upland Britain, with no documented episodes of cut-off or alluviation. Results presented here counter these conclusions, suggesting that at *ca.* 7500 BC and *ca.* 5000 BC two periods of enhanced fluvial activity occurred.

Additional analysis of the technique for classifying deteriorated pollen grains may also be a valuable future avenue for research. Once again new coring techniques may aid these studies, as sub-sampling can be undertaken at sub-cm resolution under laboratory conditions. This will allow samples to be taken from a range of sediments derived from different palaeochannel conditions. Modern fluvial samples of water-borne pollen, during a range of river stages, may also provide additional information upon the technique of analysing deterioration states.

Many opportunities can, therefore, be seen to exist. Some of this work is already underway, with work upon flood histories at Brownchesters and other regional sites the subject of an ongoing PhD study in the Geography Department at Newcastle University. The extension of the application of palynological tools to other regional contexts is also beginning with funds being sought for work upon palaeochannel sequences at Thirlings and other areas of the Milfield basin. It is hoped that this PhD will facilitate further analyses of these environments in a regional sense and has flagged avenues that might be most beneficially explored within a wider British context.

Chapter 9

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Appendix 10.1: Details of radiocarbon dating assays for upland sites in this study

Core Ref.	Depth	Lab Ref. (Beta)	Beta Code	Date and S.D. (1 sigma)	Calibrated Date 95%	Midpoint	Material
BM1	221-228	94632	BM1a	1290 + / - 110 BP	AD 575 - 990	AD 705	Peat
BM1	421-428	94633	BM1b	2900 + / - 70 BP	BC 1285 - 900	BC 1045	Peat
BM1	590-595	90754	BM1	4930 + / - 80 BP	BC 3940 -3845,BC 3830 - 3620, BC 3575 - 3535	BC 3700	Peat
DF2	181-188	94634	DF2a	1880 + / - 50 BP	AD 45- 245	AD 130	Peat
DF2	305-312	94635	DF2b	2880 + / - 70 BP	BC 1265 - 855	BC 1020	Peat
DF2	513-520	94636	DF2c	3940 + / - 70 BP	BC 2590 - 2205	BC 2460	Peat
DF2	721-728	94637	DF2d	6030 + / - 70 BP	BC 5050 - 4805	BC 4925	Peat
SB1	213-220	94638	SB1a	2800 + / - 50 BP	BC 1045 - 825	BC 925	Peat
SB1	313-320	94639	SB1b	3490 + / - 70 BP	BC 1965 - 1630	BC 1765	Peat
SB1	449-456	94640	SB1c	5180 + / - 60 BP	BC 4090 - 3925, BC 3875 - 3810	BC 3975	Peat

Appendix 10.2: Details of radiocarbon dating assays for valley floor sites in this study

Terrace	Depth	Lab Ref. (Beta)	Beta Code	Core Ref.	Date and S.D. (1 sigma)	Calibrated Date 95%	Midpoint	Material
T3	146-156	119823	BCb	BC 5	8960 + / - 90 BP	BC 8100 - 7900	BC 8005	Peat
T3	242-250	96126	BC5a	BC 5	8510 + / - 70 BP	BC 7595 - 7445	BC 7525	Wood
T4	224-241	96127	BC6a	BC 6	6110 + / - 80 BP	BC 5240 - 4825	BC 5030	Wood
T4	80-95	119824	BC d	BC 6	4310 + / - 60 BP	BC 3045 - 2870, BC 2795-2770	BC 2905	Peat
T5	140-142	96124	BC4a	BC 4	3900 + / - 70 BP	BC 2570 - 2145	BC 2400	Wood
T5	340-350	96125	BC4b	BC 4	5110 + / - 80 BP	BC 4055 - 3715	BC 3950	Wood
T6	158-166	96122	BC2a	BC 2	3410 + / - 80 BP	BC 1890 - 1520	BC 1690	Wood
T6	337-340	96123	BC2b	BC 2	3910 + / - 80 BP	BC 2585 - 2140	BC 2440	Wood
T7	Base	80068	Brownc 1	Bank Section	2350 + / - 60 BP	BC 200-800	BC 395	Wood
T8	75-90	119822	BCa	BC 3	1320 + / - 60 BP	AD 635 - 865	AD 685	Peat
T9a	50-56	96121	BC1a	BC 1	730 + / - 60 BP	AD 1215 - 1325, AD 1340 - 1390	AD 1285	Peat
T9b	130-135	90753	BC3	BCC3(2b)	650 + / - 80 BP	AD 1245 - 1430	AD 1305	Wood
T9b	210-220	90752	BC2	BCC3(2b)	1370 + / - 60 BP	AD 600 - 780	AD 665	Peat
T?	145	111013	OTT 5	Tom	3320 + - 70 BP	BC 1750 - 1430	BC 1605	Peat
T?	185	111012	OTT 4	Tom	2820 + / - 80 BP	BC 1200 - 815	BC 940	Peat

Appendix 10.3: Troels-Smith sediment log for Drowning Flow

Depth	Nig	Mun	Strf	Elas	Sicc	Humo	Composition
0-12	3	10R 1.7/1	0	1	2	1	Sh2, Tb1, Th1
12-31	2	2.5R 2/2	0	2	2	0	Dh2, Th1, Tb1, Sh+
31-58	2	2.5YR 3/4	0	2	2	1	Tb3, Th1
58-65	2	2.5YR 3/4	0	2	2	1	Tb2, Th2
65-88	2	2.5YR 3/4	0	2	2	1	Tb3, Th1
88-98	2	2.5YR 3/4	0	2	2	1	Th2, Th2
98-122	2	2.5YR 3/4	0	2	2	1	Tb3, Th1
122-145	3	7.5R 2/1	0	3	2	2	Tb3, Th1, Sh+
145-176	2	2.5YR 3/4	0	3	2	2	Tb3, Th1
176-190	3	7.5R 2/1	0	3	3	3	Sh2, Tb1, Th1
190-247	2	2.5YR 3/4	0	3	3	2	Sh1, Tb1, Th2
247-254	2	2.5YR 3/4	0	3	3	2	Sh1, Tb2, Th1
254-271	2	2.5YR 3/4	0	3	3	2	Sh1, Tb1, Th2
271-298	3	7.5R 2/2	0	2	3	2	Sh1, Tb2, Th1
298-370	2	2.5YR 2/2	0	2	2	3	Sh2, Tb2, Th+
370-380	2	2.5YR 2/2	0	2	2	2	Sh1, Tb1, Th2
380-402	2	5YR 2/3	0	2	2	3	Sh2, Tb2
402-420	2	5YR 2/3	0	2	2	2	Tb2, Sh1, Th1
420-435	2	7.5YR 2/1	0	3	3	2	Tb3, Th1
435-448	3	7.5YR 2/1	0	2	3	3	Sh2, Th2
448-472	3	5YR 3/2	0	2	2	2	Sh1, Tb1, Th2
472-479	2	5YR 3/3	0	3	2	2	Sh1, Th3
479-498	2	2.5YR 2/2	0	2	3	2	Sh1, Th2, Tb1
498-510	3	5YR 1.7/1	0	2	2	2	Sh2, Th2, Tb+
510-576	2	5YR 3/6	0	3	2	2	Tb2, Th1, Tl1
576-601	2	5YR 3/6	0	3	3	2	Th3, Tb1
601-625	2	5YR 3/6	0	3	2	2	Tb2, Th1, Tl1
625-630	2	5YR 3/6	0	3	2	2	Tb2, Th2, Tl+
630-653	2	2.5YR 2/3	0	2	3	2	Tb2, Th2
653-694	2	2.5YR 2/3	0	2	3	2	Tb2, Th1, Tl1
694-712	3	2.5YR 3/3	0	2	2	2	Tb3, Th1
712-720	2	5YR 3/4	0	1	2	2	Th2, Tb1, Sh1, Ag+
720-732	4	5YR 1.7/1	0	1	2	2	Sh2, Ag1, Tb1, Th+
732-736	2	5YR 4/6	0	1	2	1	Sh2, Ag1, As1

Appendix 10.4: Troels-Smith sediment log for Bloody Moss

Depth	Nig	Mun	Strf	Elas	Sicc	Humo	Composition
0-8	2	5YR 3/6	0	3	1	0	Tb4
8-20	3	2.5YR 2/1	0	2	2	1	Sh2, Th2
20-29	2	5YR 3/6	0	3	2	1	Tb3, Th1
29-37	3	2.5YR 2/1	0	2	2	1	Sh2, Th2
37-46	2	5YR 3/6	0	3	2	1	Tb3, Th1
46-68	Unrecovered						
68-75	3	2.5YR 2/1	0	2	2	1	Sh1, Th1, Tb2
75-89	2	10YR 3/4	0	3	2	0	Tb3, Th1
89-100	Unrecovered						
100-263	3	7.5YR 2/1	0	2	2	1	Sh2, Th2
263-300	3	7.5YR 2/1	0	2	2	2	Sh3, Th1
300-318	3	7.5YR 2/1	0	2	2	3	Sh4, Th+
318-364	3	7.5YR 2/1	0	2	2	2	Sh2, Th2
364-508	3	7.5YR 2/1	0	2	2	2	Sh3, Th1
508-564	3	7.5YR 2/1	0	2	2	2	Sh3, Tl1, Th+
564-644	3	7.5YR 2/1	0	2	2	2	Sh2, Th2, Tl+

Appendix 10.5: Troels-Smith sediment log for Sells Burn

Depth	Nig	Mun	Strf	Elas	Sicc	Humo	Composition
0-6	1	2.5Y 6/8	0	3	2	0	Tb4
6-22	2	7.5YR 4/4	0	2	2	1	Tb2, Th2
22-38	3	7.5YR 2/2	0	3	2	1	Tb1, Th3
38-54	3	2.5YR 2/2	0	3	2	2	Th3, Sh1
54-123	3	2.5YR 2/1	0	3	2	2	Th3, Sh1
123-154	3	2.5YR 1.7/1	0	3	2	2	Th2, Sh2
154-200	3	2.5YR 2/1	0	3	2	2	Th3, Sh1
200-448	3	2.5YR 1.7/1	0	3	2	2	Th2, Sh2
448-453	2	7.5YR 4/4	0	1	1	1	Sh2, Dl2, Ga+, Ag+
453-488	1	7.5YR 4/6	0	1	0	1	Ga1, As1, Ag1, Dl1

Appendix 10.6: Sediment Logs for Brownchesters

Underlining convention – solid underlining is a distinct transition to lower unit, dashed underlining represents gradual transition to lower unit.

Brownchesters 1 (Terrace T9a)

0-22	Compression
22-30	alluvial topsoil
30-43	brown sandy silty clay, frequent oxidised organic flecks
43-54	dark brown clayey silty peat
54-57	dark brown silty peat
57-69	dark brown/ black peat with frequent reed fragments
69-74	dark brown clayey silty peat, frequent reed fragments
74-77	grey clayey silt, well-humified organics
77-83	dark brown peat with frequent reed fragments
83-110	dark grey fine sandy clayey silt, occasional fine sand laminae and organic flecks
110-120	grey silty fine sand, laminated
120-122	grey medium sand
122-200	well laminated brown peaty clayey silts / grey fine sandy clayey silt / fine- medium sands (latter distinct between 122-124, 148-150, 153-154, 160, 173-176, 183, 191-193)
200-216	lost

216-262	grey laminated clayey fine sandy silt, frequent thin oxidised fine sand laminae, frequent organics
262-287	finely laminated grey clayey silt (1-2mm parings) / fine sandy silts, frequent organics and leaf remains
287-290	grey medium sand
290-310	as 262-287
310+	gravelly coarse sands

Brownchesters 2 (Terrace T6)

0-22	compression
22-52	alluvial topsoil (grey / brown, oxidised mottling)
52-62	light brown /grey homogenous clayey silt
62-82	dark grey slightly clayey silt, occasional fine sand laminae and organic fragments towards base
82-85	peaty silty clay
85-94	light grey (50-50) silty clay, occasional fine sand and organic flecks
94-100	light brown / grey silty clay, some organics
100-110	lost
110-130	grey clayey silt, occasional fine sandy silt laminae, frequent oxidised organic flecks
130-146	grey fine sandy clayey silt, frequent organic flecks
146-158	dark brown / grey peaty silt, frequent wood inclusions
158-166	wood
166-177	light brown peaty silt, frequent wood
177-190	brown silty peat
190-200	lost
200-206	dark reedy peat
206-268	silty peat, frequent wood 200-230
268-271	coarsening upwards light grey slightly silty medium sand, at base silty fine sand, upper and lower boundaries of unit very well delimited
271-282	silty peat
282-286	wood
286-300	lost
300-325	brown / grey fine sandy clayey silt, slightly peaty with frequent organics towards base - fine laminae
325-334	fine sandy clayey silt, occasional organics but decreasing down unit
334-340	fine gravelly sand, large wood at 337-340

Brownchesters 3 (Terrace T8)

0-22	compression
22-51	topsoil
51-63	light grey slightly sandy clayey silt, oxidised brown mottling
63-79	peaty clayey silt, less peaty towards base of unit
79-87	lost
87-100	light grey peaty clayey silt - as 63-79
100-111	light brown silty peat
111-130	light brown silty peat, very dense 'leaf stalks?'
130-132	light grey fine peaty sandy silt (flood?)
132-136	as 111-130
136-159	light brown peaty silt, some fine sand and 'leaf stalks'
159-182	light brown / grey peaty clayey silt
182-206	brown peaty slightly clayey silt
206-220	silty peat, becoming more minerogenic towards base of unit
220-239	homogenous peaty clayey silt, bulk sample taken 220-235
239-250	fine 2mm laminae of fine sandy silt and peaty clayey silt
250-278	fine sandy silts with occasional organic flecks, frequent medium /
coarse	sand laminations 2-3mm thick
278-300	fine sandy gravel

Brownchesters 4 (Terrace T5)

0-16	compression
16-38	topsoil brown / grey oxidised
38-47	grey fine sandy silty clay, lots of organics
47-55	dark grey fine sandy slightly clayey silt, some organics
55-66	same as 38-47, more organic
66-81	peaty slightly fine sandy silt, peatier towards base of unit, occasional minerogenic horizons - mainly fine silt / sand, well defined at 69-70
81-84	fine sandy silt, some organic content, flood?
84-100	dark brown silty peat, occasional fine sandy silt laminae
100-107	contamination
107-127	dark brown silty peat, as 84-100
127-134	brown homogenous silty peat
134-150	light grey clayey silty / fine sand (50-50). Wood fragments throughout
150-154	finely laminated silty sands and peaty silts, organics throughout, light grey / brown laminations
154-159	brown peaty silt, occasional very fine sand laminations
159-166	laminated light grey fine silty sands and peaty silt
166-179	brown silty peat, becoming laminated towards base with light grey silty sands
179-185	wood
185-190	brown silty peat
190-200	wood and silty peat
200-214	lost
214-226	slightly silty peat, frequent wood inclusions
226-252	dark brown woody peat, occasional thin laminae of fine sandy silt
252-278	alternating bands of light grey sandy silt and silty sand with some wood and organics (at 52-54, 56-58,60-61, 68-70, 71-73, 75-77) with laminae of peaty silt
278-288	wood
288-300	dark brown peat, abundant wood
300-310	lost

310-324	dark brown / grey fine sandy silty peat, occasional fine sand laminations, frequent wood
324-340	brown silty peat, frequent wood, occasional fine sandy silty laminae
340-342	light grey fine silty sand
342-360	brown peaty silt, fine sandy silt laminae throughout, more minerogenic towards base of unit, frequent wood
360-363	fine laminations of fine grey sands and sandy silts, occasional organic flecks
363-369	light grey / brown fine sandy peaty silt, some laminations
369-388	brown fine sandy silty peat, frequent laminations of fine silty sand
388-389	light grey fine silty sand
389-400	fine sandy silty peat / peaty silt
400-406	lost
406-415	brown peaty fine sandy silt, occasional silty sand laminae
415-418	brown peaty fine sandy silt, wood fragments
418-450	brown / light grey fine silty sand, occasional fine / medium sand laminations, occasional wood fragments, slightly peaty 425-428
450-500	sandy gravel with wood fragments

Brownchesters 5 (Terrace T3)

0-23	compression
23-51	topsoil
51-52	dark clayey silt, black colorations, possibly charcoal from burning
52-79	brown / grey silty clay, frequent oxidised flecks associated with root penetration, occasional organics
79-96	brown / grey silty clay, some fine sand, increase in organics
96-100	lost
100-109	as 79-96
109-115	grey clayey fine sandy silt
115-120	grades back into brown / grey colour as 100-109, 79-96
120-129	grades back to 109-115, wood at 122-124
129-137	fine sandy silty peat, increasingly minerogenic to base of unit
137-164	grey fine sandy clayey silt, some organics
164-182	light brown peaty silt, some fine sand
182-200	light brown silty peat, lots of wood
200-210	lost
210-227	as 182-200
227-240	brown silty peat, less wood, more consolidated than overlying unit
240-243	two distinct light grey laminae 0.5 cm width, very fine sandy silt
243-252	as 227-240
252-258	grey / brown clayey silt, large wood fragments
258-264	grey clayey silt, some organic inclusions
264-268	grey / brown silty peat, small wood fragments, visible plant remains
268-300	lost - too wet
300-333	lost
333-338	grey / brown clayey silt, occasional organics
338-341	brown peaty silt, some sand
341-344	organic silt, large plant remains, seeds and leaves
344-394	grey clayey silt, some fine sand, frequent dark well humified organic laminae, some light brown minerogenic laminae - approx 1mm thick, unit becomes increasingly sandy down profile

394-400	lost
400-408	lost
408-472	fairly homogenous grey silty clay, some evidence of light brown minerogenic banding
472-500	coarse sandy gravel

Brownchesters 6 (Terrace T4)

0-30	compression
30-49	topsoil
49-56	light grey fine sandy silty clay, homogenous bar occasional oxidised organic flecks
56-59	dark brown fine sandy clayey silt, occasional organics, more sand than above
59-64	grey clayey sandy silt, some organic flecks
64-66	dark grey fine sandy silt, some organics
66-78	peaty fine sandy clayeysilt, occasional oxidised mottling, organics increase down profile, occasional fine sandy laminae
78-100	dark brown silty peat
100-107	lost
107-112	as 78-100
112-130	light grey fine sandy silt, getting coarser down profile tosilty fine sand, some laminations and organic flecks throughout
130-150	fine sandy clayey silt, organic flecks and occasional wood
150-158	wood
158-160	grey clayey silt, occassional organics
160-200	brown silty peat, wood at 178-180, minerogenic bands (fine laminae) between 160-178
200-207	lost
207-218	as 180-200
218-224	slightly silty peat
224-241	wood
241-266	brown peaty fine sandy silt, laminations of fine silty sand throughout, freq wood, less organic down profile
266-273	laminated fine sands, silts and clays, occasional wood fragments
273-300	laminated fine / medium light grey sands and organic rich fine sandy silts, occasional wood and organic flecks
300-306	lost

306-316	laminated medium lighgt grey coarse sand and brownfine clayey silty sand
316-348	laminated fine / coarse sands, some silt, frequent wood fragments
348-365	finely laminated (~2mm) grey silty clays and silty fine / medium sands, occasional organic flecks
365-370	well sorted grey medium / coarse sand
370-384	well bedded fine / medium sands and silty fine sand, occasional organic flecks
384-400	light grey silty clays, occasional fine laminations of fine silty sand
400-520	light grey silty clay with fine sandy laminations which become less frequent down profile
520-525	clayey silty sand
525-550	fining upward coarse to fine sands, occasional shale / coal bands
550-570	gravelly coarse sand, B axis ~1cm
570-600	slightly gravelly coarse sand

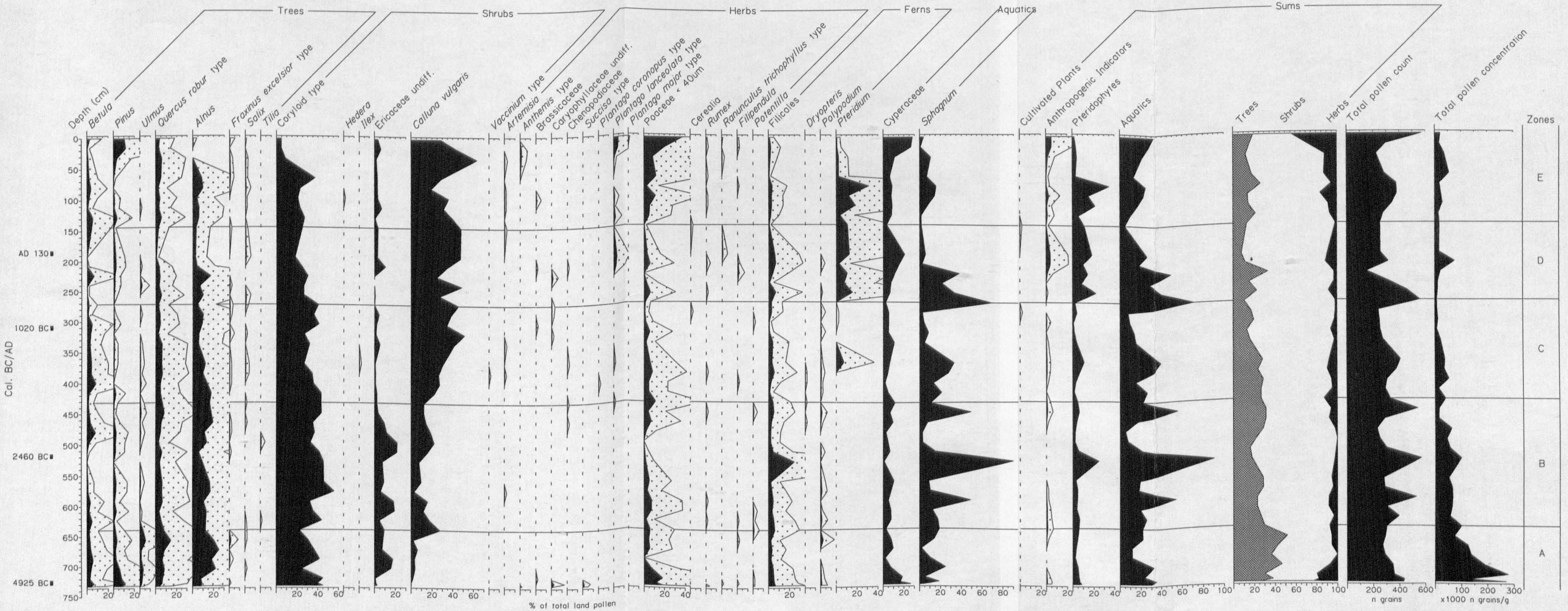
Appendix 10.7: Sediment Log for Snabdaugh

Snabdaugh (Terrace T5)

0-40	dark brown silty sand topsoil
40-50	fining upward brown medium-fine silty sand
50-105	fining upward orange-brown medium-coarse sand, occasional laminations
105-135	laminated fining upward light brown coarse-fine sand
135-210	unstructured dark grey fine sandy silt peat, occasional wood and plant fragments, less peaty up-profile between 135-160
210-240	fining upward dark grey peaty fine sands and silts with occasional wood and plant fragments
240-270	grey medium-fine sands with occasional laminations

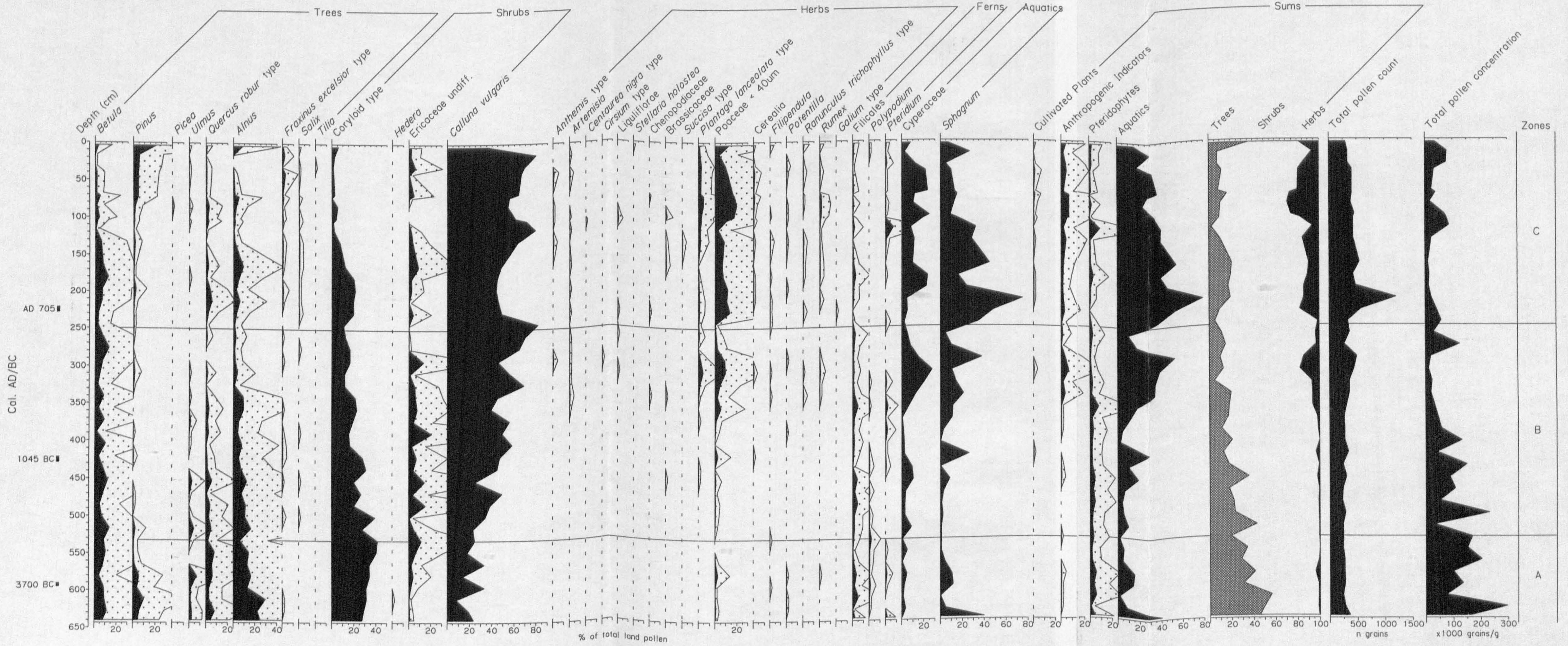
Appendix 10.8: Drowning Flow

Percentage pollen diagram
Exaggeration x5



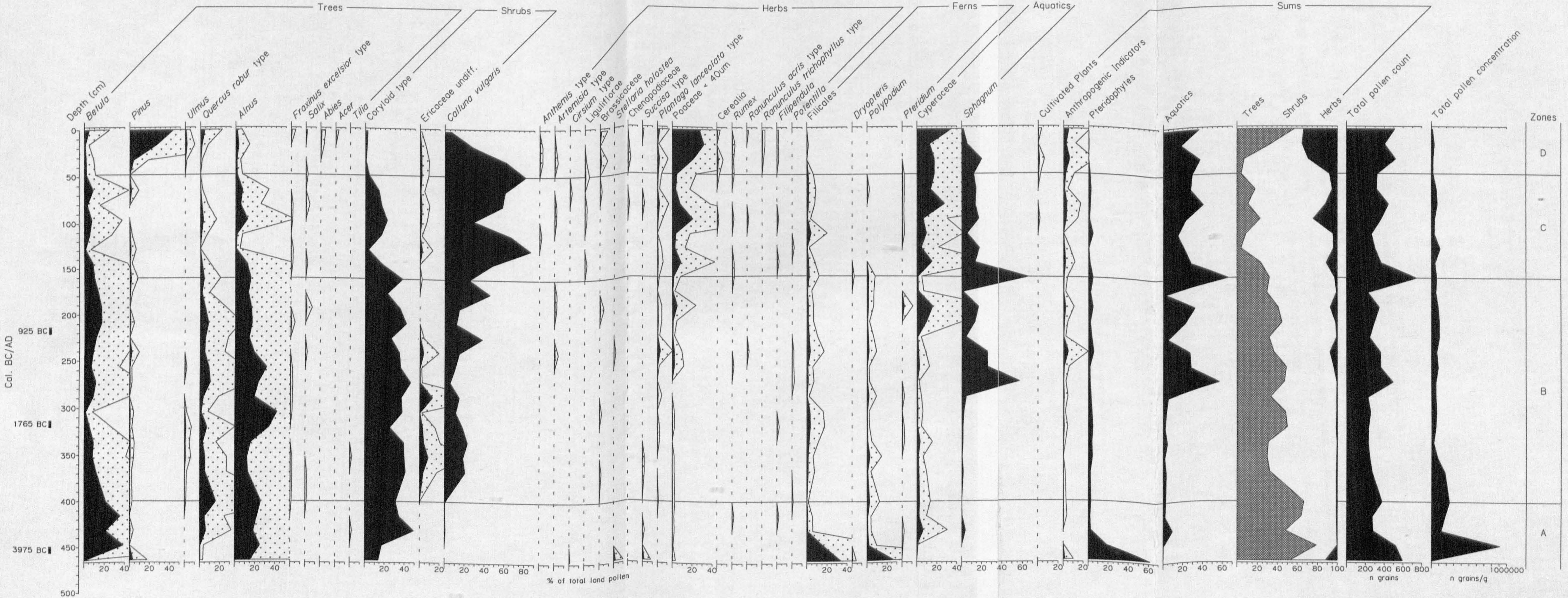
Analysis: A. Moores, Newcastle University (1998)

Appendix 10.9: Bloody Moss
Percentage pollen diagram
Exaggeration x5



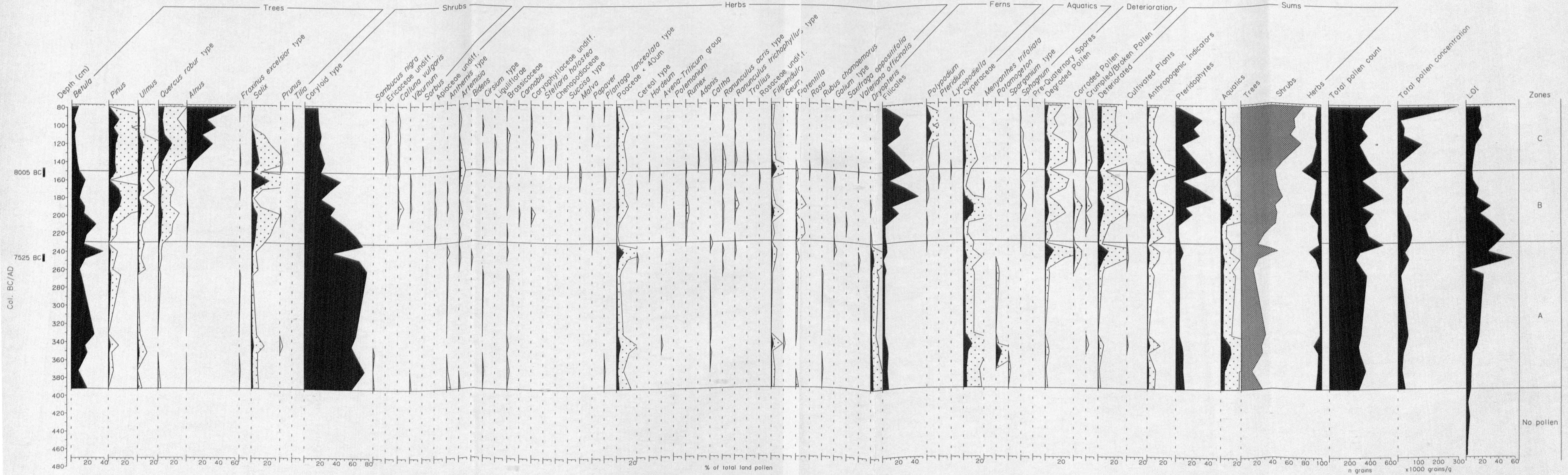
Analysis: A. Moores, Newcastle University (1998)

Appendix 10.10: Sells Burn
Percentage pollen diagram
Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

Appendix 10.11: Brownchesters Farm Terrace T3
Percentage pollen diagram
Exaggeration x5

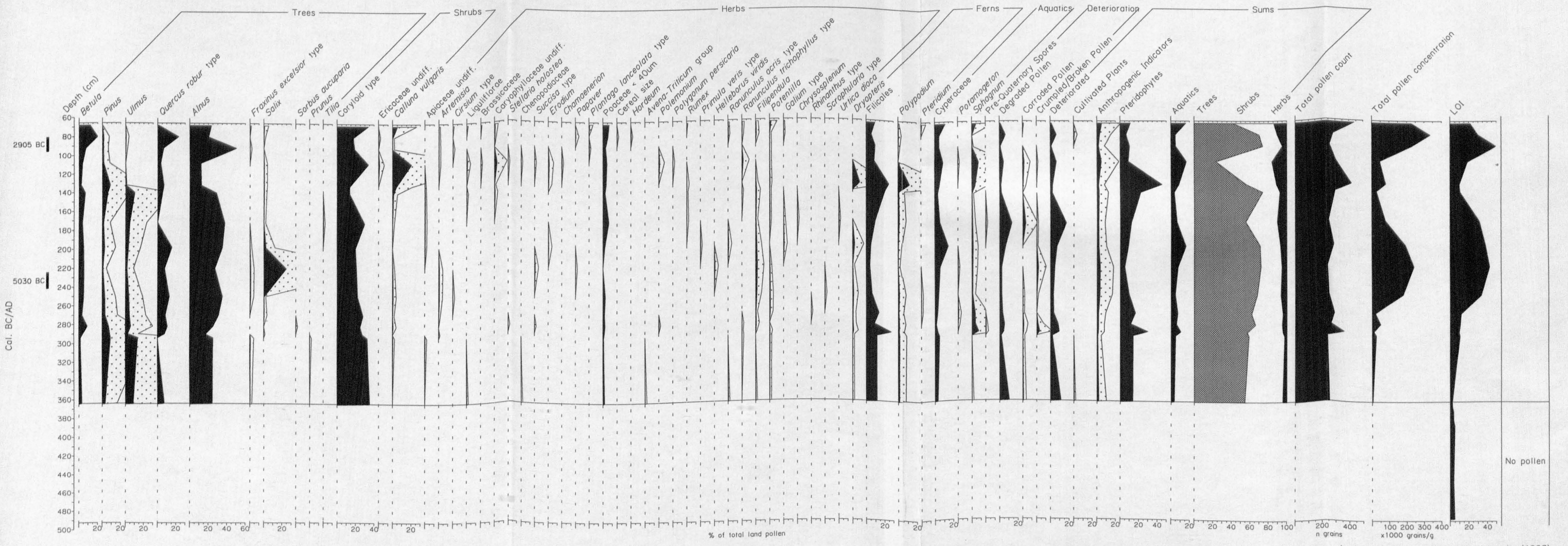


Analysis: A. Moores, Newcastle University (1998)

Appendix 10.12: Brownchesters Farm Terrace T4

Percentage pollen diagram

Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

Appendix 10.13: Brownchesters Farm Terrace T5

Percentage pollen diagram

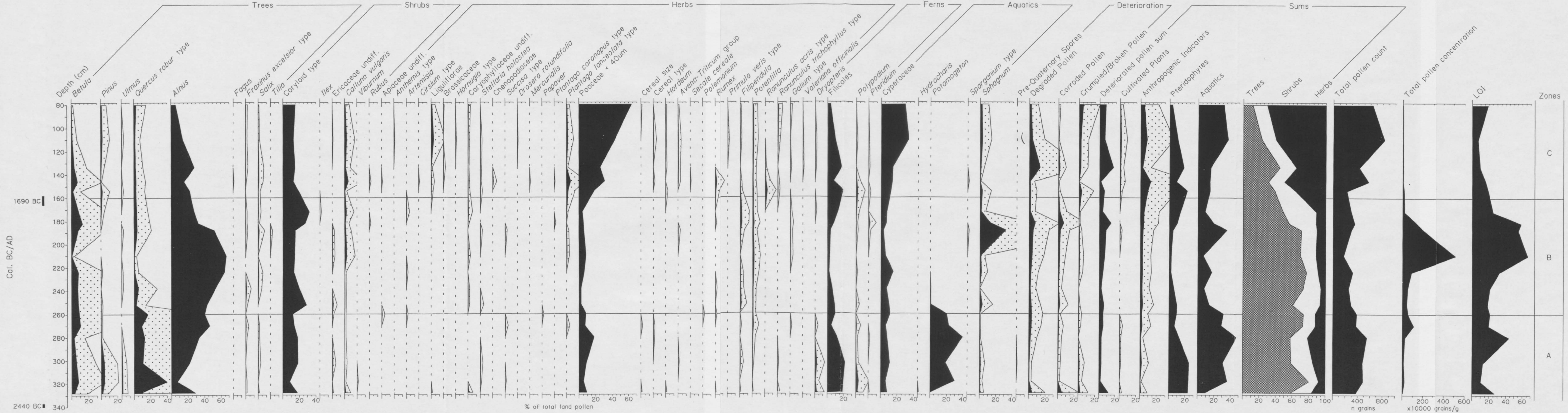
Exaggeration x5

Analysis: A. Moores, Newcastle (1998)

Appendix 10.14: Brownchesters Farm Terrace T6

Percentage pollen diagram

Exaggeration x5

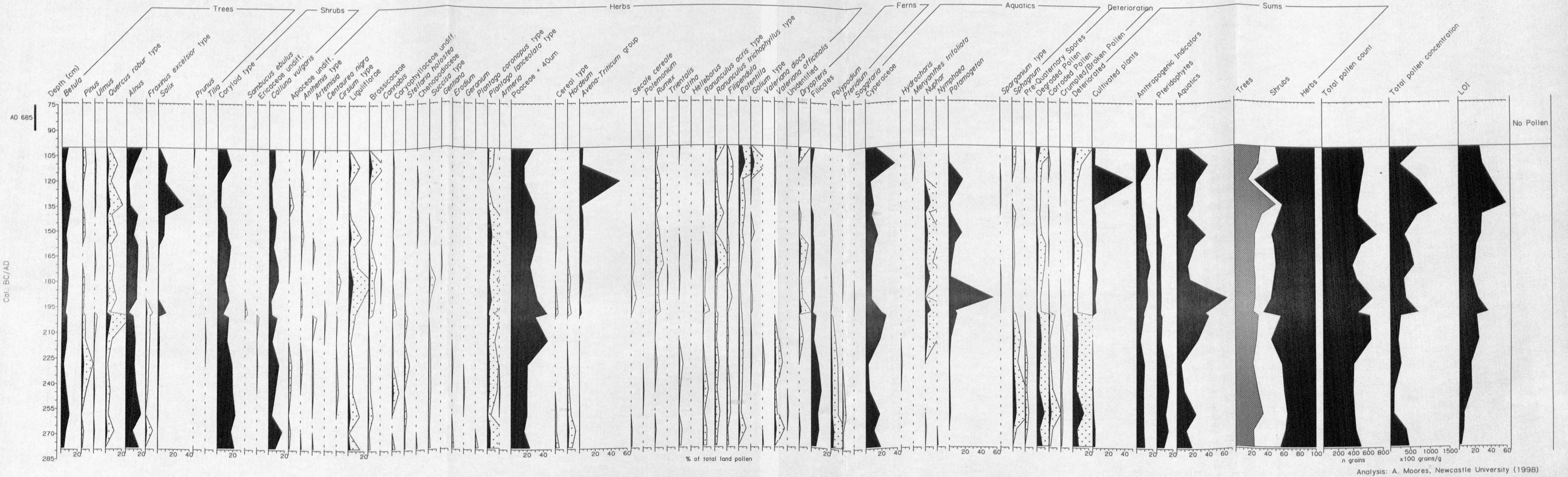


Analysis: A. Moores, Newcastle University (1998)

Appendix 10.15: Brownchesters Farm Terrace T8

Percentage pollen diagram

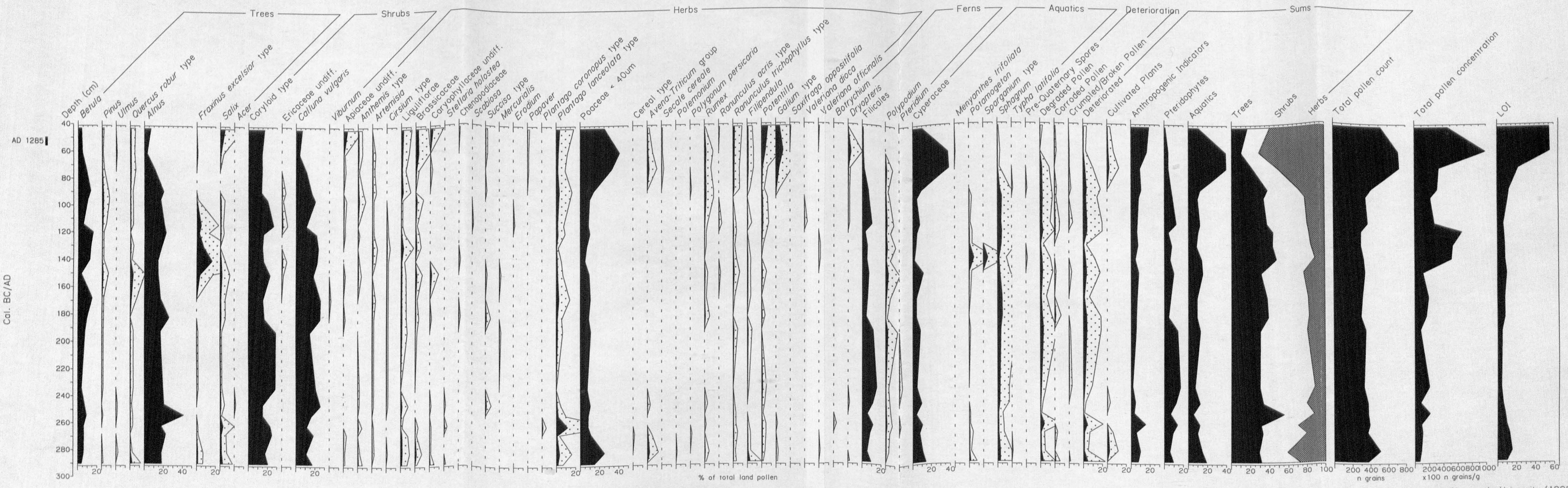
Exaggeration x5



Appendix 10.16: Brownchesters Farm Terrace T9a

Percentage pollen diagram

Exaggeration x5



Analysis: A. Moores, Newcastle University (1998)

Appendix 10.17: Snabdaugh Farm Palaeochannel T5

Percentage pollen diagram

Exaggeration x5