Development of methods for investigating settlement and land-use using pollen data : a case study from north-east England circa 8000 cal. BC - cal. AD 500.

Kathryn Elizabeth Pratt

Development of Methods for Investigating Settlement and Land-use using Pollen Data:

A Case-study from North-east England, *circa* 8000 cal. BC - cal. AD 500

Volume one
Text of Chapters 1-10, Appendices and References

Part one
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Development of Methods for Investigating Settlement and Land-use using Pollen Data: A Case-study from North-east England, *circa* 8000 cal. BC - cal. AD 500

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This study investigates methods for using pollen data from large numbers of pollen cores, both on their own and in conjunction with archaeological evidence, to shed light upon past settlement and land-use. These methods are investigated using the pollen data from the large number of pollen cores available for north-east England, and are used to address issues of settlement and land-use in this region from the Mesolithic period to the end of the Roman period, from approximately 8000 cal. BC to cal. AD 500. The thesis divides into three main parts. The first part of the thesis describes the pollen and archaeological databases created for the study. The North-east England Pollen Database brings together for the first time pollen data from over 180 pollen cores from the region, both radiocarbon dated and non-dated cores. The archaeological database brings together evidence for settlement and land-use from 8000 cal. BC to cal. AD 500, drawing upon a wide range of sources.

The second part of the thesis critically evaluates methods which use pollen data, or a combination of pollen and archaeological data, to reconstruct settlement and land-use. Traditional approaches which use pollen data alone to reconstruct past human activity are evaluated. These include the use of anthropogenic indicators and arable: pastoral indices. The indicator approach is evaluated by assessing the indicator value of a range of herb pollen taxa commonly used as indicators of human activity. The index approach is evaluated by comparing different arable:pastoral indices to find the most useful index to differentiate between different types of land-use. New, "combined", approaches are then proposed which use both pollen and archaeological data to shed light upon past settlement and land-use.

The third part of the thesis applies all these methods to investigate settlement and land-use in the north-east from the Mesolithic to the end of the Roman period. Pollen maps are produced for 500-year periods for herb pollen types commonly used as anthropogenic indicators, as well as summary maps of total trees, shrubs, herbs and Ericaceae. These maps, together with the results of the "combined" pollen and archaeological approaches, are interpreted in the light of existing views on settlement and land-use in each period.

Statement of Copyright

Declaration

I certify that no part of the material offered has previously been submitted by myself for a degree in this or any other University

Signed ....KEPratt.............

Date................8/8/96.................

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N.B. There are no figures for Chapters 9 and 10 or for Appendices B and C and no tables for chapters 1, 2, 8, 9 and 10, or for any of the Appendices.

N.B. For tables and figures for Chapter 7 refer to Volume 3.

Part I

Introductory chapters and guides to the pollen and archaeological databases

1 Introduction

1.1 Introduction

The aim of this study is to investigate methods for using pollen data from large numbers of pollen cores to investigate past settlement and land-use. A range of approaches will be evaluated which use pollen data, or a combination of pollen and archaeological data, to shed light upon settlement and land-use. These methods will then be applied to the investigation of settlement and land-use across north-east England, from the Mesolithic to the end of the Roman period, *circa* 8000 cal. (calibrated years) BC - cal. AD 500. The study region covers the four counties of north-east England; Northumberland, Tyne and Wear, County Durham and Cleveland (Fig. 1.1).

The study divides into three main parts; the first describes the pollen and archaeological databases that were created for the purposes of this study. The pollen database, the North-east England Pollen Database, consists of pollen data and background information for both radiocarbon dated and non-dated cores from the region, whilst the archaeological database contains archaeological evidence for past settlement and land-use from the region from the Mesolithic to the end of the Roman period.

The second part of this study evaluates a range of different of methods for using pollen data to shed light upon settlement and land-use, both methods already used in the literature, which use pollen data alone, and also new methods developed in the course of this thesis which use not only pollen data but also a combination of pollen and archaeological evidence for settlement and land-use. Methods traditionally used in the pollen literature to reconstruct past human activity from pollen will be critically evaluated and suggestions made as to how to improve upon these approaches. The various approaches are evaluated by using modern or recent pollen data from north-east England and comparing the results with the known patterns of modern land-use across this region.

In the third part of this study some of the most useful methods investigated in the second part of the study are applied to the investigation of settlement and land-use across north-east England during the period circa 8000 cal. BC - cal. AD 500, from the Mesolithic to the end of the Roman period. As part of this investigation a series of pollen maps are produced for ten 500 year time periods from the Mesolithic to the end of the Roman period. The implications of these findings for existing archaeological theories on settlement and land-use in each period for this region are discussed.

1.2 A review of previous research

Pollen has long been used as a source of evidence for reconstructing human activity in the landscape in the past, ever since the early days of pollen analysis (Iversen 1941; Faegri 1944; Godwin 1944) when human activity was held responsible for certain changes in past vegetation, such as Iversen's (1941, 1956) explanation of Neolithic declines in mixed oak forest and accompanying increases in herbaceous pollen taxa including *Cerealia*-type (cereal-type), *Plantago* (plantain) and Gramineae (grasses), in terms of shifting agriculture. The use of pollen to reconstruct past human activity is based upon the uniformitarian assumption that plant taxa observed to be associated with human activity today can be used to indicate the presence of human activity in the past, on the basis of their identification in the pollen record. As a result, a number of indicator types have been identified which are today found in environments associated with human activity, including woodland clearings, trampled ground, highly disturbed or cultivated ground, waste dumps or household refuse or grazed grassland.

These indicator taxa form the basis of most approaches in the pollen literature which use pollen to identify human activity. The indicator approach relies upon the presence of single indicator taxa to identify human activity (Behre 1981, 1986). The index approach uses evidence from groups of indicator types to identify the relative proportions of arable versus pastoral herbaceous pollen types (Steckhan 1961; Godwin 1968; Turner 1964; Roberts *et al.* 1973; Lange 1975; Brown 1977; Kramm 1978; Riezebos and Slotboom 1978; Donaldson and Turner 1979) or arable types as a proportion of total agricultural type herbaceous taxa (Fenton-Thomas 1992), to identify the relative importance of these different types of land-use around a pollen site. These indicator types include a range of herb pollen taxa, although the levels of tree and shrub pollen taxa at a pollen core have also been used as indicators of clearance episodes which may be attributable to human activity, based upon modern observations that different tree and shrub taxa tolerate different degrees of openness or shade, and that some types are good colonisers of open and disturbed ground, whilst others tend to occur in undisturbed woodland.

There are a number of problems with the reliance upon the use of indicator taxa which forms the basis of all the approaches in the pollen literature which will be summarised here, although they will be considered in detail in a later chapter. The first problem concerns the ecology of many pollen taxa commonly used in the pollen literature as anthropogenic indicators. Despite the common use of indicator taxa to reconstruct human activity, surprisingly little research has been carried out into the ecology of indicator types, in particular into the range of different environments in which these types occur today, to investigate how reliable each type is as an indicator of human activity.

An additional problem concerns the taxonomic level to which pollen can be identified. Many of the commonly used anthropogenic indicators can only usually be identified to the genus level at best, and others can only be identified to the family level. The reliance upon families or genera to indicate a specific type of environment such as human altered landscapes is highly problematic, since they may contain a large number of species occurring in a range of environments, only some of which are associated with human activity.

A further problem with indicator taxa is that they have often tended to be uncritically applied to a wide range of different environments and conditions where they may be inappropriate as indicator types. An example of this is the use of the family Chenopodiaceae as anthropogenic indicators in coastal environments. In most other environments the occurrence of Chenopodiaceae is a good indicator of disturbed, often fertile environments such as arable land, waste ground, rubbish dumps and manure heaps, near human habitation and other areas where nitrogen levels tend to be high (Grime *et al.* 1990), since most species belonging to this family occurring in inland environments tend to occur in this type of environment today. However, along the coast and estuaries there are a wide range of species occurring in natural coastal vegetation communities. It is therefore apparent that each indicator type is only useful in certain types of environment and when using each indicator, the range of species that could be present in the environment around a pollen site in the past must be considered, before necessarily interpreting the presence of the indicator in terms of human activity. However, few detailed accounts of the ecology of indicator taxa exist and also there has been little attempt to produce lists of useful indicator types for different types of environment.

A further problem with the use of indicator types is the paucity of research into the pollen productivity and dispersal of indicator herb types and the pollen rain associated with different types of land-use. The reconstruction of land-use from pollen is far from straightforward and there are numerous complicating factors, pollen taphonomic factors, which need to be taken into account when interpreting the significance of the occurrence of indicator types in the pollen record (comprehensive accounts of the various biasing factors of differential pollen productivity, dispersal, survival and problems of identification are given in Birks and Birks 1980 and Moore, Webb and Collinson 1991, and will be only summarised here).

The reconstruction of vegetation, let alone land-use, from pollen is not straightforward, primarily because the pollen from a core does not give a 1:1 representation of the vegetation on the site of the core, but instead contains pollen transported to the core site, not only from the core site itself but from the local area around the core and also from vegetation further afield. Therefore if one is trying address issues such as the relative importance of different types of land-use at a site, or the distance away from a site of arable fields, or clearance activity in woodland, it is vitally important to be able to "source" the pollen from the core. This is important for example in order to distinguish whether large amounts of cereal pollen indicate that cereal cultivation, processing, storage or transport was being carried out right on the location of the core spot, or whether it was brought in from further afield.

In order to address such issues there are a complex range of factors that need to be considered, including the pollen dispersal mechanism of the indicator taxon (i.e. insect, wind or self-pollinated), since this affects how far the pollen tends to travel, the pollen productivity of the indicator taxon, as well as the pollen catchment area of the site in the period being studied.

The effect of pollen catchment size on the pollen reaching a core site, and the effects of surrounding vegetation on catchment area has been much discussed in the pollen literature (Tauber 1965, 1967; Janssen 1966; Jacobson and Bradshaw 1981) and will only be briefly covered here. Put basically, a site with a large pollen catchment area, such as a site with open vegetation and little tree cover, or a lake, is more likely to pick up indicator types being transported from further afield (either by wind transport or in the case of a lake, by inwashing from the watershed of that lake) than a site with a small pollen catchment area, such as a site surrounded by dense woodland. Therefore when interpreting the significance of the occurrence of indicator types in a particular period in terms of importance of human activity at a site or distance of human activity from a site, it is important to consider the catchment size of the site in that period, dependent upon vegetation cover at that period on and around the site, the height of vegetation cover, the swamping effect, if any, of local vegetation or local tree and shrub cover, and the local topography and nature of the core deposit (i.e. lake, plateau, stream channel).

Additional biasing factors to consider when interpreting the significance of the presence of indicator types include differential preservation of different types of pollen grains in different types of sediment or during pollen extraction, with certain pollen types preserving only poorly, which can affect identification. In addition, certain pollen types may be difficult to identify, or distinguish from other pollen types and therefore might not be picked up by inexperienced pollen analysts.

A further problem is that comparatively little research has been carried out into what different types of land-use look like in the pollen rain in different types of environment. The use of indicator types and the use of indices to identify the relative proportion of different types of land-use is based upon surprisingly little modern research into the pollen rain associated with different types of land-use. For example Turner's (1964) arable: pastoral index was created on the basis of information derived from only 21 modern samples, although this is an improvement on other indices which appear to have been created purely on the basis of particular pollen workers' knowledge of the types of plant taxa that tend to be associated with arable and pastoral land-use today.

Despite the large amount of modern surface sampling studies that exist which investigate the pollen rain from a range of natural and semi-natural vegetation communities, and the large amount of research into investigating the fall off in pollen rain with increasing distance from woodland (a full review of examples of such surface sampling studies in a range of environments is given in Chapter 5), there are only few studies that investigate the pollen rain of agricultural fields and the fall-off in pollen associated with those fields with increasing distance from the source (these few examples include surface sampling by Berglund *et al.* (1986) in southern Sweden, Potter and Rowley (1960) in New Mexico, Heim (1962) in Belgium, Turner (1964) in Ayrshire, Vuorela (1970, 1972, 1973, 1975) in Finland, and by Caseldine (1981) on Bankhead Moss in Fife, Scotland).

In order to improve the use of indicator types and the identification of suitable indicator types to use in different environments, there is a need for a more thorough study of the range of types of environment in which different indicator types occur today. An evaluation of the indicator value of a range of herb pollen types commonly used as anthropogenic indicators is given in Appendix B, by considering the present-day plant distribution of species belonging to each pollen taxon and the range of different environments in which they occur. The above review of surface sampling work also highlights the lack of work investigating the pollen rain associated with different types of land-use in a range of different environments. However, since so little work has already been done of this type, a useful surface sampling study would require too much time to be carried out as part of this current study, since the majority of work for the current study has been orientated towards the creation of the pollen database and production of pollen maps. A research proposal for such a surface sampling study is instead provided in Appendix C.

The majority of studies reconstructing human activity from land-use have focused upon a single pollen core or small group of cores. There have been few attempts to move beyond the individual pollen core to study large numbers of pollen cores on a regional scale to investigate regional patterns of settlement and land-use. Where such larger scale studies have been carried out, they have tended only to have been written reviews of the evidence for human activity from the pollen cores from a region in a given period, summarising evidence for clearance or the occurrence of pollen types associated with disturbance or agricultural activity (examples of such reviews for the later prehistoric period in the north-east of England include Wilson 1983 and van der Veen 1985. Interestingly no such reviews are available for the period before the late Bronze Age). These reviews of the pollen evidence for human activity are usually accompanied by an account of the archaeological evidence for settlement and land-use, in the attempt to find archaeological sites or artefactual evidence that may be responsible for these events in the pollen record. There has been little attempt to move beyond qualitative description of pollen cores on a regional scale to summarising evidence for human activity from large numbers of pollen diagrams by carrying out quantitative comparisons of pollen values between different sites, or by displaying pollen data in map form.

Multivariate analyses and pollen mapping have both been commonly used in the pollen literature as a means to summarise data from large numbers of pollen cores in the pollen literature. However, the use of such techniques to reconstruct human activity is very rare (although Turner 1983 has used multivariate analysis to summarise evidence for human activity from several pollen diagrams from north-east England for the Roman period, and Fenton-Thomas 1992 has used pollen maps to present pollen evidence for settlement and land-use for the area between the Tyne and Tees for the later prehistoric and Roman periods).

The majority of studies using multivariate analysis and/or pollen mapping to present results from large numbers of pollen cores have been focused on very different issues. These include, for example, the reconstruction of distribution patterns of different tree taxa in the past (Turner and Hodgson 1979, 1981, 1983, 1991), or the investigation of the timing of spread of different tree and shrub taxa into a region following the deglaciation (Huntley and Birks 1983; Jacobson *et al.* 1987; Bennett 1989), or reconstructing the distribution patterns of vegetation units in the past and how they change in composition and extent over time (Huntley 1990 a), or the investigation of climatic change and variation across a region (Huntley 1990b, 1992, using the European palynological record over the last 13000 years, and Jacobson, Webb and Grimm 1987 studying pollen data from eastern North America during the deglaciation).

Where pollen maps have been used to help reconstruct past human activity from pollen data from large numbers of cores, they have firstly only used data from a small number of radiocarbon dated sites, and not exploited the vast amount of information available from non-dated cores. Secondly only very simple and straightforward methods have been used for presenting the data in map form. For example, Fenton-Thomas' (1992) maps of pollen data from selected radiocarbon dated sites from the area between the Tyne and Tees in north-east England for the first millennia BC and AD presented pollen values in the form of pie-charts. Although this is an effective method for clearly presenting pollen values for more than one pollen type on the same map (in this case pie-charts were used to present tree and shrub pollen as a proportion of total pollen and also arable pollen types as a proportion of all agricultural types), and has been used by other pollen workers in the past (Godwin 1940; Jessen 1949; Neustadt 1959; Ritchie 1976), it is practical only as long as a small number of pollen cores are used. This method is impractical for displaying the pollen information from the 180 pollen cores entered into the North-east England Pollen Database for the purposes of this study.

There are a range of different pollen mapping methods which have been used in the pollen literature to summarise pollen information from larger numbers of pollen cores than can not be easily summarised by pie-charts (these methods are reviewed in considerably more detail in Chapter 5). These move away from presenting results at each site location, to drawing contours to link together locations on a map with the same pollen value ("isopoll" maps) (Bertsch 1953; Sauramo 1940; Birks, Deacon and Peglar 1975; Birks and Saarnisto 1975; Bernabo and Webb 1977; Huntley and Birks 1983; Ralska-Jasiewiczowa 1983; Webb *et al.* 1983; Jacobson *et al.* 1987) or to link locations where an event in the pollen curves of a taxon (for example the first appearance of a pollen type at a site) occurred at the same time ("isochrone" maps) (Donner 1963; Moran 1973; Davies 1976, 1981, 1983, 1987; Jacobson 1979; Webb *et al.* 1983; Webb *et al.* 1984; Davies and Jacobson 1985; Gaudreau and Webb 1985; Davies *et al.* 1986). More recently it has been possible to use interpolation methods to produce continuous surfaces across a region for each pollen type, by interpolating pollen values from each core site to every point across a region based upon location and elevation as well as the variation in pollen values across the region. These methods will be explained in more detail in Chapter 5.

However a drawback of all pollen mapping methods is that they are purely for display purposes and cannot be used to carry out subsequent analysis; for example they cannot be used to quickly extract information such as interpolated pollen values for all the archaeological sites in a given period, or to easily display any combination of pollen taxa on the same map, or to show the amount of change between one map and another. These are the sorts of questions that can be investigated with the use of a Geographical Information System (GIS) (Environmental Systems Research Institute 1993), which can store information about each pollen taxon at each site, can quickly display or add together any combination of maps for pollen taxa and can display maps produced using pollen interpolation methods as grids so that information about likely pollen at any location across a region can be extracted. The use of a GIS to store, present and analyse pollen data from large numbers of pollen cores, whatever method of pollen mapping is to be used, from dots on a map to isopoll maps to complex interpolated maps, is a valuable tool to aid pollen mapping and multivariate analysis.

1.3 The aims of this study

The study aims to evaluate a range of approaches, both already used in the pollen literature and new approaches, for using pollen data to investigate past human activity. The indicator value of a series of different herb pollen taxa will be investigated by considering the modern ecology of these taxa and evaluating the extent to which each taxon can be used as an indicator of particular types of land-use in different environments. A consideration will also made of the taxonomic level to which each indicator type can be identified, and how this affects the indicator value of that taxon. A range of arable: pastoral indices and agricultural: arable indices will be evaluated by comparing the scores produced by different indices using modern and recent levels of pollen cores with the known pattern of modern land-use at these sites. Indices will be compared in terms of their ability to distinguish between sites on or surrounded by arable land and those surrounded by grassland. Lastly, the potential of surface sampling work to understand the relationship between land-use, vegetation and pollen rain with the aim of discovering suitable indicators and combinations of pollen taxa for different types of land-use in different environments, will be investigated.

A second aim of this study is to develop methods for using pollen in conjunction with archaeological data for settlement and land-use to shed light upon past activity. Methods will be investigated to identify settlement or other activity in the landscape in areas where the archaeological record is scarce, by examining the relationship between pollen evidence for human activity and archaeological evidence in areas where the archaeological record is better represented. Methods will also be investigated to shed light upon the types of vegetation cover associated with different types of archaeological evidence such as settlement evidence or lithic scatters, and examine how this changes over time, by using interpolation methods to interpolate pollen values for each pollen site.

Thirdly, the study aims to use pollen data from large numbers of pollen cores, both radiocarbon dated and undated cores, to reconstruct past human activity, and to develop methods for displaying pollen evidence for human activity in the form of maps. The aim is to use pollen interpolation techniques and Arc/Info GIS to produce maps which cannot only be used for display purposes to present the changing vegetation of a region throughout a period, but also for the purposes of analysis, particularly to carry out the combined archaeological and pollen approaches mentioned above.

For the purposes of carrying out the above studies, it was decided to use the large amount of pollen data available for the north-east of England. Over 250 pollen cores have been studied by various workers, from the four counties of north-east England and the surrounding areas (here defined as areas lying within 20 km of the boundaries of the study area), including some 31 radiocarbon dated sites and two more sites that have been dated by association with archaeological material. A map of the distribution of these pollen cores and a review of the workers responsible for the study of these cores is given in detail in Chapter 3. These pollen cores are well distributed across the region in a wide range of the environments existing today across the region, from the highest elevations on the Cheviot Hills and the Northern Pennines in the north west and west of the region to the coast in the east, and across a wide range of different types of solid geology and soil types. The very high density of pollen cores available for north-east England therefore makes it an ideal data set to use to investigate different methods for using pollen to reconstruct past human activity in the landscape.

The North-east England Pollen Database created for the purposes of this study is the first attempt to produce a comprehensive regional database for the vast amount of pollen information available for this region. These pollen data were previously only available in the form of raw pollen counts from individual pollen workers and not all of it published.

Although Ferrell (1992) has produced a list of pollen cores from north-east England, including a large number of non-dated cores, this list is not completely up to date or comprehensive for the whole region. The database brings together information from a wide range of sources to facilitate easy retrieval of pollen count information and also background information about site location, pollen core depth, solid geology, soils, present day vegetation, publications associated with each core, pollen workers responsible and dating information. Pollen databases have been created for other areas, usually on a far larger scale than the north-east of England, but these rarely include information from non-dated cores or short cores, except for those areas where the distribution of dated cores is sparse. The North-east England Pollen Database is designed along the same lines as the European Pollen Database (Gear and Keltner 1991), with the aim of it being compatible, although since non-dated cores are included a number of features have had to be modified accordingly. A comprehensive guide to the structure of the pollen database is provided in Appendix A and the database is discussed in Chapter 3.

The final part of the study will use the methods investigated for reconstructing human activity from pollen examined in this study to investigate settlement and land-use in North-east England from the Mesolithic period to the end of the Roman period from *circa* 8000 cal. BC to cal. AD 500. It aims to use both pollen based approaches and approaches using a combination of pollen and archaeological data to investigate issues and questions concerning settlement and land-use arising from each period. Examples of interesting issues relevant to all time periods include the reconstruction of the nature of land-use in each period, how it varies spatially and temporally, the density and distribution of settlement, and the rôle of human activity in changes in the vegetation in this period.

Pollen evidence is a particularly valuable source for investigating settlement and land-use in the past in north-east England. Not only is the available pollen data abundant, but also the available archaeological evidence for the region is patchy in distribution. Owing to a combination of research interests biasing in favour of certain areas, the destruction of land through urbanisation, forestry or extractive industry and the methods of archaeological survey used, the archaeological evidence for settlement and land-use is more plentiful for certain areas and periods than others. These biasing factors affecting the archaeological record for the north-east will be discussed in far more detail, with examples from the region, in Chapter 4. As a result of the patchiness of the archaeological dataset for many periods and areas of the region, it is insufficient to address many of the interesting questions concerning the nature of settlement and land-use.

In addition, very few palaeoeconomic studies of archaeological sites have been carried out, with few well preserved faunal assemblages and only a small number of sites where carbonised or waterlogged plant remains have been studied (although the number of sites studied has been recently considerably increased by the work of van der Veen 1985, 1992).

In comparison, the pollen dataset, especially if the large amount of potential information from undated cores is used, presents a valuable data source for investigating questions of settlement and land-use. This data has never been brought together before for the whole of the region for the whole of the period from the Mesolithic to the end of the Roman period to investigate human activity. The studies by Turner and Hodgson (1979, 1981, 1983, 1991) have brought together the large numbers of pollen cores available for the Northern Pennines, although this was for the purposes of investigating patterning in the pollen of different tree taxa, and not for investigating human activity.

As mentioned above, several studies have brought together evidence from selected pollen cores, mostly radiocarbon dated cores, from across the region to examine pollen evidence for clearance and agricultural activity which have all concentrated upon the later prehistoric period (Late Bronze Age and Iron Age periods, in the first millennium BC and early first millennium AD) (Wilson 1983, van der Veen 1985, Ferrell 1992, Fenton-Thomas 1992) . A thorough review of the environmental evidence for the north-east from all periods, including pollen evidence, but also faunal evidence and waterlogged and carbonised plant remains from archaeological sites, has recently been provided by Huntley and Stallibrass (1996).

However, with the exception of Fenton-Thomas (1992), all these reviews have been written accounts summarising the pollen evidence for this period. Fenton-Thomas has mapped pollen data for selected sites from the area between the Tyne and the Tees for the period 1000 BC-AD 1000, by producing pie-charts showing proportions of trees and shrubs of total pollen and proportions of arable taxa of total agricultural taxa. This study was limited in scope, being an undergraduate thesis, and did not draw upon the large numbers of non-dated cores, or extend the study north of the Tyne, or earlier than the later prehistoric to fill the gap in understanding of pollen evidence for settlement and land-use earlier than this for the region. Fenton-Thomas' maps form the starting point for this present study, which aims to produce maps of pollen evidence for settlement and land-use for the whole of north-east England, for the whole of the period from the Mesolithic to the end of the Roman period, and using data from as many of the pollen cores as are available from the region.

It was decided to restrict the study to the counties of Northumberland, County Durham, Tyne and Wear and Cleveland since this region has been the focus of many archaeological studies, particularly Ferrell's 1992 study of settlement evidence for north-east England for the later prehistoric and Roman periods. It was decided to aim to make this study complement Ferrell's settlement study by presenting maps for pollen data from exactly the same area. In addition this region was used because most surveys of archaeological data are organised on the county level, and this would facilitate the compilation of an archaeological database for the purposes of this study (described in Chapter 4) to test the combined pollen and archaeological approaches discussed above. The use of this region would also encompass the large number of archaeological studies focusing upon the Tyne-Tees area.

It was decided to focus upon the period from the Mesolithic to the end of the Roman period because, as well as covering the pollen evidence for the later prehistoric and Roman period much studied for the region, particularly the Tyne-Tees area, and addressing the issues brought to light by these studies using a larger pollen dataset, including non-dated sites, this study would also fill the gap in the study of pollen evidence for the early prehistoric period. For the early prehistoric period, the pollen evidence exists, but is seldom discussed with reference to human activity, and there have been no attempts to bring all the evidence together before for this period. It is for this earlier period in particular that this study hopes to make particularly useful findings about settlement and land-use.

1.4 Chapter plan

The study falls into three main parts: Part I covers the introduction (Chapter 1), the background to the study area, including information about the present day vegetation of the region and how it relates to present day land-use, solid geology, soils and climate (Chapter 2), a description of the pollen data set - the North-east Pollen Database (Chapter3) and the archaeological data set (Chapter 4) constructed specifically for the purposes of the study. Part II, the methodological section, evaluates methods not only which reconstruct settlement and land-use from pollen alone, but also methods which use a combination of pollen and archaeological data. Chapter 5 investigates the purely pollen-based approaches (the indicator approach, index approach and comparative approach) and discusses the available pollen mapping methods to present the results, whilst Chapter 6 investigates combined approaches, which use pollen and archaeological evidence to shed more light upon settlement and land-use. Part III uses the methods investigated in Part II to investigate questions and issues about settlement and land-use for the North-east from the Mesolithic to the end of the Roman period. Chapter 7 presents the results of the purely pollen based approaches evaluated in Chapter 5, in the form of pollen maps for each period. Chapter 8 presents the results of the combined pollen and archaeological approaches discussed in Chapter 6 for each period. Chapter 9 discusses the results of Chapters 7 and 8 in the light of existing views on settlement and land-use in north-east England from the Mesolithic to the end of the Roman period. Chapter 10 gives a summary and conclusions of this study and suggests possible work that could be carried out following on from this study.

2 Background to the study region

2.1 Introduction

Numerous descriptive accounts exist of the physical and environmental characteristics of the four counties of the study region, such as their topography, drainage, climate (Glaspoole 1932; Harris 1982; Manley 1932, 1935, 1936, 1941, 1946; K. Smith 1970; L.P. Smith 1984), solid (bedrock) geology (Calvert 1884; Cochrane 1977; Robson 1980) and soils (Jarvis *et al.* 1984; Soil Survey of England and Wales 1983). Many studies have been specifically interested in the influence of such physical and environmental factors on the flora and vegetation of the region (Arnold 1986; Baker and Tate 1868; Bellamy 1970; Graham 1988; Heslop-Harrison 1918; Lunn 1976, 1993; Ratcliffe 1978; Swan 1993; Sykes 1993).

This chapter will review the background to the study region from the perspective of investigating the influence of physical and environmental factors upon modern land-use in the region. Many of these environmental and physical factors will have remained constant since 8000 cal years B.C., and will be important in considering patterning in past land-use, whilst others such as climate and soils will have changed over time. The first section will briefly outline the distribution of modern land-use across the region, whilst the second section discusses how various non-anthropogenic factors influence this distribution. Changes over time in climate and soils will be noted and discussed in the light of how they may have affected land-use.

This chapter will not give a detailed account of the present distribution of different plant species, since this is covered in detail in the various floras for the region (Swan 1993 for Northumberland, Graham 1988 for County Durham, Arnold 1986 and Sykes 1993 for the Cleveland Hills). However, the chapter will discuss the distribution of different vegetation types across the region including maps of present day land cover of arable land, grassland, rough grassland, moorland vegetation, urban areas and woodland.

Although this chapter focuses only on physical and environmental factors, the type of land-use in a particular area at any point in time is shaped by a complex interrelationship of anthropogenic and non-anthropogenic factors. Environmental and physical factors should not be seen as determining the land-use practised at a location, but they can be used to predict the optimum type of land-use to be practised at that location, which can then be compared with actual land-use. The actual type of land-use practised at any given time may in fact differ from the optimal due to a wide range of anthropogenic factors.

The previous history of land-use in a particular area is also an important factor in influencing the use of the landscape. For example, overuse of the soil may lead to a decline in soil nutrient levels which may influence subsequent use of the land. However, other factors such as the type of soil will influence how long a particular area will be able to withstand such overuse before nutrient levels fall to a sufficiently low level to affect land-use, and social and economic factors may also influence the point at which a particular type of land-use is abandoned in favour of an alternative.

2.2 Modern settlement and land-use across north-east England

Maps of present day land cover across north-east England are presented in Figures 2.1 to 2.6. These show the percentage cover of each 1 km square across the region taken up by each of 6 different classes of land cover used here: arable land, built-up land, pasture, rough pasture, moorland and woodland respectively. The maps were constructed from digital land cover data provided for the whole of Great Britain by the Institute of Terrestrial Ecology at Monks Wood, called the "Land Cover Map of Great Britain" (a description of which is provided in Fuller 1995). The land cover information, provided by the ITE in the form of grid maps of different types of land cover, was obtained by combining data from summer and winter Landsat satellite images, from which different types of land cover could be identified on the basis of their spectral signatures, ranging from sea and inland water bodies, beaches, bare ground, developed land and arable to a range of semi-natural vegetation types. The accuracy of land cover determinations from satellite was checked by comparison with ground surveys of land cover (Fuller *et al.* 1994). The information in digital format provided by the ITE consists of raster images (grids) at two resolutions: 25 metre grids or 1km summary grids for 25 different classes of land cover types. There are 25 "layers" or grids provided, one for each land cover type. For the 1km resolution summary data, within each layer, each 1km grid cell is assigned a value which represents the percentage of that particular cover type occurring within that grid cell. For example, if a particular grid cell on the layer containing information about tilled land has a value of 20%, this means that 20% of the 25 metre cells making up the 1km grid square were classified as "tilled land".

Arc/Info G.I.S. was used to display this data in the form of 1km resolution grids for the north-east of England. The 25 land cover categories provided by the ITE were summarised into the six land cover categories listed above by combining grids of similar types of land cover. For example, the category "pasture" was created by combining data on land cover for meadows, verges and mown and grazed turf. The resultant maps of land cover are presented in Figures 2.1 to 2.6.

As noted by Lunn (1993), a notable contrast exists between the landuse of the western uplands and the lowlands of the region, which largely reflects the contrast in the physical environment between the two areas. In the uplands of the region permanent grassland dominates the land cover (Figures 2.3 and 2.4), grazed by cattle and sheep, with rough grazing on the predominantly unenclosed moorland grassland lying over 400 metres above sea level (a.s.l.). In the lowlands land cover is mostly dominated by arable agriculture (Figure 2.1) with some mixed livestock and arable farming in parts of the region. Considerable amounts of the lowland area between the Tyne and Tees is taken up by urban development and industrialised land (Figure 2.2). In many respects this upland/ lowland, pastoral/ arable division is related to the climatic and soil requirements of the major crops, many of which are unsuited to the uplands, with their wetter climate and largely acidic, waterlogged soils (Smith 1984).

Material in the following sections is based upon accounts provided by Jarvis *et al.* (1984) for northern England as a whole, Lunn in Swan (1993) for Northumberland, and for County Durham upon accounts by Graham (1988), the papers in Clapham (1978) and Dewdney (1970). The following sections are also based upon interpretation of the land cover maps in Figures 2.1 to 2.6.

2.2.1 The lowlands

In the lowland areas arable agriculture forms a higher percentage of the total area (Figure 2.1), although within this category there is a wide range of variation in types of cultivation. This varies from mixed arable and livestock farming over much of lowland County Durham and parts of Northumberland, to predominantly cultivated areas in the lower Tweed valley and the coastal areas of Durham and Northumberland. Over much of the lowlands an extensive drainage system has been developed over the last centuries, to dry out the wetter, heavier soils. Of the cereal crops grown in the region, barley, mostly spring barley, is by far the most important, especially in the east, in the lower Tweed valley and coastal Durham and Northumberland, where it is grown for malting and stock fattening. Wheat and winter barley are more important on the heavier soils in the lowlands. Recently oilseed rape cultivation has increased rapidly and it is now found in all eastern lowland arable areas, where it replaces grass, and it is increasingly found on clayey, heavy soils. On the mixed farms, where cattle, mostly beef cattle, are fattened, barley is grown on a smaller scale for stock feeding and fodder crops, such as turnips and field beans are grown, where they are often the only arable crop. Over the last decades the amount of beef cattle rearing and fattening has decreased, with an overall increase in arable farming, particularly in Northumberland. Dairying is locally important in eastern Cleveland, the valleys of the North York Moors and the Tyne valley.

The landscape in the south east of Northumberland and lowlands of Durham has been shaped by centuries of coal mining, although today it only continues in isolated areas. Opencast mining on a large scale affected most farms in these areas, putting agricultural land out of production for many years, involving five years of restoration, drainage and grassland before agriculture could be resumed. This has produced a poor quality, high clay and silt content soil, which is poorly drained (Figure 2.16 shows those areas with soils damaged by coal mining and other extractive industries in the region). The landscape in these areas is also heavily dominated by urban development, particularly along the lower Tyne and Tees and in those areas on the Coal Measures (Figure 2.15). Prior to urban development, these areas would have most likely had soils made up of fine loam over clay, or fine clay or silt, and would have been fairly poorly drained in those areas nearest the rivers. It is likely that much of these areas would have been put over to permanent meadow or, if drainage was carried out, the full potential of these fertile but often waterlogged soils could be exploited by arable agriculture.

2.2 The uplands

In the uplands land-use today divides between the moorlands, with rough grazing for sheep, grouse moorland and forestry (Figures 2.4, 2.5 and 2.6), and upland dales hill farming with more intensive agriculture, grass cultivation and stock rearing.

Until recently, upland farming was dominated by hill-farming with traditional, species-rich hay meadows with permanent grassland near the farms for winter feeding and richer grazing, and rough upland grassland for summer grazing and grouse rearing. However, over the last decade much permanent grassland in the dales has been changed by ploughing, reseeding, all year round grazing and heavy application of nitrogen fertilisers. In many areas the moorland edge has been reclaimed for more intensive agriculture. Sheep dominate the economy in the uplands, and have become particularly important over the last few decades due to EEC (now EU) policies. Where in the past lambs tended to be fattened in the lowlands, now this is possible in the uplands with land improvement. On slightly better pasture some cattle are kept with sheep, usually as a secondary enterprise, and are fattened on lowland farms. Oats are only found in areas of the region where land is marginal for cereal production. Rye is nowhere important today.

Throughout this century a major land-use change in the uplands has been the large scale conifer afforestation changing the landscape from moorland to plantations, the largest of which lies in the Kielder area of Northumberland (Figure 2.6). Before this century, plantations of broad leaved woodlands were made on private or church land on the lower ground of the Pennines. Smaller areas of plantations occur on the Fell Sandstone moorlands and in the Cheviots. Much less afforestation has been carried out in the Northern Pennines, due to a higher proportion of common land, and the greater amount of land reclamation of moorland for agriculture, since the 18th century by lead mining smallholders. This leaves only high altitude moorlands which have a climate unsuited for good timber yields. Peaty soils require drainage and fertiliser for plantations.

A further dramatic change in land use in many parts of the uplands, particularly the Northern Pennines, since the last century, has been the cessation of lead mining activity, which was particularly prevalent in Upper Weardale. As has already been mentioned, this led to the reclamation of moorland in these areas by lead mining smallholders for agriculture and as a result the moorland edge in the Northern Pennines occurs at a higher altitude around 350-400 metres a.s.l. than further north in Northumberland, where it occurs around 250 metres a.s.l. (Lunn 1993). The creation of lead mining spoil heaps has resulted in a very distinctive landscape in the valley of Upper Weardale, and has influenced the vegetation cover by encouraging the growth of metallophyte plant species (Swan 1993; Graham 1988).

2.3 Non-anthropogenic factors influencing the nature of land-use

This section will discuss the various physical and environmental characteristics of the study region and consider the extent to which each affect the nature of modern land-use. Most of these non-anthropogenic factors are influential on the type of agriculture practiced because they affect the nature of vegetation that can grow in different areas, primarily through soils and growing season. The ecological requirements of different crops affect which areas they are best grown in. The distribution of other types of land-use, such as mining and quarrying, and industrial development, is affected by other factors such as bedrock geology.

2.3.1 Elevation and climate

A major source of variation affecting vegetation and agriculture in the region is the wide range in elevation across the region, from sea level in the east to 893 metres a.s.l. on Cross Fell on the Northern Pennine escarpment in the west and 815m on the Cheviot in north west Northumberland (Figure 2.7). The geomorphological areas of North-east England are defined by elevation and dissected by the various rivers of the region (Figures 2.7, 2.8 and 2.9) (Lunn 1993; Beaumont 1970). The uplands consist of, north to south, the Cheviot Hills, the Fell Sandstone moorlands in central and north-east Northumberland rising to 440m, the Border Hills in the area of Redesdale and the upper North Tyne rising over 600m, the ridges around the Roman Wall in the Tyne Corridor, and the Northern Pennines between the Tyne Corridor and Stainmore Gap (Figure 2.9). In County Durham the East Durham Plateau rises from the surrounding lowlands in an escarpment to over 100m, forming an area of "lowland upland". In the south east, in Cleveland, land rises from the Cleveland Plains in a sharp escarpment to 433m on the Cleveland Hills. The lowlands of the region comprise the Tees lowlands in the south east of the region, the Wear and Tyne lowlands to the north and the lowlands of Northumberland along the eastern coast and to the north in the Tweed valley.

Lunn (1993) has defined the upland/lowland division of land-use (Figure 2.10) as occuring at 250m in Northumberland (where upland comprises 40% of the total county area) and above 300m in County Durham. The moorland edge is higher in Durham owing to the greater degree of land reclamation of moorland in upper Weardale and upper Teesdale during the period of lead mining, as has already been mentioned. In the north-east the upland starts at such a low elevation compared to elsewhere in England, since only a modest increase in elevation brings severe limitations on agriculture, largely due to climate, which affects the soils. North-east England is the coldest part of England in both summer (when isotherms trend west-east) and winter (when they trend north-south) (Manley 1936) In addition, the localised effect of the North Sea along the coastal lowlands of the region strongly effects summer (particularly May-June) temperatures. Only a small change in elevation will have large effects on species that are in many cases already at the limits of their tolerances; temperatures decrease with elevation at a lapse rate of about 0.6 degrees Centigrade for every 100m (Smith 1984). Figure 2.11 maps the variations in mean accumulated temperature above 0°C over the period January to June across the region, which clearly shows that over this period the accumulated temperature is greatest in the Tees lowlands and lowest in the uplands of the region.

Precipitation is not directly linked to elevation, although it does increase both westwards and with increased elevation (Figure 2.12), so that the cool, wet climate of the uplands promotes leaching and infertility in coarse-textured soils (podsolisation) and waterlogging (gleying) in finer textured soils (Lunn 1993). This promotes the spread of ombrogenous (blanket) peat (Figure 2.16). Upland soils also suffer from the additional problem of being shallow and on steep slopes. Plants do not respond to precipitation *per se*, but to the effects it has on soil. The mean accumulated maximum potential soil moisture deficit is a guide to the distribution of excess soil moisture and waterlogging (Figure 2.13) (Smith 1984). This is calculated as the difference between potential transpiration and waterlogging in the growing season (Swan 1993). Blanket bog formation tends to occur when there is a minimum rainfall of 1000mm and a minimum of 160 wet days a year (defined as a day when 1mm or more precipitation occurs) plus a cool climate with mean temperature less than 15°C in the warmest month.

In addition, there are direct climatic limitations on plant growth in the uplands (growing season, temperature, exposure) which limit land-use in the uplands to a predominantly "pastoral" regime, whilst the lowlands are more suited to arable agriculture. A good measure of suitability of land for arable has been suggested by Smith (1984) as the date in autumn when soils return to field moisture capacity. The higher the rainfall and lower the temperature, the earlier the return date and the less suitable the land is for cultivation.

Whilst elevation and solid geology will have remained constant since 8000 cal. BC, changes in climate have occurred which are likely to have affected the quality of the soils, by affecting the degree of waterlogging and leaching, the growing season and affecting the growing ranges and distributions of plants. These changes will have affected the suitability of land for different types of land-use, and in particular for crop cultivation. Pollen evidence has been used as a major source for reconstructing past changes in climate, although other sources of palaeoenvironmental evidence which have been used to shed light upon climate include palaeoentymological evidence (the reconstruction of climatic conditions at a given time and place on the basis of identification of insects characteristic of particular types of environment) (Atkinson, Briffa and Coope 1987). Pollen data contains a large amount of potential information relating to palaeoclimatic conditions (Huntley 1990a).

Reconstructions of past climatic conditions using pollen data are fundamentally based upon knowledge of the climatic tolerances of different taxa and the uniformitarian assumption that the climatic conditions in which particular taxa are found have not changed significantly over time. The majority of studies reconstructing climate from pollen data use data from large numbers of pollen core sites, usually on the continental or sub-continental scale, since climatic changes tend to operate on a very large scale, and by looking at large numbers of pollen sites it is possible to filter out large scale changes shared by many pollen sites from more locally occurring changes which could be caused by other, non-climatic factors.

Maps plotting variations in abundance of pollen of various pollen taxa across regions and continents at different time periods have been used by pollen workers to reconstruct past climatic conditions (Huntley and Birks 1983). By interpreting such maps in the light of knowledge of present day distributions and ecological tolerances of different tree and shrub taxa, it is possible to reconstruct the likely range of temperature and wetness in any given area from the abundances of different pollen types (once taphonomic factors such as variable pollen production, dispersal and survival have been taken into consideration, and other factors affecting abundance of different tree and shrub taxa, such as variations in timing of expansion of different taxa into a region following deglaciation).

A combination of pollen mapping and multivariate analysis has been used to assess patterns and rates of change in various pollen spectra with the aim of identifying periods where major changes occcurred which might have a climatic interpretation (Huntley 1990b, 1992, using the European palynological record over the last 13000 years, and Jacobson, Webb and Grimm 1987 studying pollen data from eastern North America during the deglaciation). Huntley (1992) has demonstrated that the major points of change identified from the European pollen data correspond well with the start of the deglaciation around 13000 years BP and also with the marked oscillation in climate that occurs following this in the Younger Dryas period, involving a brief return to glacial conditions around 11000 years BP. It is particularly interesting, in the light of this present study, that when pollen data is mapped on a large, continental or sub-continental scale, climatic changes appear to be the most important factor in these changes, and

"Human impact upon ..vegetation history is seen to be relatively unimportant when the vegetation is viewed at a continental scale." (Huntley 1990b p.103)

It is therefore apparent that the choice of spatial scale used for pollen mapping and analysis is closely related to whether one wishes to study macro-scale climatic changes (by using continental or sub-continental scales) or small scale changes between pollen sites such as small scale climatic differences which are more likely to be due to local differences in topography, or changes due to variations in human activity in the landscape (by using a smaller, regional scale). For example, the series of studies and multivariate analyses of tree and shrub taxa from large numbers of pollen diagrams from the Northern Pennines by Turner and Hodgson (1979, 1983, 1992) have been used to reconstruct changes in climatic conditions in the region since the Boreal period (*circa* 8800 - 8000 cal. BC) on the basis of the relative abundances of different tree and shrub taxa, as well as documenting the spread of various tree and shrub taxa following deglaciation, and the subsequent deforestation of the landscape up to the present day. In addition, a study of pollen diagrams from around and on the summit of Cross Fell in the Northern Pennines, the highest point in the north-east of England, demonstrating the presence of thermophilous tree taxa in the vicinity during the Atlantic period (*circa* 8000 - 6000 cal. BC) has been used to support a picture of much more favourable conditions for the growth of such taxa in this area in this period (Turner 1984).

A diagram showing the Blytt-Sernander periods commonly used in the pollen literature plus their durations in calibrated years BC/AD is provided in Table 4.1, showing their relationship with the pollen zonation scheme devised by Godwin (1940, 1975), archaeological periods and the 500 year periods used in this study. A period by period account of changes in the climate of the north-east since 8000 cal. BC will not be presented here, but instead will be covered in Part III with a discussion of the pollen maps.

3.3.2 Solid (bedrock) geology, drift geology and soils (Figures 2.14 to 2.16)

Figure 2.14 maps solid geology across the region, whilst Figure 2.15 represents drift geology, mapping the distribution of glacial drift and till deposits. Figure 2.16 shows the distribution of different soil types across north-east England.

This account is based upon descriptions of the solid and drift geology for north-east England provided in Robson (1980), in Lunn (1993) for Northumberland, in Calvert (1884), Graham (1988) and by Johnson in Dewdney (1970) for County Durham. Figures

2.14 and 2.15 are based upon the Ordnance Survey Solid Geological Map of Northern Britain at 1: 650 000, the Geological map of North-east England produced by Cochrane (1977), Ordnance Survey drift geology maps at 1: 250 000 for the region, and maps in Jarvis *et al.* (1984). Information on soils is derived from the Soil Survey of England and Wales soil map of Northern England at 1: 250 000 and the descriptions of soil types in Stevens and Atkinson (1970) and in Jarvis *et al.* (1984).

The influence of bedrock and drift geology on agriculture is mostly secondary in nature, affecting (in a complex relationship together with climate, elevation and slope and drainage patterns) the nature of the soils. However, it has a far more direct influence on the distribution of extractive industries such as quarrying and mining.

Carboniferous Series sedimentary rocks dominate most of the study region and vary from limestones to mudstones, shales, siltstones and coals, becoming progressively younger in age as one goes south east. In Northumberland the Carboniferous Series is represented by the Fell Sandstones, the Scremerston Coal Measures, the Limestone Groups - which mostly consist of sandstones and shales rather than limestone, and the Coal Measures. In County Durham the Carboniferous Series is only represented by the Limestone Groups, Millstone Grit Series and Coal Measures. Here the strata are nearly horizontal, and form wide plateaux of Millstone Grit sandstones, dissected by dales in the underlying Limestone Groups, with their sequential outcrops of sandstones, limestones and shales. Where sand content of soils is high (such as on the Millstone Grit and the Fell Sandstones in Northumberland, and sandy parts of the Limestone Groups) and they are free draining, high rainfall produces leaching and podsolisation, leading to subsurface horizons rich in iron, aluminium and organic matter.

Podsolic soils also occur on the igneous rocks of the Cheviots, where the granite and volcanics produce sandy and base-deficient soils, which tend to be shallow. The Whin Sill, an igneous quartz-dolerite intrusion which occurs on the Farne Islands, around the Roman Wall area and in Upper Teesdale, produces dry shallow soils supporting grassland and species that can take nitrogen stress (due to the thinness of the soil). On less well drained soils such as on the shales and mudstones of the Limestone series in the Northern Pennines, the Roman Wall area and Border hills, gleying is widespread, and soils are covered in often thick layers of peat, to produce stagnohumic gleys. Blanket bog is widespread on both types of upland soil.

The fine, thick erodable mudstones and shales of the Carboniferous Series have also had a widespread influence on soils owing to their contribution to glacial drift. Glacial drift covers most of the bedrock geology in the lowlands, dales and lower hillslopes, and soils in these areas are highly influenced by the drift. Glacial till covers much of the eastern lowlands, and varies in nature from clayey to silty, loamy or sandy. Across most of the lowlands the soils are surface-water gleys with mineral topsoil (stagnogleys) and impeded drainage due to the fine nature of the substrate. This underlies most of the agricultural land in the lowlands and much of the marginal land on the moorland edge. Prior to drainage these soils would be heavy, poorly drained and difficult to work. In the middle ages they were commonly worked using rigg and furrow and this can still be seen under permanent pasture. In the lowlands there has been considerable drainage and subsoiling and since the 18th century there has been a gradual creation of an artificial underground drainage system. This has led to the drying out of surface soils and their greater suitability for arable.

The dominant soil type on the Coal Measures, the pelo-stagnogley, has a higher than normal clay content and a very high drainage impedence. The local Coal Measure shale plus the glacio-lacustrine clays contribute to this. When combined with coal-mining subsidence, this has led to severe agriculture drainage problems. When compacted with heavy machinery after mining, these soils become immature gleys. Pelo-stagnogleys also exist on the glacio-lacustrine clays and silts around Wooler in northern Northumberland and produce particularly poorly drained soils. The most fertile soils in the lowlands - the brown soils - are either found on coarser tills or thin tills over a permeable bedrock or on drift free sandstones or water-lain sandstones and gravels, such as river alluvium (brown alluvial soils) or glacial outwash deposits. Alluvial deposits, floodplains and terraces cover much of the lowlands. Erosional hollows created by glaciation in till, and kettle holes result in a series of ponds, carrs and mires in the lowlands. Although most have been reclaimed by drainage, some still survive in areas of intensive farming (e.g. near the river Skerne in the Durham lowlands.) Along the Northumberland coast these brown earths are fine enough to cause some gleying (stagnohumic brown earths), and are used as fattening pastures, especially around Bamburgh. Brown earths are also produced in the hills surrounding the Cheviots, where andesite coupled with lower rainfall produces quite base-rich, fertile soils.

Calcarous brown earths and rendzinas do occur as shallow soils on outcrops of limestone in the Roman Wall area, and in the Northern Pennine dales where the Limestone groups are exposed from the till and alluvial soils. In Upper Teesdale where the intrusion of the Whin Sill has metamorphosed the limestone, a sugar limestone is produced which has resulted in a unique and much studied vegetation.

Bedrock geology also influences extractive industries: in the Alston Block, the Northern Pennine Orefield was a major lead-producing area until the late 19th century, and zinc was produced well into the 1940. Cadmium and copper are also present in low concentrations, and flourite, baryte and witherite have also been mined. The landscape of the upper dales is dominated by evidence of former mining activity. Many soils are contaminated by heavy metals (lead, zinc, cadmium, copper), toxic to many plants when present above certain critical levels. These soils occur around mines, in mine dumps and in river alluvium. Several studies have been made into the unique metalliferous plant communties associated with these soils. The influence of the Coal Measures on the landscape as a result of mining has already been demonstrated. The presence of limestone in the Durham dales and the Magnesian limestone on the East Durham Plateau has also resulted in a concentration of quarrying activity in these areas.

2.4 Conclusions

The relationship between land-use, environmental and physical characteristics of the landscape, and anthropogenic factors is very complex. This chapter has nevertheless attempted to briefly account for the ways in which non-anthropogenic factors can influence, rather than determine, the land-use carried out in a particular area. Many of these factors are likely to have remained constant and unchanging over the last 6000 years, whilst others, such as climate and soils, have changed. The various influences of such environmental factors upon land use in different periods from the Mesolithic to the end of the Roman period will be discussed in Part III.

3 The pollen data set: The North-east England Pollen Database

3.1 Introduction

For the purposes of this study, databases for both the pollen data and archaeological evidence for settlement and land-use have been constructed for the study region. The following two chapters discuss the pollen database and archaeological database in turn, describing for both the criteria for including data, database design, data entry and modification. An account is also given of the distribution and characteristics of pollen core sites and archaeological sites in the database.

The pollen database produced here - the North-east England Pollen Database (NEEPD) - was constructed for two main reasons. Firstly to serve as a source of data for investigating settlement and land-use for the purposes of this study, and secondly to serve in the longer term as an archive of pollen data for use by other pollen workers. To date, no attempts have been made to construct a comprehensive regional database for the large amount of available pollen information for north-east England. Apart from the analyses by Turner and Hodgson (1979, 1983, 1991) using up to fifty cores from the Northern Pennines, most pollen work in the region has focused upon single cores or small groups of cores. The creation of well designed regional-scale pollen databases is of great value for the long-term curation of pollen data, which are usually published only in summary form as pollen diagrams, and whose collection is highly labour intensive. A detailed guide to the North-east England

Pollen Database, including a diagram of the database structure and full description of the structure of each table comprising the database is provided in Appendix A.

3.2 Criteria for collection of pollen data

Over 140 pollen cores are known to have been studied for the four counties of north-east England and the surrounding areas of North Yorkshire, Cumbria and southern Scotland (Tables 3.1, 3.2). Maps showing the distributions of the pollen cores entered into the database are presented in Figure 3.1 and Figure 3.2. The pollen cores available for north-east England vary considerably in quality and detail, in the timespan covered, the pollen sum used, the use of radiocarbon dating, the detail to which taxa are identified, the number and density of levels studied in a core, and in the type of locations the cores were taken. The wide variation in pollen data is largely due to the wide range of research aims that the pollen cores have been taken to investigate; focusing upon tree taxa to investigate timing of tree spreading (Hall 1975; Hodgson 1974; Turner 1984; Turner and Hodgson 1979, 1981, 1983, 1991); focusing upon local bog taxa to look at changing conditions on the bog surface (Barber 1978, 1981); or using herb taxa to investigate possible human activity in the surrounding area (Roberts, Turner and Ward 1973; Donaldson 1975; Donaldson and Turner 1979; Davies 1978; Davies and Turner 1984). Changing conventions between the 1930s and the present about the presentation of pollen data in publications also contributed to this variation; from the earlier focus on tree taxa, the use of relative pollen diagrams[1], and expressing all taxa as a sum of total tree pollen, to the more recent use of absolute pollen

[1] With **relative** pollen diagrams, all pollen types are expressed as a percentage of a pollen sum (typical pollen sums include total tree pollen and total dry land pollen.) The problem with this is that the proportional representation of all types is affected by real fluctuations in the abundance of any of the others. For example, if *Betula* (birch) pollen rises from 10% to 60% of the pollen sum, all other pollen types will show a corresponding decline, thus keeping the total at 100%. This can be misleading, as these other pollen types in reality may not have changed.

diagrams[2], the more detailed identification of non-tree pollen types, the use of radiocarbon dating, and the use of more sophisticated pollen sums.

The following criteria were used for selecting pollen cores to enter into the database. These criteria were chosen in order to best provide those cores most suitable for investigating land-use and settlement in the study region from *circa* 8000 calibrated (cal.) years BC to *circa* cal. AD 500. Table 3.3 lists those sites unsuitable for entry in to the NEEPD along with the reason for their unsuitablility.

a) Location: Pollen core sites must lie within the study region (the four counties of Northumberland, Tyne and Wear, County Durham and Cleveland), or within 20km of those county boundaries if they are particularly 'good' sequences: long, detailed cores preferably with radiocarbon dates. Pollen core sites from outside the boundaries of the study region are included since they help in assigning dates to non-dated sites just within the boundary. They are also of use when constructing pollen maps by providing extra data for interpolating pollen values in the border areas (see Chapter 5 for details on interpolation techniques used in the construction of pollen maps.)

b) Dating: Ideally, pollen core sequences should have radiocarbon dates. However, a large proportion (82%) of the available cores from the region are undated. Cores should only be included if they have sufficient numbers of levels, or sufficient features in the pollen curves to enable dates to be assigned by cross-correlation from radiocarbon dated sites. (cf. This chapter, sections 3.4.4, 3.4.5)

c) Detail of taxon identification: Ideally sites to be included should have a full range of taxa, with herb taxa identified where possible to genus and species, if we are to gain a good picture of land-use. However, the majority of cores only have herb taxa identified to family level, with occasional taxa identified to a more detailed level. A

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[2] With **absolute** pollen diagrams, pollen data are expressed in terms of number of pollen grains accumulating/unit area of sediment per unit time. This means the value of any given pollen type is independent of all the others. (Moore, Webb & Collinson 1991)

typical example of the level to which herb taxa are identified by pollen workers is provided in Table 3.4. This is the minimum level of identification acceptable in this study. Cores where only tree pollen have been counted are insufficient. Cores with data presented as summary diagrams are also unacceptable, since certain taxa are omitted.

c) Pollen sum: Where possible, pollen data should come in the form of raw pollen counts, rather than converted into percentages of a pollen sum. This is so that the data from all the cores can be in the same format. However, in the cases where raw counts are not available, and a pollen sum has been used, the data must be converted back. The necessary information must be present to carry out this conversion. For example, if data are expressed as a percentage of total tree pollen, we need to know what percentage of the total pollen is accounted for by the trees if we are to convert this data to alternative sums.

d) Use of pollen diagrams: The pollen data should preferably be on computer disk in a format that is easily imported into the pollen database (see section 3.3 for discussion of suitable formats). However, given that computerization of pollen data is relatively recent, the majority of cores that will only have data in the form of tallies on count sheets, which have to be manually entered into the database. In some cases, where data are no longer available except in the form of a published pollen diagram, values have to be read off the diagram. The potential errors associated with this are discussed in section 3.3.

e) Closing date of entry into the NEEPD: Although ideally the database should be an ongoing project, being updated as new sites come in, for the purposes of this study only data from cores available up to 1/1/95 were used. A number of cores are currently under study or still being used in publications, and so the data for these were not available at the time of the closing date.

f) Timespan of core: Since this study focuses on pollen data from *circa* 8000 cal. years BC to *circa* cal. AD 500, cores with sequences wholly before this date are omitted from the NEEPD. This includes cores focusing on the end of the last glaciation and early postglacial. At the other end of the timescale, pollen cores with sequences more recent than cal AD1000 have been included in the database, since modern and recent pollen data from the tops of pollen cores are used in Chapter 5 to test the usefulness of various anthropogenic indicators and indices that have been proposed by pollen workers as a means to reconstruct settlement and land-use from pollen data. This is done by comparing the scores for different indices from modern or recent pollen data with maps of modern land cover.

3.3 Design and construction of the NEEPD

3.3.1 Information to be included in the pollen database

The types of information to be entered into the pollen database falls into two main groups background information about the core site, and the actual pollen count information. Background information includes site location (easting, northing and elevation in metres above sea level); the underlying bedrock geology and soil type, slope and aspect of the site; the number of pollen cores taken at each site location; information about the type of pollen site (bog, lake, soil sample) and the pollen catchment area of the site (very local, local, regional). (As discussed in Chapter 1, the pollen catchment area is a very important indicator of the size of area from which the site is getting its pollen rain and indicates whether the site is giving a picture of regional vegetation or very local conditions.) Additional information concerns the date the pollen core was taken, the workers responsible for taking the core and studying it, publications associated with the core and the authors. A note is also made of the form of pollen data supplied to the NEEPD (diagram/ pollen count data, pollen sum used).

Information about the pollen counts includes the number of levels in the pollen core and their depth from the surface in centimetres; the number of radiocarbon dates (if present), the laboratory in which the dating was carried out, the depth of each dating sample and the calibrated date in years BC/ AD calculated for each date; the date calculated for each pollen sample by cross-correlation from dated sites and interpolation from dated levels; the timespan covered by each core; a taxon list for each core, and the pollen counts themselves.

3.3.2 Choice of database design: a review of existing pollen databases

During the design stage of the NEEPD, a review was made of available pollen database structures used by other workers to enter pollen data on a regional scale. The databases used by Turner and Hodgson (1979, 1983,1991) for their Northern Pennine pollen data were a valuable starting point for collection of pollen sites, but only dealt with single time periods and tree pollen data. More extensive and detailed pollen databases have been assembled as part of the Cooperative Holocene Mapping Project (COHMAP) for North American data and by Huntley and Birks (1983) for given time intervals for Europe, focusing mainly on tree and shrub data, with only selected herb taxa. Subsequently the European and North American Pollen Databases were constructed out of the need to compile comprehensive and detailed central databases of pollen data for large numbers of pollen cores.

The structure of the EPD and NAPD has been drawn upon by a number of other smaller, compatible, databases, notably the database used by the project on European Palaeoclimate during the last deglaciation (Huntley, Gear and colleagues, Durham), the database for the project on Palaeoclimate and Vegetation of the last interglacial in Europe (Field and Gibbard in Cambridge), the East Mediterranean database constructed as part of the EPOCH project on global climate change over the last 30,000 years (Bottema at Groningen), and the Alpine Database which is part of a larger project on long-term vegetation dynamics in the Alps (Amman, Birks, Hegg, Juggins, Kienast, van der Knapp).

Although this study operates on a far smaller spatial scale than any of the above, considering the large number of available pollen cores for the region, it was decided to base the structure of the NEEPD upon the European Pollen Database. (cf. Gear and Keltner (1991) "Pollen Database Manual" for details on the structure of the EPD) This is because the structure of the EPD already existed, was easy to use, and so that the NEEPD could be compatible with the larger European database. However, for the purposes of this study, a number of modifications to the structure of the EPD were made. This was because the requirements of the two databases differ in a number of ways. For example, the EPD uses data from throughout Europe and can afford to have strict criteria about the quality of pollen cores entered, whereas the NEEPD covers a much smaller region and timescale and has to use a larger proportion of poorer quality cores. Secondly, the EPD only uses sites with dates, whereas the aim here is to incorporate the lage numbers of non-dated sites from the north-east.

Like the EPD, the structure of the NEEPD is divided into two main areas: the background information about the cores, which is held in Paradox (a relational database) and information about the actual pollen counts, which are held in Tilia (a pollen data spreadsheet package). Paradox enables information about cores to be entered into a series of related tables so that the data can be easily searched and queried (cf. "Introduction to Paradox ver.3.5." Borland International.) For example, one could ask for all the core sites above 1000ft worked on by Dr.J.Turner. This would combine data from two separate tables, one about site location, the other about pollen workers. Additional tables could then be queried if, for example, more details were required about publications referring to those sites.

Pollen count information is entered via the Tilia pollen spreadsheet package, since this is better designed for the entry and manipulation of individual core counts than Paradox. With the EPD, pollen data in Tilia are made compatible with the rest of the database in Paradox by converting it using a Paradox script (TILTOPD). With the NEEPD pollen count data is converted by exporting it from Tilia as an ASCII text file and importing directly into Paradox as a table.

A plan of the structure of the NEEPD is provided in Fig.A.1 (in Appendix A), and a summary of the information in each table is given in Table 3.5. The full structure of the NEEPD is explained in more detail in Appendix A ("A Guide to the North-east England Pollen Database").

3.4 Collection and entry of pollen data

A list of suitable pollen cores fulfilling the necessary criteria outlined above for entry into the NEEPD was compiled through literature searches and consultation with known pollen workers in the north-east to find in particular unpublished cores and recently studied cores. A number of reviews of pollen work in various parts of the region have provided useful starting points for collection of data. (Clack 1982; Fenton-Thomas 1992; Turner 1970, 1979, 1983; Turner & Hodgson 1979,1983,1991; van der Veen 1985, 1992; Wilson 1983).

Where possible, raw pollen counts were required. However, raw counts are rarely available in publications, the data having been modified by converting into a pollen sum and summarized in pollen diagrams. It was therefore necessary to contact the relevant workers to gain access to the raw counts (contact addresses and other information about pollen workers is stored in the NEEPD table WORKERS (Appendix A)).

3.4.1 Formats of pollen data

Material provided has come in a variety of different formats: raw pollen count sheets, computerized pollen counts in Tilia format, tables of pollen counts and pollen percentages, and pollen diagrams. Table 3.6 shows the number of pollen cores in each category. Pollen diagrams were used when data were no longer available in raw counts or the worker could no longer be contacted. Pollen values were read directly off the pollen diagram. Although this sacrifices accuracy, in that the exact original values can not be read off pollen diagrams, in most cases accuracy within 2-3% of the original value could be attained. The pollen values were converted from the pollen sum used in the diagram back to raw counts. In most cases the sum used was total tree pollen: if the percentage of total pollen accounted for by trees was known, the values could be converted back. In some cases the values could only be converted to a percentage of total dry land pollen, as follows:

trees + shrubs + dwarf shrubs + herbs - aquatics and pteridophytes ,

where dwarf shrubs indicate relatively low growing, shrubby taxa typically common on moorland and heath, such as members of the Ericaceae family (including *Calluna* (heather) and *Erica* (heath)), and such as *Empetrum* (crowberry), *Cytisus* (broom) and *Ulex* (gorse).

This was acceptable, since all the pollen data were ultimately to be converted into a percentage of total dry land pollen for the purposes of analysis.

3.4.2 Level of taxonomic detail

Taxa were recorded at the most detailed level available for each core. Cores tend to vary in the taxonomic level to which their taxa (particularly herb taxa) are identified, depending upon the aims of the research. For example, for some cores all members of the Compositae family would be grouped together as "Compositae", whereas at others they would be divided into the two main groupings of Compositae Liguliflorae (sometimes termed Compositae Cichorioidae) and Compositae Tubuliflorae (otherwise termed Compositae Asteroidae) (Clapham *et al.* 1987). At others, members of the Compositae would be identified to genus level (for example *Bellis*) and, more rarely, to species level (for example *Bellis perennis*). The majority of pollen workers tend to follow the same conventions (cf. Table 3.4 for a typical taxa list), but occasional pollen cores are identified at a higher level of detail.

Pollen values for each core were entered into Tilia as individual *.til files for each core. Depths in cm for the surface for each level were noted, taxon lists compiled, and the values for each taxon entered.

3.4.3 Conversion and standardisation of pollen data

Once all the pollen counts were entered into Tilia, data from each site were converted into percentages of the total dry land pollen sum. This was carried out in Tilia as follows:

Total dry land pollen (Z) = trees + shrubs (A) + dwarf shrubs (C) + herbs (B)

Pollen counts of trees, shrubs, dwarf shrubs and herbs calculated as percentages of Z.
Pollen counts of pteridophytes calculated as percentages of Z + Pteridophytes.
Pollen counts of aquatics calculated as percentages of Z + Aquatics.

It was decided to use total dry land pollen rather than other pollen sums for the following reasons. This sum is one of the most frequently used as a basis for modern percentage pollen diagrams. For the purposes of this study, a pollen sum is required which does not distort the representation of herb pollen, which is the main focus of interest when reconstructing land use. There are disadvantages to using total tree pollen as a sum: herb pollen (and other types) can be subject to artificial increases and decreases as the result of fluctuations in the tree pollen curves, and it is also difficult to see changes in total tree pollen as this always adds up to 100%. The use of the total dry land pollen sum removes the dependence of the herb curves on the tree pollen curves. The influence of very local bog surface plants and aquatics (for example *Sphagnum* mosses), which often have large fluctuations in pollen input and produce corresponding fluctuations in other curves if included in the sum, is removed. One problem with the total dry land pollen sum is that some taxa included in the sum, such as Gramineae, can occur in bogs and mires as well as occurring as dry land taxa. It is conventional to include these problematic taxa in this pollen sum.

3.4.4 Assigning dates to the pollen data

Of the 180 cores included in the NEEPD, some 32 (17.8%) have radiocarbon dated levels. The rest are undated. A date in calibrated years BC/AD was calculated for each level from each pollen core, so that pollen data could subsequently be extracted for a series of time periods for mapping. It was decided to use calibrated dates BC/ AD, rather than raw radiocarbon dates or calibrated dates BP (before present, i.e. before 1950 using the Libby half-life, Stuiver and Reimer 1993) which is the most common method to express dates in the pollen literature, primarily for ease of comparison with the archaeological data. Table 3.7 lists the radiocarbon dates available for pollen cores in the study region and gives the calibrated age estimates for these dates. Dates from four radiocarbon dated cores not included in the NEEPD (owing to unavailability of raw data) were also used to improve the dating framework (Table 3.8).

Raw radiocarbon dates from the dated cores were calibrated from radiocarbon years BP to calibrated years BC/AD, using the Calib3 calibration program (Stuiver and Reimer 1993). Calibration of radiocarbon dates does not produce one single calibrated date for a given radiocarbon date, but an age range. This is because a radiocarbon date is not one single date, but is given as a mean value plus a figure indicating one standard deviation around the mean (for example, with the radiocarbon date 5246 ± 100, 5246 is the mean age of the radiocarbon determination, with the ± 100 indicating that the "real" age has a 68.26% probability of lying within plus or minus 100 radiocarbon years of this mean). Calibration plots the corresponding calibrated date for the mean radiocarbon age, plus it also plots the range of calibrated dates corresponding to one standard deviation around the mean radiocarbon age and also two standard deviations around the mean radiocarbon age (a 95.46% chance that the "real" age lies between the two standard deviations age range). Since conventional statistical practice indicates that we should not normally be satisfied with less than a 95% probability, rather than a 68% probability (Shennan: 1988), two standard deviations are most commonly used. Sometimes, following calibration more than one date range is produced for a given radiocarbon date. This happens most commonly when there is a "wiggle" in the calibration curve, where more than one calibrated date corresponds to a given radiocarbon date. In these cases, the calibration program indicates which of the several date ranges has the highest probability. In this study, calibrated dates are expressed as the midpoint of the calibrated date range with the highest probability. (Dumayne 1993; Pearson & Stuiver 1986; Pearson *et al.* 1986; Stuiver & Reimer 1986). The midpoint was chosen since only one date can be assigned per level (rather than a date range) when interpolating dates in Tilia. When using midpoints to date levels, it must be borne in mind that they are not precise dates, as each date lies within a range.

These midpoint dates were assigned to the relevant pollen levels, and dates were interpolated for all the levels between the dated levels using Tilia. Age/depth curves were drawn for all the dated sites to check the accuracy of the interpolations (Fig 3.3); the presence of hiatuses and stratigraphical changes which could affect the accuracy of the age/depth curves were noted.

3.4.5 Assigning dates to non-dated cores

Dates were then calculated for each level from each non-dated core. This was done by careful cross-correlation from suitable cores with radiocarbon dates. Cross-correlation is carried out by finding events common in the pollen curves between the radiocarbon dated sequence and the non-dated sequence. If the two cores, dated and undated, are from a similar type of location (including elevation), it is assumed that the common events occurring in both pollen curves will tend to have a similar date. This assumption that similarity in pollen curves implies similarity in date, however, does have its problems, which will be discussed below, and in making cross-correlations, considerable care must be taken. The method of cross-correlation to assign dates to non-radiocarbon dated sequences is commonly used by pollen workers to correlate non-dated sites with nearby dated sites (for example, Tipping (in press) with the Cheviot sites, Mannion (1978) correlating Threepwood Moss with nearby Din Moss (Hibbert & Switsur: 1976). Tree and shrub pollen curves in particular tend to be used, since the greater distance over which tree and shrub pollen can travel compared to pollen of herbaceous taxa means that two pollen sites close together are more likely to share similarities in tree and shrub pollen curves than herbaceous pollen curves (which also vary considerably with changes in local conditions). Commonly used biostratigraphical events include the *Corylus* (hazel) rise, the rational rise[3] of *Alnus* and the *Ulmus* decline, all of these being characteristics used by Godwin (1940, 1975) to demarcate his pollen zone boundaries. (Table 3.9 gives radiocarbon and calibrated midpoint dates BC/ ADfor the *Corylus* rise, *Alnus* rational rise and *Ulmus* decline from radiocarbon dated sites across north-east England).

The validity of using such events in the pollen curves to date non-radiocarbon dated sequences has been queried by calling into question the assumed synchroneity of such events. Recently there has been considerable evidence to suggest that these stratigraphic events are far from synchronous over large areas (Smith and Pilcher 1973), and that even over small areas the timing of such events may vary quite considerably, owing to variations in local conditions (for example at North Gill in the North York Moors the occurrence of the *Ulmus* decline has been shown to vary from 5600 BP to 3500 BP between sites only 350 metres apart (Turner, Simmons and Innes 1993). These studies shed doubt on the validity of the use of these events as chronologically synchronous markers. However, if used with care between similar types of sites over small areas, and taking into consideration changes across the whole pollen diagram rather than just the particular stratigraphic marker taxon itself, it is possible to gain an idea of the rough date of these events for non-dated cores. The validity of such dates is further strengthened if spatial trends in the timing of such events can be discerned from the radiocarbon dated sites. For example, if the *Alnus* rise is dated at Mordon Carr (Bartley *et al.* 1976) in the Tees lowlands at 6540 cal. years BC, and at Weelhead Moss (Turner *et al.* 1973) in upper Teesdale at 5140 cal. years BC, and we know from plotting all the dates for the *Alnus* rise onto a map that there is a trend that this event occurs earliest in the south east of the region and latest in the west, then it may be predicted that a site lying between the two will have a date intermediate between the two. Once dates had been assigned to these events, dates were interpolated for all the other pollen levels in between, as before.

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[3] The **rational** rise of a pollen taxon refers to the first continuous occurrence of that taxon above 2-3%, as opposed to the **empirical** rise of a taxon, which refers to its first ever occurrence in a pollen diagram.

Assigning dates more recent than the *Ulmus* decline proved to be problematic, for a number of reasons. Firstly there are no major events occurring commonly in the tree and shrub pollen curves of many pollen diagrams that can be assumed to be synchronous enough to be used for cross-correlation (by "synchronous enough" it is meant that the event should fall at all sites where it is radiocarbon dated to within a 500 year period, since this is the duration of period used for pollen mapping in this study). The exception to this, perhaps, is the appearance of (beech) pollen (Birks 1989), and the reappearance of gymnosperm pollen (*Pinus* (pine) and *Picea* (spruce)) at the top of many pollen diagrams associated with the spread of conifer plantations after the 1750s (Davies and Turner 1979).

Secondly, if any major events in the tree pollen curves did occur, they could be much obscured and modified by human activity in the landscape, such as woodland clearance. Thirdly, events associated with human activity, such as rises in *Cerealia*-type (cereal) pollen cannot be assumed to be widely synchronous. Using this sort of information to date cores could easily lead to circular reasoning, if it is the timing and nature of such human activity that we are aiming to investigate.

Despite these problems, interpolating dates in post *Ulmus* decline levels can be improved if very strong similarities in the pollen curves are observed in cores in close proximity, on similar types of land. In these cases, dates can be cross-correlated with more confidence. Also, where the top of the core can be shown to be the present day, interpolations can be worked back from the present.

Bearing in mind the pitfalls associated with both cross-correlation and interpolation, and the general problems of accuracy of radiocarbon dates, the dates assigned to each level must be viewed with some care, and used with a large error margin. Obviously, cores far away from any others and very different in nature from others will have far greater margins of error than those close by and similar in nature to radiocarbon dated sites. On account of these errors, a time resolution of no finer than 250 years at most will be used in producing maps, and in most cases 500 year time periods will be used.

3.5 The pollen dataset for north-east England: an overview of its characteristics

In all, some 180 pollen cores from 149 site locations meet the criteria for entry into the NEEPD (Table 3.1). Not included in the NEEPD, but noted, are 64 further pollen cores which for a number of reasons did not meet the criteria for entry (Table 3.2). Either data were not yet available, because cores were still being studied or were still being used in publications (for example Walton Moss, Fozy Moss (Dumayne 1992, 1993; Dumayne and Barber 1994; Barber, Dumayne and Stoneman 1993), data were not available in sufficient detail, i.e. only summary diagrams were available (for example Bolton Fell Moss (Barber 1978, 1981) or Summerlodge Tarn and Cotterend Tarn (Hall 1979), where only tree pollen data were available), or published diagrams were not clear enough to read off data (for example Simy Folds (Donaldson 1983)). Other pollen cores had insufficient levels or information to enable dates to be assigned (for example Waskerley (Hodgson 1974)), or no grid references were available and the sites could not be located (e.g. Bink Moss, Black Hill, Brown Dod (Turner, unpublished). Further sites were not entered because they were very close to, or on the site of, another more recently created or more detailed sequence that covered the same time period (for example Upper Valley Bog (Johnson and Dunham 1963)), or were outside the study region boundaries but not sufficiently detailed or dated to be included (for example Abbot Moss (Walker 1966) and North Gill A (Simmons 1969)). Table 3.3 summarizes reasons for such sites failing the criteria for entry into the NEEPD.

3.5.1 Core site distribution

In order to reconstruct past vegetation and land-use across the region, it is important that the pollen cores used represent as many of the different types of landscape in the region as possible. The following section will discuss the distribution of core sites and consider whether they are evenly distributed across the range of landscape types discussed in Chapter 2. Information about the distribution of the pollen cores respective to county, elevation, and underlying geology is summarised in Tables 3.11 to 3.15.

A major drawback with using pollen cores is that, by their very nature, they tend to be restricted to certain types of landscape where pollen preservation is favoured - predominantly in areas of peat cover on moorland uplands where local pollen rain will be dominated by taxa characteristic of blanket bogs and mires. However, pollen cores from alluvial sediments, lakes, infilled glacial features such as kettle holes, and soils (including sediments from archaeological sites) can provide a picture of more lowland landscapes.

The actual distribution pattern of pollen cores is a product largely of research interests, as well as being restricted by where pollen is well preserved. Figs.3.1 and 3.2 show the distribution of pollen cores across the study region. The following account describes the distribution of core sites across the region and the research projects responsible.

3.5.2 The uplands

Most notable is a distinct concentration of cores taken in the North Pennine uplands and the uplands of southern Northumberland around the upper South Tyne and its tributaries. A large proportion of these cores have been taken by Dr J. Turner and her students and colleagues with the aim of discerning patterning in the distribution of tree taxa from the Boreal period to the Sub-Boreal (Casiker 1973; Godfree 1975; Hall 1975; Hodgson 1974; Turner and Hodgson 1979,1981,1983,1991; Sturlodottir 1983; Sturlodottir and Turner 1985). Despite the large number of cores, many of these are quite short in timespan (many covering only one of Godwin's pollen zones) and the majority are undated. Exceptions to this are the long sequence at Pow Hill in the upper Derwent valley (Casiker 1973; Turner and Hodgson 1981), and a group of cores taken to investigate land use in the upland valleys (notably Steward Shield and Bollihope Bog (Roberts *et al.* 1973). The concentration of core sites is most marked in the Upper Tees valley and Cross Fell area, unsurprisingly since it has been the focus of botanical research into the distribution and history of the Teesdale rarities (the Cow Green Reservoir project in particular looks at this issue (Turner *et al.* 1973), as well as doctoral research by Squires (1970), and research by Simpson (1976) at

Howden Moss and the work in the Cow Green Reservoir and Widdybank Fell area by Chambers, Hewetson, and Lowry (in Turner *et al.* 1973) and studies by Piggott (1956) in upper Teesdale, Godwin and Clapham (1951) and Turner (1984) on Cross Fell. Sites in this area provide some of the longest, radiocarbon dated sequences from the Tyne-Tees uplands, such as Valley Bog (Chambers 1974, 1978) and Weelhead Moss (Chambers 1974; Turner *et al.* 1973). Other studies in the Northern Pennines include pollen cores from upper Weardale (Rendell 1971) and to the north at Quick Moss (Rowell and Turner 1985), which focuses on an analysis of bog development.

A further concentration of upland pollen cores lies in the Cheviot Hills/Borders area, of which six closely distributed and well dated sites have been recently studied by Tipping (in press). A number of surrounding sites have long sequences (Mannion 1975, 1978 a, b), and many are dated or well correlated with the long dated sequence at Din Moss (Hibbert and Switsur 1976). Sites have either been studied to look at tree patterning or to supplement archaeological research in the area (Butler 1992 a; Davies and Turner 1979; Shennan and Innes 1987). Other pollen studies in the north of Northumberland and the Borders region of southern Scotland include C.H. Turner's study at Trickley Wood (1968), the core from Akeld Steads (Borek 1975), two cores from Black Lough and Edlingham studied by Moyle (1980), the core from Wooler Water (Clapperton *et al.* 1971), a series of southern Scottish cores by Newey (1967) and studies of late-glacial deposits in the Borders region by Mitchell (1948) and Webb and Moore (1982), which are not included in the database since their sequences finish before 8000 cal. BC. To the south, in the uplands of central and western Northumberland, work around the Roman wall has concentrated on investigating human activity in the landscape (Davies 1978; Davies and Turner 1979; Dumayne 1992, 1993; Dumayne and Barber 1994), with the exception of Muckle Moss (Pearson 1954, 1960) and Coom Rigg Moss (Chapman 1964). Scaleby Moss (Godwin, Walker and Willis 1957; Walker 1966), to the west in the Cumbrian lowlands, was included to provide a very long, well dated sequence for this part of the region. Other sites from this area, worked on by Blackburn in the 1930s (Blackburn 1947, 1953; Raistrick and Blackburn 1931, 1932) were of insufficient detail to be included; only summary diagrams are available and many herb taxa are omitted. These omissions make site representation in central Northumberland quite sparse, especially since the available cores only cover short, recent, time periods.

To the south east of the region, a number of sites along the Cleveland Hills and northern North York Moors were included in the database to help in characterising the vegetation of the southern part of Cleveland, which differs considerably from the neighbouring lower Tees lowlands in character. These include a group of sites studied by R.L.Jones (1971, 1976 a,b, 1977, 1978; Jones, Cundill and Simmons 1979), and sites investigated by Innes, Simmons and Turner as part of their studies of Mesolithic activity in the landscape (Innes 1981, 1989; Simmons 1969; Simmons and Innes 1981, 1985, 1987, 1988 a,b,c,d; Simmons, Turner and Innes 1987; Turner, Innes and Simmons 1989, 1993). To the south west, in Swaledale and Wensleydale, several pollen cores have been studied by Turner and students to investigate patterning in Atlantic tree pollen (Hall 1979), but since only tree pollen values were available, they were not included in the NEEPD.

3.5.3 The lowlands

Whilst there is a distinct concentration of cores in the uplands, the lowlands have not been neglected. The Tees lowlands and Magnesian limestone East Durham Plateau have been covered by Bartley *et al.* (1976) and Chambers (1974) with a group of long, well dated sequences, whilst to the north west on the lowlands around Durham there are a group of long, dated sequences studied by Turner and students, some, such as Hallowell Moss (Donaldson 1975; Donaldson and Turner 1977) and Cranberry Bog (Kershaw 1967; Turner and Kershaw 1973), focusing in detail upon land-use. The pollen data from Pity Me Carr (Talbot 1977) was not available in sufficient detail to be included in the database. Late-glacial cores not used in this study because their sequences finish before 8000 cal. BC have been studied at Neasham Brick Pit (Blackburn 1952) and at Romaldkirk and Burtree lane in Teesdale by Bellamy *et al.* (1966). A concentration of pollen cores in the Tees estuary and surrounding coastland have been studied as part of research carried out to investigate changes in sea level in this area (Tooley 1978). The lowlands of Northumberland are in contrast poorly represented, apart from a concentration of sites in the northern lowlands between Lindisfarne and Alnwick, where research has been carried out mostly by Bartley (1966), but also by Borek (1975), Davies (1978), Moyle (1980) and the Department of Archaeology at the University of Leicester (unpublished), on Lindisfarne. Camp Hill Moss (Davies 1978; Davies and Turner 1979) and The Lough on Lindisfarne are the only dated cores in this area, but the dates are recent (from 1500 BC at Camp Hill Moss.)

To summarise, the area between the Tyne and Tees is the best represented by pollen cores, with the greatest concentration of sites in the North Pennine uplands. The lowlands of this area have fewer sites, but a higher proportion of long, well-dated sequences. The distribution of cores in Northumberland is more patchy, with good coverage in the Cheviots, the uplands in south west Northumberland and the northern lowlands. Central Northumberland and Tyne and Wear are the most poorly represented areas; Tyne and Wear only has one recorded site, Cranberry Bog (Kershaw 1967; Turner and Kershaw 1973) The lack of sites here is most probably due to the highly urbanised nature of the county. Table 3.11 gives a summary of pollen core distribution by county, with Table 3.12 giving the distribution of dated cores by county.

Overall, therefore, the uplands of the region are very well represented by cores. Although Table 3.13 shows that the distribution of pollen cores in the different elevation bands from sea-level to 800 metres a.s.l. is quite even, the majority of these cores actually lie on moorland. Lunn, in Swan (1993), states that in Northumberland the moorland edge lies at only 200-250 metres a.s.l., and in County Durham slightly higher at 300m a.s.l. (owing to recent reclamation of moorland for agriculture, as has been explained in Chapter 2). This low moorland edge means that some 76% of cores technically lie in the moorlands, leaving 23% to cover the lowlands. (Tables 3.13 and 3.14). Similarly, if we look at the distribution of pollen cores according to bedrock geology (Table 3.15), there is a preponderance of cores on rocks of the Millstone Grit Series (42.7%), followed by the Carboniferous Limestone Series (24.4%), both of which are found mostly in the uplands of the region. Although it is unsurprising that a large proportion of cores should come from the blanket peat dominated uplands, the uplands cover the majority of the area of the region and most of the variation in elevation. Although in comparison the lowlands have a lower density of sites, there are a good number of cores at a range of elevations from sea level to 200 metres and on each of the different bedrock geology types. In addition, there are a greater proportion of longer, dated cores in the lowlands (Table 3.13) which offset the lower number of overall cores to some extent.

3.6 Conclusions

As new pollen cores are studied and the gaps in the distribution pattern are filled, it will be of great interest to compare the results with the pollen maps produced in this study. It is hoped that the NEEPD will continue beyond the requirements of the current research project, for archiving and curating pollen data for the region, for providing a research tool and reference source for other pollen workers and archaeologists studying in the region and beyond, and for serving as a guide for the construction of pollen databases for other regions.

4 The archaeological data set

4.1 Introduction

This chapter describes the nature of archaeological evidence available for reconstructing settlement and land-use in north-east England from the Mesolithic to the end of the Roman period. It also covers the construction of and summarizes the data entered into the archaeological database constructed for the purposes of this study. This archaeological database, containing archaeological evidence for settlement and land-use for each period from the Mesolithic to the end of the Roman period, was constructed using Paradox for Windows for comparison with the pollen data set using the combined archaeological and pollen methods discussed in Chapter 6. These data will be used to investigate particular issues concerning settlement and land-use in each period, the results of which are presented in Chapter 8.

The chapter divides into two parts. The first part discusses, period by period, the types of archaeological evidence available for the region, how they may be used to shed light upon settlement and land-use, and highlights problems with the data owing to research, recovery, and preservation biases peculiar to each period. A note is also made of the research carried out, survey projects and excavation work undertaken which are relevant to each period, and the sources of the archaeological data used in this study. For each period also, the problems with dating of evidence will be considered, including dating resolution (i.e. whether an artefact type be assigned only to the Neolithic, or early or late Neolithic, or given a more precise date) and type of dating available for the region. It is important that for the purposes of comparison with the pollen data each archaeological entry in the database be assigned a date within a 500-year period. However, as will be shown below, for certain periods the dating resolution of the archaeological data is poorer than the pollen evidence. Archaeological evidence can be dated by a variety of different means, including radiocarbon dating, but in most cases by typological similarities with evidence from stratified sequences or dated levels. In the majority of cases archaeological evidence is only assigned to a period or a subdivision of a period, e.g. Neolithic, or late Neolithic, rather than a specific date. For comparison with the pollen data, these periods and sub-periods had to be assigned dates. Dates in calibrated years BC/AD were assigned to each of the archaeological periods covered, by reviewing the range of available radiocarbon dates for archaeological evidence ascribed to each period and converting these dates to calibrated dates BC/AD using the calibration program Calib3 (Stuiver and Reimer 1993). Where radiocarbon dates were not available for the region for a period, dates were taken from surrounding regions, such as North Yorkshire, Cumbria or the Borders region of Scotland, from similar types of archaeology. Figure 4.1 shows the archaeological periods referred to in this study, their assigned date ranges in calibrated years BC/AD, their relationship with the 500-year periods used for pollen mapping, and with Godwin's (1940) pollen zones and the Blytt-Sernander units commonly used to refer to different periods in vegetation history. Tables of radiocarbon dates available for different types of archaeological evidence for each period are presented in Tables 4.1 to 4.4. Radiocarbon dates are given as calibrated midpoint dates (Chapter 3 describes how calibrated midpoint dates are derived from raw radiocarbon dates), to be consistent with the pollen radiocarbon dates, which are also given as calibrated midpoint dates.

The second part of the chapter describes the construction of the archaeological database put together for the purposes of this study, such as criteria for including archaeological sites in the database, and methods used to assign a date and period to each archaeological entry in the database. This section also presents some summary statistics about numbers of different types of evidence included in the database, broken down by period, by county, and also by elevation. The database was constructed by listing sites from all the available gazetteers and compilations for archaeological evidence for settlement and land-use for the region for period under study. This was brought up to date by searching in the relevant literature and journals. However, the database is by no means a totally complete and up to date list of all the relevant archaeological evidence, since it does not include finds from unpublished excavations and surveys recently carried out.

4.2. Research, destruction and recovery biases and archaeological distribution maps: some general comments

The types of evidence which have been used in the archaeological literature to shed light upon settlement and land-use range widely in type, from field systems, palaeobotanical evidence (carbonised seed and other plant remains) and bone assemblages which can most directly be used to shed light upon the nature of past economic activity, to evidence for settlement structures and artefact scatters which are used to gain a picture of density and distribution of activity in the landscape. Obviously, the nature of the archaeological evidence available varies from period to period.

The distribution patterns of such types of evidence must however be treated with caution, and must not be interpreted as directly reflecting the "actual" pattern of settlement or land-use in the past. The dangers of accepting archaeological distribution patterns uncritically have been much discussed in the archaeological literature (discussions pertaining to north-east England include Young 1986, Haselgrove 1982, 1986 and Haselgrove and Healey 1992). Numerous factors biasing distribution patterns need to be taken into consideration, and these are discussed below.

Biases due to research interests in certain types of artefacts, or certain types of site, or interest in particular parts of the region lead to some areas and artefact types being more completely studied than others.

An example of this is the traditional focus in studies of the Roman period upon the study of Roman military sites as opposed to rural settlement. Subsequent research, however, involving aerial reconnaissance programs (initiated by Harding 1979, Riley 1980 and others), field walking, and excavations of sites revealed by survey, have revealed a large number of settlement sites dating to the later Iron age and Roman period to redress the balance. This has had a particularly notable effect on the settlement distributions of lowland County Durham and Cleveland. Prior to widespread aerial reconnaissance only two sub-rectangular, "rectilinear" enclosures dating to the later Iron age and earlier Roman period were known, at West Brandon in County Durham and Whickham in Tyne and Wear (Haselgrove 1982), whilst now more than fifty such sites are known for the area (Haselgrove 1984). However, even such recent work is producing a biased picture; an example is the concentration of excavation work on sites at, and in the vicinity of, the major late pre-Roman Iron age to first century AD site of Stanwick (Turnbull 1981; Haselgrove *et al.* 1990), such as recent excavations at the sites of Melsonby (Haselgrove *et al.* 1994), Scotch Corner (Abramson 1985) and Rock Castle (Fitts *et al.* 1994). Further examples of the research interests of a particular worker or project biasing the distribution pattern of sites, include the large number of sites produced by intensive survey by Coggins (1986) and co-workers in Upper Teesdale, the work by Young in Weardale (Young 1980,1984, 1985, 1987,1989,1992,1993,1994) the intensive survey of the Milfield Basin area and Yeavering area, near Wooler, with its large numbers of henges and related monuments (Miket 1976; Harding 1981; Ferrell 1990), the considerable amount of work by Jobey in Northumberland, and projects such as the Durham Archaeological Survey, involving intensive field walking of fields in specific study areas of the county (Haselgrove *et al.* 1988.)

The method of archaeological investigation being used can also lead to certain types of evidence being over-represented compared to others, and certain areas of the north-east being favoured. For example, results of aerial reconnaissance will produce site distributions biased towards those areas covered by the flight paths. An example of this is that the distributions of sites recognized by aerial survey in Durham reflect the search area of D.W. Harding (Harding 1979) and Gates (Gates 1982), whilst that in the area north of Newcastle reflects the research interests of McCord (McCord and Jobey 1968, 1971). In addition, sites will only be identified from aerial photographs if they are visible, and visibility of sites can be affected by a variety of factors, including time of year, time of day and weather conditions of a flight, the type of crop growing in a field, and dryness of the soil. Long-term aerial reconnaissance programs can, however, offset many of these problems. A further problem with cropmark and earthwork information from aerial surveys is that these types of evidence are very difficult to date, and in areas with few excavated sites, it may be very difficult to gain an understanding of the chronology of settlement and other structures. It cannot necessarily be assumed that similarity of shape implies similarity of date (Young 1993).

Another method of survey, field walking, will, by its nature, be restricted to areas being ploughed, which in the north-east of England, is almost entirely restricted to the eastern lowlands. As a result, distributions of artefact scatters are likely to be biased in favour of the lowlands, unless comparable work is undertaken in the uplands in meadow now being ploughed up for resowing, and in areas of peat erosion (Young 1986). Such work could go a long way towards redressing the balance of Mesolithic flint scatter distributions, which tend to be biased in favour of the coastal strip and, as the result of projects such as the Durham Archaeological Survey, to lowland study-areas that have been field walked (Haselgrove *et al.* 1988; Haselgrove and Healey 1992).

It is clear that the preservation and visibility of archaeological evidence are strongly affected by the nature of modern day vegetation cover and the nature of land-use following the construction of a site or deposition of an artefact. In the lowlands, where arable agriculture is more common, and most of the ploughed land in the region is situated, sites are only likely to survive as crop marks. Furthermore, aerial survey for crop marks will be biased against those areas under woodland, under modern industrial usage, under built-up areas, and under pasture. However, the creation of new buildings and roads can actually result in concentrations of archaeological sites as the result of rescue archaeology projects in these areas. In more upland areas, where land tends to be under more permanent pasture (although recently this has been replaced by ploughing and reseeding of once permanent pasture) or moorland, sites are more likely to survive as earthworks. However, here earthworks may have been obscured by later, medieval rigg and furrow, afforestation, the creation of reservoirs (although many sites in the Kielder Water area in Northumberland and Cow Green area of Upper Teesdale were discovered as a result of rescue excavation prior to building the reservoirs), the creation of spoil heaps from the mining of lead in Upper Weardale, and through the destruction of land due to quarrying. In lowland areas of pasture, such as the land along the lower Tees, sites are unlikely to be visible today as earthworks owing to subsequent alluvial deposition. A good example of subsequent land-use affecting the survival and visibility of earthworks is provided by Young (1992) for the cairnfield site of Crawley Edge, Stanhope, Weardale. The location of such cairnfields on high land marginal to present agriculture, usually just outside the boundary of modern enclosed land, suggests that this distribution might be largely an artefact of ploughing and other destructive land-use at lower elevations destroying cairnfields. An additional factor at this site is quarrying, which may have destroyed numerous cairns at one end of Crawley Edge, making it a larger cairnfield than the 41 cairns surveyed so far. Also, the higher elevation of the boundary of modern enclosed land in Weardale and Teesdale compared to further north in Northumberland and in the North York Moors, due to the extensive lead mining activity in these valleys, may have resulted in the greater destruction of cairnfields which in other areas would have survived. Young (1993) also notes earthworks in Weardale that are only likely to have survived since they are located within the boundaries of the Bishop's hunting park, and therefore have not been subject to ploughing or urbanisation. Such areas are "...islands of preservation in an overall sea of site destruction in Weardale." (Young 1993 p.14).

Distribution maps showing the location of areas where archaeological evidence has been destroyed by industry or development, and obscured by forestry have been produced by Ferrell (1992), the Durham Archaeological Survey (1988) and for Weardale by Young (1986). Figure 4.2 maps those areas of north-east England where land has been destroyed and clearly shows the concentration of "destroyed land" in the south of the region, particularly in the lowlands between the Tyne and the Tees. The urban developments in Tyneside and Teesside are clearly evident, as is the concentration of afforested land in the Border Hills of Northumberland in the Kielder Water area. Coal mining is responsible for the majority of destroyed land in County Durham and south-east Northumberland, in those areas that have not been damaged owing to urban development. In the upper valleys of the Northern Pennines, lead mining, limestone quarrying and other extractive industries, as well as the concentration of settlement in the valley bottoms, has contributed to the majority of destroyed land in these areas. In comparison the area covered by destroyed land across most of central and northern Northumberland is small, with those existing shaded areas being accounted for by forestry and settlement.

4.3. Nature of the available archaeological evidence for settlement and land-use for north-east England, from the Mesolithic to the end of the Roman period

4.3.1 The Mesolithic

a) Dating the Mesolithic (Table 4.1)

The date circa 8000 cal. BC was chosen for the start of this study, not because this marks the earliest known Mesolithic activity in the region, but because it marks, in the vegetation history of the region, the point at which tree pollen had increased to its maximum levels following deglaciation, and after this point the vegetation history of north-east England is dominated by the progressive deforestation of the landscape. Calibrated radiocarbon dates from Mesolithic sites dating to earlier than 8000 cal. BC are available for the north of England, from North Yorkshire, at the well-known Mesolithic sites of Star Carr and Seamer Carr. At Seamer Carr, a date on a wild horse mandible from the Mesolithic site preserved in peat deposits, produced a calibrated midpoint date of 9188 cal. BC (the derivation of a calibrated midpoint date from a radiocarbon date is described in Chapter 3). No dates as early as this are available for the study region itself, and no Mesolithic sites producing as much information on Mesolithic economy and technology have been excavated from the region. A list of some radiocarbon dates for the Mesolithic, and their associated calibrated midpoint dates, is presented in Table 4.1.

b) Lithic evidence

Most of the material record for the Mesolithic from the north-east is in the form of lithic scatters discovered during field walking or as chance finds, and very few sites have been excavated, let alone dated. There are no recorded traces of other activity, such as habitation structures, hearths or charcoal, which have a Mesolithic date. The flint finds from the region range from isolated single or small numbers of flint finds, to large assemblages of thousands of artefacts. It is important to note, however, that assemblage size may be strongly influenced by the nature of discovery. For example, large assemblages tend to be the product of excavation, systematic test-pitting or field-walking projects, whereas isolated finds tend to result from chance discoveries. Most field walking projects to date have occurred in the lowlands, owing to the higher proportion of ploughed land (Haselgrove *et al.* 1988; Haselgrove and Healey 1992). Upper Teesdale, predominantly unploughed, is dominated by small or single flint finds, although at some sites heavy river erosion has brought to light more extensive scatters (for example, at Staple Crag and Merrygill Holme, Coggins 1986). Only one site has been excavated in this area, Middle Hurth, with an assemblage of over 350 flints (Coggins 1986).

Numerous sites in the region have been listed in Raistrick's (1933) paper on the distribution of sites in northern England, Wymer's (1977) "Gazetteer of Mesolithic Sites in England and Wales" and in Weyman's (1984) gazetteer of "The Mesolithic in north-east England." The Durham Archaeological Survey presents results of field walking in three areas of the lowlands of County Durham (Haselgrove *et al.* 1988). Research on the Mesolithic by Young (1984, 1986, 1987) has been concentrated largely on Weardale.

The majority of flint finds and assemblages from the north-east have been assigned to a "later Mesolithic" tradition. There are no definite examples of lithics belonging to the "earlier Mesolithic" tradition, similar to those found at sites in the Vale of Pickering. However, two possibly early Mesolithic assemblages are mentioned by Coggins (1986) at Staple Crag and at Lartington (lower down the Tees), on the basis of the presence of shouldered points and perforated shale beads. No radiocarbon dates as yet have been produced to support this. This is on the basis of the presence of a high proportion of geometric forms such as microlithic tools, scalene triangles and points. The earliest radiocarbon date from the region for a "later" assemblage is from Filpoke Beacon which after calibration gives a calibrated midpoint date of 7772 cal. BC (Stuiver and Reimer: 1993). Weyman (1984) quotes radiocarbon dates from Seaton Carew ranging from 6750 to 6150 BC, from a fragment of red deer antler associated with flints (original source, Harrison and Mellars 1970).

Coggins (1986) assigns a much later date to most of the lithic finds from upper Teesdale, on the basis of their association with dated levels in pollen cores. For example, at Hard Hill, a stray flint find occurs in a peat level ascribed to the end of Godwin's pollen zone VIIa (Johnson and Dunham 1963). At the nearby pollen site of Valley Bog, this level has produced a calibrated midpoint date of 4830 cal. BC. The flint site of Merrygill Holme is found in a peat level dated at the nearby pollen site of Fox Earth Gill, which has produced a calibrated midpoint date of 4304 cal. BC.

Since so few dates are available which directly date Mesolithic assemblages, it is difficult to assign each site to a time period more specifically than "later Mesolithic". In many cases little information is provided about a site, except the location and sometimes the number of artefacts. Only rarely is information about typology and assemblage composition given, which might help the construction of a regional typology, and also which might be used to shed light on issues such as site function, on the basis of the stages of the manufacturing process present at a site, and the types of flint artefacts present. Because of the difficulty of dating, it is here assumed that the majority of flint find locations are dated to the later Mesolithic. The lack of dating, of evidence for structures, features, hearths and evidence other than lithics in the north-east is in direct contrast with sites in Cumbria to the west, such as the Mesolithic occupation sites at Monk Moors and Williamson's Moss at Eskmeals, where samples from hearths and other features on a postglacial raised shoreline associated with later Mesolithic type artefacts have produced a later Mesolithic calibrated midpoint date of 5642 cal. BC (Table 4.1).

b) Faunal evidence

The number of faunal remains for the region, like the number of excavated sites, for the Mesolithic in the north-east is low when compared to other areas, such as the Vale of Pickering to the south in Yorkshire, where well known sites such as Star Carr and Seamer Carr have produced abundant concentrations of artefacts and faunal remains. A number of faunal remains have been noted for Upper Teesdale, which also point to Mesolithic activity (Coggins 1986). At Middle End Moor a horn sheath most probably of *Bos primigenius* was recovered with traces of charring and cutting. *Bos* horns associated with flints were noted at Fendrith Hill and Teeshead. Other *Bos* horns have been found in the area in layers of zone VIIa peat, which would place them roughly contemporary with Coggins' proposed dates for Mesolithic activity in Upper Teesdale.

A discussion of the problems with attributing a date to the Mesolithic/ Neolithic transition in the north-east will be discussed in the next section. For the purposes of this study, the first three 500 year periods used for pollen mapping, 7800-7300 cal. BC, 6800-6300 cal. BC and 5500-5000 cal. BC are all attributed to the later Mesolithic, since the earliest dated context with later Mesolithic type lithic artefacts from the region has produced a calibrated midpoint date of 7772 cal. BC which falls in the first period.

4.3.2 The Neolithic

a) Dating the Neolithic (Table 4.2)

The term "Neolithic" as used in this study refers to the time period from the earliest appearance in the region of evidence of agricultural activity and Neolithic artefact types, including pottery, down to the end of the third millennium BC. Placing a precise date for the start and end of this period is difficult. Firstly, to determine the start of the Neolithic is difficult because of the relative paucity of Neolithic pottery from the north-east when compared to southern Britain, particularly from County Durham, where there is no recorded Neolithic pottery, and especially from radiocarbon dated contexts. Secondly, evidence for early agricultural activity is also scarce, in that there are no studied carbonised plant assemblages or faunal assemblages from the region from earlier Neolithic contexts. A further problem is that the use of traditional archaeological terminology such as Mesolithic and Neolithic stresses change rather than continuity, and in fact there may have been considerable continuity throughout the fifth-fourth millennia BC. The presence of *Cerealia*-type pollen in pre-*Ulmus* decline deposits has been used as evidence for early agriculture (Edwards and Hirons 1984) in the earlier fourth millennium BC. However, the accuracy of identification of *Cerealia*-type pollen from pollen of other large Gramineae must be considered in each case where pre-*Ulmus* decline *Cerealia*-type pollen has been claimed. Problems with the identification of Cerealia-type pollen and criteria used have been discussed thoroughly in Edwards (1989) and will be discussed in more detail in Chapter 5 in the discussion of the use of cereal pollen as an anthropogenic indicator.

Some early radiocarbon dates are available for Neolithic monuments and contexts with Neolithic pottery from North Yorkshire, although dates are scarce for the earlier part of the Neolithic from the north-east region itself (Table 4.2). Calibrated midpoint dates ranging from 3811 cal. BC to 3366 cal. BC have been produced for the long barrow site at East Heslerton near Malton in North Yorkshire, and dates of 4099 cal. BC and 3803 cal. BC for the long barrow at Seamer Moor, Vale of Pickering, 3845 cal. BC for the long barrow at Raisthorpe Manor, Thixendale, and dates ranging from 3499 cal. BC to 3208 cal. BC for the mortuary structure at Street House Farm, Loftus in Cleveland. Dates for contexts with earlier Neolithic type pottery come from Callis Wold, near Bishop Witton, Yorkshire, where earlier Neolithic Towthorpe Ware is associated with a Neolithic platform burial, producing calibrated midpoint dates of 3740 and 3540 cal. BC. Earlier Neolithic Grimston Ware pottery from a pit at Thirlings, Northumberland, has produced a calibrated midpoint date of 4027 cal. BC. Long barrows and similar mortuary facilities are generally accepted to be early Neolithic structures, but unfortunately very few definite examples of this type of structure are known from the study region. In the absence of dates earlier than the very beginning of the fourth millennium BC for Neolithic artefacts, contexts or structures from the north-east, the early Neolithic is here defined as extending from the early fourth millennium to the first half of the third millennium (and thus follows Chappell's (1987) definition of the early Neolithic and Whittle's (1980) "earlier Neolithic" period). This period corresponds to the 500 year period 3800 - 3300 cal. BC used for pollen mapping in this study.

The second group of radiocarbon dates available for the Neolithic from the north-east, when calibrated, fall into the second half of the third millennium BC (Table 4.2) and date late Neolithic pottery and structures such as henge monuments and stone circles. This corresponds to Chappell's (1987) definition of the late Neolithic as running from the middle of the third millennium BC to the end of the millennium. Defining the end of the Neolithic, however, is problematic, since although the start of the Bronze Age is conventionally put around 2000 BC (Manby 1986) there is a considerable overlap in radiocarbon dates between contexts with late Neolithic type pottery, other artefacts and henge sites on the one hand, and radiocarbon dates for contexts with Beaker pottery and other early Bronze Age pottery types (such as Food Vessels and Collared Urns). For example, contexts with late Neolithic type Peterborough Ware at Meldon Bridge in the Borders region range from 2236 to 2132 cal. BC, pits with late Neolithic type Grooved Ware pottery associated with a henge at Milfield North, Northumberland have produced calibrated midpoint dates from 2322 cal. BC to 1966 cal. BC (Harding 1981), pits with Grooved Ware at Thirlings, Northumberland have produced calibrated midpoint dates of 2159 cal. BC and 1962 cal. BC (Harding 1981) and at Whitton Hill hengiform monument, Northumberland, a cremation burial with late Neolithic Peterborough Ware pottery has a calibrated midpoint date of 1850 cal. BC (Miket 1985) (Table 4.2).

There is considerable overlap between radiocarbon dates for artefacts and structures assigned to the late Neolithic and those assigned to the early Bronze Age. Very similar late third millennium BC dates to the late Neolithic exist for Beaker and other early Bronze Age contexts from the region (Table 4.3). Calibrated midpoint dates earlier than 2000 cal. BC are common from Beaker contexts such as at Callis Wold, near Bishop Witton in Yorkshire and at Heslerton and Wetwang Slack in the Vale of Pickering, North Yorkshire. Calibrated midpoint dates of 2174 cal. BC, 2244 cal. BC and 2187 cal. BC have been produced for contexts at Milfield North, Northumberland with Beaker and Food Vessel pottery, and these are very similar to dates for the late Neolithic Grooved Ware pottery associated with a henge in the same area (Harding 1981). In addition, at Street House Wossit, near Loftus, Cleveland, contexts containing Bronze Age Collared Urns have early calibrated midpoint dates of 2066 cal. BC and 2133 cal. BC. It is clear that the transition between the Neolithic and Bronze Age is far from straightforward, and to date it to 2000 cal. BC is simplistic. The use of the traditional three age system terminology significantly overlooks a fair amount of overlap between artefact types and structures traditionally attributed to the different periods. However, for the purposes of this study, the date 2000 cal. BC is a convenient cut off point. The 500 year period 2800 - 2300 cal. BC is for the purposes of pollen mapping used to refer to the late Neolithic whilst the period 2000 - 1500 cal. BC is used to refer to the early Bronze Age.

b) Lithic evidence

The archaeological evidence for Neolithic in the region is mainly restricted to artefact scatters, predominantly lithic, and includes flint and chert artefacts, and polished stone axes and perforated tools. Lithic scatters are commonly used to test models of settlement (for example Haselgrove and Healey 1992), although technically they should be seen solely as indicators of activity, since no evidence of habitation (such as pits, hearths, structures, palaeo-economic evidence) has yet been found associated with lithic scatters in the region, and lithic scatters may be hunting sites, or lithic procurement sites rather than settlement sites. However, distribution patterns should be interpreted with extreme caution since they are largely a product of research interests and recovery techniques. Stone axes have been recently used to shed light upon land-use: they have been interpreted by Young (1994) as the by-product of Neolithic forest clearance in the uplands and agricultural activity, rather than as reflecting trade routes, using White and Modjeska's (1978) study of New Guinea stone axe deposition/loss/discard practices as an analogy.

Until recently, stone axe finds have not been catalogued in any great detail for the region, and records were spread disparately, although work by Burgess *et al.* (1981), and Cummins and Harding (1988) for the whole of the north-east, and Young (1994) for the area between the Tyne and the Tees have provided useful lists of stone axe and perforated stone tool find spots, as well as providing results of petrological examinations. Listings are also provided in Coggins (1986) for Upper Teesdale and Annable (1987) for some sites from the entire region, although her listing is not complete. No stone axes were found during field walking undertaken as part of the Durham Archaeological Survey (1988) in the lowlands of County Durham. A problem with stone tools is that most are single finds, many are un-provenanced, lost, untraceable or badly recorded. Dating of stone axes is also problematic as there are no definite occurrences from excavated settlements of a Neolithic date (although stone axes have been found at three possible Neolithic sites in the Durham dales, Young 1984).

> "...there is little evidence of an archaeological context for stone implements in north-east England.."(Cummins & Harding 1988).

In the absence of secure dating, stone axes from the region can only be ascribed a Neolithic/ early Bronze Age date range based on typological/stylistic similarities with artefacts from the rest of Britain from dated contexts.

Neolithic flint and chert scatters and finds from the region range from isolated single or small finds to large assemblages of thousands of artefacts. It is important to note, however, that the size of the assemblage is strongly influenced by the nature of discovery. Large assemblages tend to be the product of excavation, systematic test-pitting or field-walking, whereas isolated finds tend to result from chance discoveries. Most field walking projects to date have been located in the lowlands where almost all the ploughed land is situated

(Haselgrove *et al.* 1988; Haselgrove and Healey 1992). The uplands, predominantly unploughed, are dominated by small or single flint sites, although at some sites heavy water erosion has brought to light more extensive scatters (Coggins 1986). The number of excavated sites is small, and no traces of hearths, pits, structures or palaeo-economic evidence has been found. Neolithic finds are not covered in the extensive Mesolithic gazetteers by Raistrick (1933), Wymer (1977) and Weyman (1984), although the Archaeology in the North gazetteer (Clack and Gosling 1976) lists Neolithic scatters from the entire region, the Durham Archaeological Survey for areas in the Tyne-Tees lowlands, and Young (1987) for Weardale. Dating of lithics is problematic since in many cases sample sizes are too small to provide diagnostic lithics which can be dated with stratified, dated assemblages from outside the region. Where diagnostic lithics occur, they can be ascribed to an earlier Neolithic tradition and a later. Early Neolithic flint working is often hard to identify: in the south of England Mesolithic-type blade-like artefacts occur with leaf-shaped arrowheads. In the north-east, however, these arrowheads are typically isolated finds, with no associated industry, and therefore dating is more difficult. The late Neolithic is indicated by oblique transverse arrowheads, transverse points, flint knives, abundant scrapers and choppers. The presence of a transverse point, which occurs in late Neolithic/ early Bronze Age assemblages, has been used to date a small lithic assemblage at Ingleby Barwick (Adams and Carne 1995). At High House, Matfen, Northumberland, the presence of a flint knife and a high proportion of scrapers in the lithic assemblage as well as association with Grooved Ware pottery, characteristic of the late Neolithic (discussed in the pottery section below), was used to date the assemblage (R.Turner, 1989). This distinctive form of flint knife occurs commonly on the abundant Grooved Ware sites in East Yorkshire. A further dating aid is material; according to Young (1987) chert was not used in any quantity until the Neolithic and Bronze Age.

c) Ceramic evidence

Ceramic evidence is less common, particularly in County Durham. No pottery of Neolithic type was found during the Durham Archaeological Survey field walking project in the lowlands (1988), probably due to the low survival of local prehistoric pottery fabric. However, Neolithic type pottery is mentioned in Young (1984) for Weardale and two sherds of Neolithic pottery have been recovered from excavations at Catcote, near Hartlepool

(Long 1988). A possible Neolithic sherd of pottery has also been recovered from Site P, Village 3, Ingleby Barwick in Cleveland (Adams and Carne 1995). There are, however, several sites with sizeable Neolithic assemblages in Northumberland, such as at excavated sites in the area of the Milfield Basin near Wooler, an area with a complex of henges, ditches, standing stones and other supposedly "ritual" features. Pottery assemblages have been studied for Yeavering (Harding 1981; Ferrell 1990), Thirlings (Miket 1976) and Whitton Hill (Miket 1985). Pottery distributions can be interpreted as indicating settlement, although the portability of ceramics may mean that their final location may not necessarily be their place of use or manufacture.

Pottery is ascribed to the Neolithic on the basis of stylistic similarities with material from excavated sites from the region and elsewhere in Britain where dating has been carried out by association with diagnostic Neolithic artefacts and from radiocarbon dating. Pottery of the Grimston Ware type has been attributed an early Neolithic date. At Broomridge in Northumberland Grimston Ware is associated with early Neolithic type flints such as leaf arrowheads, as well as a Neolithic axe head, whilst at Yeavering it occurs in the earliest detectable phase of occupation of the palace site (Ferrell 1990) and in a pit from the henge site (Harding 1981), and at Thirlings more than four hundred sherds of Grimston Ware have produced a calibrated midpoint date of 4027 cal. BC (Miket 1976). It is generally held to have gone out of use by around 2700 cal. BC. Sites with pottery ascribed to the late Neolithic (Grooved Ware and Peterborough Ware) are very rare in north-east England, with Grooved Ware only being recorded from the Milfield Basin in Northumberland and at Hart in County Durham. Peterborough Ware has only been recorded from seven locations (R.Turner 1989), as it is most abundant in southern England and is rarely found north of the Wash (Ferrell 1990). However, a small amount has been identified at Yeavering, accompanying a cremation burial at the hengiform monument at Whitton Hill (Miket 1985). Also, to the north, in the Borders region, a more sizeable assemblage of late Neolithic type Peterborough Ware has been recovered from the defended Neolithic settlement site of Meldon Bridge and at Thirlings Peterborough Ware pottery has also been discovered (Miket 1976). Calibrated dates for Peterborough Ware from the region range from 2562 cal. BC to 2132 cal. BC (Table 4.2).

d) Structural evidence

Structural evidence divides into settlement evidence (which is sparse, especially in County Durham), funerary monuments and monuments such as circles, henges and standing stones.

> "Archaeological evidence of earlier prehistoric settlement in County Durham is still..sparse, particularly when compared to neighbouring counties such as Cumbria or Northumberland." (Haselgrove and Healey 1992).

One possible causewayed enclosure and cursus monument is however recorded at Hasting Hill, Offerton, Co. Durham.

i) Burial evidence

The majority of recorded structures occur in upland situations, particularly stone circles and standing stones, whilst the distribution of structures in the lowlands is far thinner, being mostly funerary or interpreted as ritual in nature, and include cairns and possible long barrows. A non-monumental burial at Hartlepool has been ascribed to the Neolithic (Annable 1987). An excavated Neolithic burial site exists at Copt Hill, at Houghton-le-Spring in County Durham (Harding 1970; Trechmann 1914; Young 1988). Further north, in Northumberland, a cremation burial at Whitton Hill has been ascribed a late Neolithic date from its association with Peterborough Ware pottery sherds (Ferrell 1990). However, when compared to the large numbers of long barrows to the south in Yorkshire, the numbers of recorded Neolithic burial sites is sparse. In the absence of settlement sites, funerary sites have been used as rough indicators of settlement by numerous workers, although in fact they are more an indication of activity than of settlement.

ii) Henges, stone circles and standing stones

Several henge monuments have been recorded for the Milfield Basin area, accompanied by a large number of other Neolithic structures (Harding 1981; Miket 1976). A henge monument has been excavated at Yeavering, to the south of the Milfield complex of Neolithic structures (Harding 1981), accompanied by a standing stone. In the central Milfield Basin the henges appear to be linked in a complex interrelationship with a series of parallel ditches termed an "avenue", but which is too irregular to be termed a "cursus".

Ceramic sherds from structures in this area range from late Neolithic types such as Peterborough Ware and Grooved Ware to Beaker and Food Vessel pottery types, implying a period of activity dating to the later Neolithic and Bronze Age.

e) Carbonised plant remains

Palaeobotanical evidence for Neolithic subsistence has been studied by van der Veen (1985) at two late Neolithic sites in Northumberland, Whitton Hill and Thirlings. No prehistoric settlement sites sampled for palaeobotanical evidence have so far produced waterlogged plant remains, and only carbonised plant remains are available. Carbonised plant remains from late Neolithic contexts are rare in Britain, but as Jones (1980) has pointed out, this may largely be the result of inadequate recovery techniques rather than absence of crop cultivation. The majority of late Neolithic sites from across Britain with carbonised plant remains produce small amounts of cereals and weed seeds, some fruits and large amounts of hazelnut fragments.

4.3.3 The Bronze Age

a) Dating the Bronze Age (Table 4.3) and ceramic evidence

A discussion of Bronze Age chronology is closely tied up with a discussion of the ceramic evidence, since it has played an important role as a relative dating tool in the creation of many a chronology for the period. Because of this, a discussion of the Bronze Age ceramic evidence available for the north-east will be included in this section.

The term "Bronze Age" as used in this study refers to the period extending roughly from the start of the second millennium BC to the early first millennium BC. This corresponds to the three 500 year periods used for pollen mapping in this study, the earliest period running from 2000 - 1500 cal. BC, the second from 1500 - 1000 cal. BC and the last period running from 1000 - 500 cal. BC. The first period will be here termed the "early Bronze Age", the second the "middle Bronze Age" and the third the "late Bronze Age and earliest Iron Age", although the use of these terms does not imply that these archaeological periods strictly start and finish at the start and end of each of these 500 year periods. They are, instead, convenient terms used to label these 500 year periods.

The series of changes in material culture, burial evidence and settlement types that has traditionally been attributed to the Bronze Age has been placed at around 2000 cal. BC (Manby 1986). However, as was discussed in the previous section on the Neolithic the use of the traditional divisions of the Three Age system tends to simplify the complex relationship between developments around the end of the third millennium and start of the second millennium BC, between the late Neolithic and the early Bronze Age. Despite the overlap in radiocarbon dates for late Neolithic and early Bronze Age artefacts, structures and other contexts, after around 2000 cal. BC the majority of radiocarbon dates available for the region are from Bronze Age contexts (Table 4.3).

The end of the Bronze Age is equally, if not more, difficult to ascertain. The 500 year period 1000 - 500 cal. BC used in this study is termed the "late Bronze Age and earliest Iron Age" since the transition between the two periods, like the transition between the later Neolithic and early Bronze Age, is not a clear one that can be placed at 500 cal. BC. Manby (1986) defines the advent of iron technology around the sixth century BC as marking the end of the Bronze Age, although Harding (pers. comm.) has placed the boundary at around 800 cal. BC. However, for the north-east of England the number of iron finds dating to the period 800 - 500 cal. BC is very scarce indeed (Haselgrove pers. comm.). In addition many of the developments occurring around this time in southern Britain, such as the adoption of spelt wheat, do not appear to occur in north-east England until later in the first millennium BC.

A further problem is that the settlement record for the first millennium BC is far from well dated, with curvilinear enclosed sites dating from the end of the second millennium BC throughout the first millennium BC at some sites, and even into the Roman period, overlapping with rectilinear enclosed sites that are more typically seen as Iron Age, and also with some unenclosed sites in parts of the region (Challis and Harding 1975; Ferrell 1992). In addition, the lack of typologically distinct pottery in the first millennium BC makes the identification of a clear break between late Bronze Age and Iron Age difficult. For the purposes of this study, it will be assumed that this transition occurs some time during the first half of the first millennium BC.

Traditionally in the archaeological literature the Bronze Age has been divided into an early, middle and late period, and even more complex subdivisions have been devised, primarily based upon the use of pottery as a relative dating tool (for example, the scheme provided by Burgess, 1980). However, radiocarbon dates from Bronze Age contexts have considerably changed the understanding of Bronze Age chronology and the dating of different types of pottery, and consequently the dating of contexts where such pottery is found. The chronology of different Bronze Age pottery types has undergone considerable reevaluation in the archaeological literature. The simple traditional linear sequence of pottery types from Beaker to Food Vessel pottery to Urns through the Bronze Age, which was the main tool for dating contexts where these pottery types were found, is no longer so straightforward, and whilst Beaker pottery types are reasonably well understood, and can be divided into early and late types, other Bronze Age pottery types are less easy to place in a clear sequence. As a result the complex subdivisions of the Bronze Age which relied mainly upon different types of pottery, such as the scheme produced by Burgess (1980), each subdivision being named after a type-site, have had to be reevaluated. Examples of Beakers, Food Vessels and various types of Urns have all been found in early Bronze Age contexts, whereas previously Beakers were thought to be confined solely to the earliest Bronze Age, Food Vessels to the early Bronze Age and the various urn types spanning the middle and late Bronze Age.

"..Beakers, Food Vessels and Urns were probably in contemporary use for much of their existence.." (Gibson 1980, p.26).

"The various urn types once thought to span the whole of the middle and late Bronze Age are now seen to have been contemporary with one another and have all been pushed back into the Earlier Bronze Age [although some are still found in later contexts]. Hence Food Vessel Urns, Collared Urns, Bucket-Shaped Urns and Cordoned Urns were all part of the early Bronze Age ceramic repertoire of northern England.." (Ferrell 1990, p.37).

To summarize, the discovery of contemporaneity of use of these various different pottery types in the early and middle Bronze Age has been ascertained primarily through the use of radiocarbon dating. This sheds doubt on the validity of the use of ceramics in the Bronze Age as a relative dating tool, and even more upon the use of ceramic types to name successive "periods" or phases within the Bronze Age. Instead variations of pottery type in burial may indicate rather more variations in social status, or local identities rather than variations in date. The use of radiocarbon dating and association with other types of artefacts should be used to ascertain the date of individual contexts instead of relying upon ceramic evidence alone.

A further problem with using pottery as a relative dating tool is its relative scarcity in north-east England compared to other parts of Britain. Pottery from this period is most often found in burial contexts, cists and barrows. However, the paucity of barrows in County Durham compared to Northumberland and North Yorkshire, and the paucity of Bronze Age pottery finds in general from the county diminish the value of ceramics as a dating tool in this area. Bronze age ceramic evidence for the north-east is covered by Gibson (1978) and Annable (1987), Beaker pottery for the north-east is reviewed by Clarke (1970) and by Tait (1965) for the Northumbrian Beaker evidence. A listing of later Bronze Age pottery can be found in Challis & Harding (1975). No Bronze Age pottery was recorded from field walking in the Durham Archaeological Survey (Haselgrove *et al.* 1988), probably due to the lack of survival of the local pottery fabric.

Despite the apparent contemporaneity of different pottery types at many sites, there are still some sites where the old linear sequence of Beaker-Food Vessel-Urn appears to hold out. An example of this is a cairn at How Tallon, part of a complex of prehistoric settlements, field systems, cairns, stone circles and cup and ring marked stones on Barningham Moor, Teesdale (Laurie 1977). Here a sequence of burials in the cist is associated with Beakers, Food Vessels and Urns (Gibson 1980). In addition, although some Beaker pottery has been found in later contexts, the majority of radiocarbon dated Beaker pottery dates to the earliest part of the second millennium BC, or earlier. Until recently, the chronology of Beakers was little known, and systematic radiocarbon dating had not been carried out on British material, being confined to Continental Beaker material. Clarke in 1970 had suggested a date around 1600-1500 BC for his "Northern British series" of Beakers, which stretch from the Forth to the Tyne, on the basis of associated metalwork, but according to Haselgrove and Hibbs (1984) a date before 2000 BC is more likely. This has been supported by more recent radiocarbon date work. Existing radiocarbon dates for Beakers were in many cases flawed owing to the use of materials not directly associated with the

Beakers. A recent program of radiocarbon dating of human bone from Beaker burials has been undertaken to find the spread of dates associated with Beaker burials (Ambers *et al.* 1992). Beaker contexts are almost always associated with inhumations rather than cremations (with the exception of two cremations from Dilston Park, Northumberland), in cists under barrows (with the exception of Kirkhaugh and Cartington in Northumberland, which have no cists) and rarely associated with rich assemblages, although flint blades, scrapers, arrowheads and bronze awls may be found.

Given that many pottery types traditionally ascribed to the middle and late Bronze Age have now been demonstrated to occur at earlier dates, there appears to be a definite ceramic "gap" in this period. It is however possible that some types may have continued in use into this later period, and more radiocarbon dated examples would be useful. Pottery found in middle and late Bronze Age contexts is difficult to date exactly on the basis of stylistic features, since in many cases decoration and other readily identifiable features are absent. Bucket urns have often been classed as a later second millennium BC Bronze Age ceramic type, as is flat-rimmed ware, occurring more commonly in Scotland, which has many parallels with bucket urns (Gibson 1980). The bucket urn from Eggleston in County Durham has been assigned to the middle Bronze Age on the basis of similarity in style, fabric and grit inclusions with pottery from Bracken Rigg, further up Teesdale, where the open settlement has produced a calibrated midpoint date of 1451 cal. BC (Coggins and Fairless 1984) and is associated with typologically middle Bronze Age flints (which are described below in the lithics section.) The Bracken Rigg pottery assemblage is of great value, since it is the only domestic assemblage from an area where Bronze Age pottery is scarce, and mostly funerary in nature. The large bucket urn from this site is similar to the cremation urns from Eggleston, Kirk Arran, Middleton in Teesdale (Coggins 1986) and West Hartlepool and its existence may indicate that these types of pottery were not solely for funerary purposes. Apart from these examples, the incidence of such pottery is very low in north-east England. The identification of pottery which can be definitely ascribed to the late Bronze Age or Iron Age is very difficult, since the distinguishable features of earlier Bronze Age pottery are now absent and most pottery is of a coarse, undecorated type. This will be discussed in more detail below in the section on the Iron Age.

b) Lithic evidence

Lithic scatters and finds continue to occur in Bronze Age contexts and the presence of types restricted to the early or middle Bronze Age, have been used as a tool for relative dating. Lithic scatters have been seen by Manby (1986) as some of the earliest evidence of bronze age settlement sites, although no excavations have been carried out on such lithic scatter sites, and there is no evidence for hearths, pits, structures or palaeo-economic evidence. Some flint scatters are associated with cairnfields and field systems, and therefore have been ascribed an early Bronze Age date. Bronze age lithic scatters have been listed in Haselgrove and Healey (1992) and Haselgrove *et al.* (1988) for the Tyne -Tees lowlands survey. An early Bronze age date is ascribed to most lithic scatters on the basis of typological similarities with lithics from outside the region of known date. Small leaf-shaped points and scrapers, barbed and tanged arrowheads and transverse arrowheads have all been ascribed to the early Bronze Age. However, a flint assemblage at Bracken Rigg in Upper Teesdale, containing characteristic Bronze Age types, such as a bi-facially flaked willow-leaf shaped point, serrated and notched flakes and a high proportion of scrapers, has been ascribed a later second millennium BC date from radiocarbon dating (Coggins and Fairless 1984). This suggests that these typologically Bronze Age lithics continued in use throughout the second millennium, and should not necessarily be restricted to the early Bronze Age.

c) Metalwork evidence

Metalwork finds ascribed the bronze age have been catalogued by Burgess (1986) for the later Bronze Age of northern England (1000-700 BC), Annable (1987) notes finds from the north-east for the whole period, and Manby (1987) notes finds for western Yorkshire and surrounding areas (including Teesdale) for the whole period. Challis and Harding (1975) list later Bronze Age gold find spots, whilst Coggins (1986) provides a listing for Upper Teesdale. Metalwork finds have been used to indicate settlement by certain authors:

> "Bronze implements are the most universal indicator of Bronze Age settlement at present available." (Burgess 1986).

However, the interpretation of isolated finds in terms of settlement has to be used with caution, since if they do not occur in stratified deposits it is difficult to disprove movement. Bronze finds may also indicate ritual deposits or agricultural use rather than indicating location of settlement sites. A well-known example of this is the Heathery Burn hoard of late Bronze Age metalwork in Weardale (Harding and Young 1986). The presence of metalwork should more realistically be used as an indicator of general activity, rather than settlement in particular, complicated by the possibility of movement of metal artefacts, and reuse.

d) Structural evidence

ii) Barrows and cairns

Structural evidence for the earlier second millennium BC is dominated by monuments interpreted as funerary in nature, with comparatively little evidence for settlement sites. Burial evidence, dominated by barrows and cairns (although as discussed below it should be noted that not all cairns are necessarily funerary in nature) has been used by many workers as an indicator of settlement, although technically it indicates only where burial was carried out rather than the location of settlement. Until fairly recently the consensus view was that barrows were rare in County Durham

"The west of the county [of Durham]...would in other similarly circumstance parts of England have been occupied with the cairns and barrows of the people who lived there; but such memorials of the dead are almost entirely if not altogether wanting on the Durham moorlands" (Greenwell 1877, p.440).

This image of an area with few Bronze Age burial sites continued up to the 1970s, when fieldwork by workers such as Coggins (1986) and Young (1980, 1984) began to redress the balance. Young (1980), in a survey of barrows and possible barrow sites from County Durham, has listed 101 recorded sites, and Coggins has highlighted many potential burial cairns in Teesdale (1986). More recent fieldwork and excavation in the Stanhope area of Weardale has brought to light a large group of some 41 cairns on Crawley Edge (the first cairnfield to be recorded for Weardale, and also the first recorded and excavated burial site) (Young and Welfare 1992), of which two have been excavated, producing a Collared Urn and tubular jet beads. A major problem with barrows is that many in this area are destroyed, mainly by ploughing out, and the distribution of barrow sites tends to be biased in favour of upland areas where ploughing does not occur. Young has discussed such problems of survival of barrows and other earthworks in detail (Young 1986, 1993; Young and Welfare 1992). Barrows and cairnfields tend to occur in areas marginal to modern agricultural activity, usually just outside the boundaries of enclosed land. Locations at altitudes around 300-400m a.s.l are common. Cairns and barrows may have occurred at lower elevations, but given the modern day concentration of ploughing and construction work in these areas, survival is unlikely. A second problem is that very few barrows or cairns have been excavated from this area, and correspondingly it is difficult to date barrows without evidence from associated artefacts or radiocarbon dates. A further problem is that without excavation it is impossible to distinguish cairns used for burial purposes from other cairns, or those which might have had only a secondary use as a burial site (the difficulties with ascertaining the function of cairnfields will be discussed below).

In comparison to County Durham, Northumberland and the Cleveland Hills are comparatively rich in barrow sites and in cairnfields, and there are a large number of excavated barrows and cairns from North Yorkshire. For example, some 1300 cairns have been recorded by Elgee (1930) for John Cross Rigg in the North York Moors, and 800 for Danby Rigg, and the numbers at this latter site have been further increased by recent work by Harding (1994). Jobey (1988) has recorded some 152 cairns at Camps Hill and Whitehill Head at Chatton Sandyford in Northumberland. In comparison to this, the numbers of cairns at Crawley Edge are small, although many may have been destroyed due to quarrying, ploughing or heather burning. It must also be noted that these high numbers of cairns do not necessarily indicate high numbers of burials; only a small sample of such cairns has been excavated, and although many of these contain burial evidence, it is also possible that cairns were created for land clearance purposes, and burial may have been a secondary function. There has in the past been considerable debate over whether cairnfields are groups of small burial cairns or instead the product of field clearance of stones for agricultural activity (as proposed by Fleming 1971), or even both, although now the consensus view appears to be that they were primarily for field clearance and may in some cases have had a secondary use for burial (Young and Welfare 1992). It is certainly possible that cairns created as the result of field clearance could be put to use as burial structures. The discovery of urns and other finds under some excavated examples has in the past been used to support the solely funerary argument, and the lack of finds under others were explained away as due to their destruction by acidic conditions (Greenwell 1877), a view which has persisted until recently. However, the use of some cairns for burial is not inconsistent with the theory of land-clearance. The use of land at such high elevations for agriculture is also plausible, given the occurrence of Medieval rigg and furrow at many cairnfield sites, such as at Crawley Edge. However, Bradley (1978) has pointed out that stone clearance does not necessarily imply land-use for agriculture, as soil erosion due to overgrazing may also result in stony ground which could be alleviated by clearance and creation of cairns. It is therefore possible that cairns may have been created either for agriculture, or grazing, or both. On the basis of the discovery of a saddle quern within a cairn on Crawley Edge, and the location of the site on a good south-facing slope leads Young and Welfare (1992) to suggest that arable use of the land in the vicinity of the cairn field is likely. However, the tendency of workers to present arable and pastoral as a dichotomy in prehistoric land-use is great, and it may be certainly possible that stones were cleared for a variety of purposes, depending upon local conditions, for grazing, for arable activity, or a combination of both. It will therefore be assumed that cairnfields represent good evidence for land-clearance, although unfortunately it is not possible to clearly distinguish whether they represent evidence for clearance for cultivation or grazing.

ii) Rock art

A further form of evidence for second millennium activity in the landscape is the existence of rock motifs such as cup and ring marked stones, usually found in groups or clusters, of which the largest are on the Fell Sandstone of Northumberland. Gazetteers of cup and ring marked stones in Northumberland are provided by Beckensall and Hewitt (1991), Morris (1989) and van Hoek (1991), and many sites are recorded in Clack and Gosling (1976). An important concentration of rock carvings occurs near Wooler, at Millstone Burn (van Hoek 1991), with multiple rings and unique markings not found at any other site, whilst at the northern end of the Northumberland group at Roughting Linn there is the largest carved rock in the area, with large numbers of a cup and concentric circles motif (Twohig 1988). A cup-marked stone also exists at the Milfield South henge (Harding pers. comm). Cup and ring marked stones have been found outside the main Northumberland area on Barningham Moor near How Tallon (Laurie 1977). A more unusual form of rock carving exists at

Goatscrag rock shelters in northern Northumberland (van Hoek and Smith 1988), in the form of carvings of deer or goats, parallels of which may exist in animal representations in southern Scotland, likely to be of Iron Age or Roman period date, but which recall Scandinavian Bronze Age rock art. The dating of rock carvings is difficult, and is based on analogy with sites where some the occurrence of such motifs in dated, stratified deposits occurs. Most cup and ring marked stones are thought to be Bronze Age in date, although they are not independently datable, based on their association with Bronze Age structures such as cairnfields. However, Burgess (1990) has made a strong case for cup-marks being a Neolithic phenomenon. The unusual Goatscrag rock shelter carvings may be of Bronze Age date, owing to the presence of an excavated Bronze Age site nearby, although this is only a possibility. The similarity with Scandinavian Bronze Age carvings may support this, although the existence of closer Scottish Iron Age and Roman zoomorphic carvings may suggest a later date.

iii) Settlement sites

Few undisputably second millennium BC settlement sites are known from County Durham, and few have been excavated. Manby (1986) notes the scarcity of second millennium BC Bronze Age house sites, and Haselgrove and Healey (1992) also note that the Bronze Age settlement evidence for Durham is sparse, with most of the known sites coming from the upper dales. Those settlement sites which have been excavated and dated suggest that the predominant settlement type of this period was of small, unenclosed structures, usually only consisting of one round house. Ferrell (1992) has termed these structures "open" sites. Jobey (1982) had also suggested that "open" settlements might fill the previous void in settlement evidence for the second millennium. Artefactual evidence from excavated sites shows a consistent early and middle Bronze age occupation. On the basis of excavated settlements, open settlements continue up to the end of the second and early first millennium BC. Excavations have been carried out at Bracken Rigg in Upper Teesdale, which has produced a mid second millennium BC radiocarbon date (1430 cal. BC) and is associated with a bucket urn burial attributable to the same period. On the basis of analogy with this site, Coggins (1986) suggests a second millennium BC date for a group of sites in the area, several of which are associated with leaf-shaped arrowheads. At Standrop Rigg the occurrence of bucket urns at this open settlement support this date (Coggins 1986). A lowland unenclosed settlement has been excavated at Catcote, next to the later pre-Roman Iron Age and Roman period settlement, which has been assigned a second millennium BC date on the basis of analogy with unenclosed houses at Staple Howe in the Vale of Pickering, North Yorkshire, and with Bracken Rigg in Teesdale (Vyner and Daniels 1989).

There are several examples of unenclosed, open, settlements in Northumberland, although previously evidence for Bronze Age settlement in Northumberland was thought to be rare. Unenclosed settlement in Northumberland usually consists of a single round house structure occasionally associated with cultivation plots and field systems (Jobey 1980). The open nature of the settlement and single round structure often make these settlement types difficult to identify and distinguish from other circular structures, and this may account for this type being under represented, although more examples have recently come to light, and some have been excavated. An unenclosed Bronze Age house site has been excavated at Lookout Plantation in the Till valley in northern Northumberland (Monaghan 1994), at Green Knowe in southern Scotland (Jobey 1981). In the Tweed valley there are a number of radiocarbon dated timber-built, unenclosed round houses which are placed in the mid second millennium BC.

In contrast with the unenclosed, open, single house settlements of the second millennium, earlier in the Bronze Age, there are many sites which have been radiocarbon dated to the early first millennium (the late Bronze Age) which are enclosed, by a curvilinear enclosure of various types. Traditionally in the archaeological literature settlement archaeology for this period and the subsequent Iron Age has been dominated by discussion of the typology and relative chronology of various types of enclosed sites, whether they are univallate, bivallate, or multivallate, palisaded or not (Manby 1986). Discussion of first millennium BC settlement has particularly been dominated by the development of "hillforts". However, such discussions have only limited relevance to north-east England, because although typical "hillfort" type settlements exist in parts of Northumberland and in Yorkshire to the south, they are virtually absent from County Durham. Exceptions to this include the promontory hillfort at Castlesteads, Dalton, North Yorkshire (Laurie 1984), the site of Maiden Castle, Durham (Jarrett 1950's) and a site near Shildon, which has not been excavated. Instead, Ferrell (1992), classes all sites surrounded by a curvilinear enclosure, whether univallate, bivallate or multivallate, palisaded or not, as "curvilinear". She attributes palisaded enclosures to the late Bronze age and earliest Iron Age (eighth-seventh century BC), whilst other curvilinear types continue through the Iron age and into the Roman period. (For example, many "enclosed" settlements, with sub-circular banks and enclosures have been dated to the late Pre-Roman Iron Age and Roman period, parallel with many rectilinear enclosures of this period, and are abundant in Northumberland and Cumbria, but sparse in Durham and other areas where rectilinear settlements predominate (Laurie 1984). It is interesting to note that many of these overlie earlier curvilinear enclosures typical of the earlier first millennium. This will be discussed in more detail below). Ferrell gives a date of approximately 1000 cal. yrs BC for early palisaded enclosures, and a date of 519 cal. BC for the start of bank and ditch enclosures (the traditional "hillforts"). Van der Veen (1992) notes that timber built palisades appear as early as the ninth century BC and are common during the first half of the first millennium BC. In Northumberland they overlap with open, unenclosed settlements, which here continue as late as 450 BC (Gates 1983). After about 500 BC many palisaded enclosures are superseded by bank and ditch enclosures. Most such hillforts are abandoned towards the end of the first millennium, although the exact timing is not known due to the lack of excavations and radiocarbon dates. Young (1987) has stated that the absence of a detailed chronology for the first millennium BC lies at the root of the problem of understanding the settlement of this period: only a few sites are excavated, there are only a few radiocarbon dates from the region, the material culture recovered from excavations is generally poor, the native pottery is insensitive to chronological seriation and several cultural groupings are aceramic, and lastly it is very difficult to date the large numbers of sites recovered from aerial photography and field survey. It is estimated that less than 5% of the known sites in the region are closely dated (i.e. within 200-300 years) (Chapman and Mytum 1983).

e) Carbonised plant remains

Carbonised plant remains radiocarbon dated to the late Bronze Age have been studied by van der Veen (1985) at the Northumberland site of Hallshill Farm, one of the later surviving unenclosed, open round houses occurring in Northumberland as discussed above, with associated field systems and cairns. These deposits are dominated by emmer and naked barley with some arable weeds and flax. Obviously this site cannot be regarded as representative of the Bronze Age as a whole, and more samples need to be taken from a wider range of excavated sites. The implications of the carbonised plant remains for late Bronze Age subsistence and land-use will be discussed in Chapter 8.

4.3.4 Iron Age and Roman period

These periods will be considered together as many types of evidence, particularly settlement evidence, continue from one period into the other, and in many areas there is continuity as opposed to change between the two periods.

a) Dating the Iron Age and Roman period (Table 4.4)

The terms Iron Age and Roman period are used here to refer very broadly to the last half of the first millennium BC and the first half of the first millennium AD respectively. This corresponds to the two approximately 500 year periods 500 cal. BC - cal. AD 70 and cal. AD 70 - 500 used for pollen mapping. (For these pollen mapping periods, the date AD 70 is used rather than the start of that century, since this corresponds to the arrival, dated by literary sources, of the Roman garrisons in northern England). As has been discussed in the previous section, the earliest Iron Age has been placed some time before 500 cal. BC, although the exact timing of the transition between late Bronze Age and the earliest Iron Age is not clear. Rather more straightforward is the dating of the start of the Roman period to the arrival of Roman garrisons in the north-east of England in the early AD 70s. However, the use of this date tends to conceal a considerable amount of continuity in the material record and settlement record of the late first millennium BC and early first millennium AD, the appearance of military installations excluded.

Examples of this continuity include the appearance of Iron Age type coarse handmade pottery in contexts dated to the Roman period, the continuity of use or alternatively the reuse for different purposes of beehive querns at many sites, despite the appearance of rotary querns and disc querns during the Roman period, and the continuity in occupation of some rectilinear enclosed settlement sites, some curvilinear enclosed sites (particularly in Northumberland) and certain unenclosed sites. For the purposes of this study the end of the

Roman period is placed at cal. AD 500, although this, again, overlooks a considerable degree of continuity in material culture and settlement types after the "official" date of the Roman withdrawal from Britain circa. AD 410.

b) Settlement evidence

In the absence of large numbers of good examples of Iron Age ceramics, relative chronologies have been devised for by relying on stratigraphical sequences at sites. However, despite the large number of settlement sites that have been revealed by aerial survey, comparatively few have been excavated, and as a result comparatively few radiocarbon dates have been produced. This makes the understanding of the chronology and interrelationship of different types of settlement form, whether enclosed or unenclosed, rectilinear or curvilinear, relatively difficult to ascertain, although Ferrell (1992) has suggested some basic chronological patterns of different types of settlement form.

It is now generally accepted that there are a variety of settlement forms which can be dated to the later first millennium BC and early first millennium AD and no fixed sequence of settlement forms, but instead a more complex picture of different types of settlement form existing at the same time in different situations and parts of the north-east. Many of these types continue into the Roman period. Ferrell (1992) establishes a general chronology for settlement types in this period. Settlements with curvilinear enclosures continue into the Iron Age and Roman period. Whilst curvilinear settlements with palisaded enclosures are allocated an earlier first millennium BC, late Bronze Age date, Ferrell (1992) attributes a third-fourth century BC date to curvilinear sites with box ramparts, whilst multivallate curvilinear enclosures are attributed to the later pre Roman Iron Age and continue into the Roman period. Running parallel to these curvilinear enclosures, settlements with sub-rectangular, "rectilinear", enclosures have been attributed a date range from the mid first millennium BC extending into the Romano-British period (van der Veen 1992). The number of known rectilinear sites has increased significantly with the use of aerial photography, particularly in the Durham lowlands. Rectilinear settlement has been divided into three size classes (Ferrell 1992), the largest of which are mostly of later Iron Age origin and some of which continue into the Roman period. The medium size class appear to have been abandoned by the Roman period, whilst the smallest size class is presently dated to the

Roman period only. Most rectilinear settlement types die out by the Roman period, although the small rectilinear settlements continue. Ferrell (1992) puts the origins of rectilinear settlements in the early Iron Age and they continue into the third century AD. Few sites are radiocarbon dated or excavated and therefore dating relies on scarce artefactual evidence. In the first centuries BC and AD those sites at higher elevations appear to have been abandoned, whilst lower-lying sites continued into the Roman period. At this time a few sites of a different nature appear in the Tees lowlands - large open, unenclosed, settlement types such as at Catcote, Ingleby Barwick and Thorpe Thewles, which expanded in this period beyond its original enclosure (Haselgrove 1982).

There is some variation in distribution of these different settlement types across the north-east. A particularly notable pattern is the widespread occurrence of curvilinear settlement in Northumberland (referred in the literature as "enclosed" settlement, Laurie 1984). Figures 4.5 and 4.6 clearly shows a concentration of curvilinear settlement in northern Northumberland, whilst further to the south, in the valleys of the North Tyne and Wansbeck, the Tyne corridor, Tyne and Wear and County Durham, curvilinear settlement is much less common, even in upland areas. Instead in these areas rectilinear settlement dominates, and the occurrence of curvilinear settlement is much more patchy. Jobey (1982) has noted that this pattern also occurs in Northumberland. Here Roman period settlement types in Northumberland divide into those with rectilinear enclosures in the eastern lowlands and southern dales, and those with curvilinear enclosures in the uplands of the north. There is, however, an interesting similarity in internal structures between curvilinear sites and rectilinear sites in the Iron age and Roman period. Both types have a standard interior arrangement of stone-built houses to the rear of a forecourt. The occurrence of similar structures inside earlier hillforts has been used to support a later date for these settlement types (Jobey 1982). Jobey (1964) has argued that the more "formal" nature of rectilinear settlements in southern Northumberland (as well as in County Durham) may be due to local Roman influence. However, the existence of rectilinear settlement in the later Iron Age appears to suggest that this pattern was in existence before the appearance of Roman garrisons after AD 70.

Despite the large numbers of settlement sites, curvilinear or rectilinear, which have been revealed through aerial photography and other survey, comparatively few sites have been excavated, particularly in County Durham. An example of an "enclosed", curvilinear settlement, typical of those found more commonly in northern Northumberland, has been surveyed near East Mellwaters Farm, Bowes, in Teesdale, County Durham (Laurie 1984). This site is similar in many ways to the Upper Teesdale sites of Forcegarth Pasture South and North (Fairless and Coggins 1980, 1986), and the unexcavated site at Wynch Bridge. All these sites have sub-circular stone banks and are located in non-defensive positions. Similar settlement types have also been discovered in the Eden valley to the west. Many of these sites overlie earlier ring-ditch, timber post construction, and in later, Roman period phases contain round, stone-founded houses. A common feature in the upland Pennines of settlement in the Iron Age and Roman period is the occurrence of extended linear settlements, with conjoined house structures and shared walls, often backing onto outcrops, such as the sites at Forcegarth Pasture South (Fairless and Coggins 1986), Dubby Sike in Upper Teesdale (Coggins and Gidney 1988), at nearby Rey Cross below a Roman camp, and at How Tallon on Barningham Moor lower down Teesdale. Many such settlements lie at high elevations, between 400-500m a.s.l., lying close to, or above, the limit of practicable permanent settlement. Coggins and Gidney (1988) have suggested such settlements may not have been permanent, since the plant remains from the site of Dubby Sike have no types suggesting arable agriculture or meadow for overwintering of stock, although it is a possibility that intensive use of the available land in the valley in this period may have pushed settlement closer to the limits of practicable permanent settlement. Radiocarbon dates from these sites suggest a later Iron Age and early Roman period date at Dubby Sike and Forcegarth Pasture North, and a late first-second century AD date for Forcegarth Pasture South. This is supported by artefactual evidence. The presence of rotary querns, disk querns and Roman period samian pottery sherds datable to the mid second century AD at Forcegarth Pasture South, unusual in an area otherwise devoid of Roman period artefacts, supports its Roman date. At Forcegarth Pasture North, in contrast, Roman pottery is absent, with only handmade Iron Age style pottery being present (Fairless and Coggins 1980). However, as will be discussed below in the pottery section, handmade Iron Age style pottery has been found in contexts dated to the Roman period, and therefore its value as a relative dating tool must be questioned.

Several recent excavations of rectilinear sites in lowland County Durham, (examples are given below) have gone a considerable way towards filling in the gaps in knowledge of settlement in this area, although the vast majority of rectilinear settlement in this area remains in the form of unexcavated earthworks identified by aerial survey. In southern Northumberland several examples of rectilinear settlements have been excavated. Many of these have a phase with a timber palisaded enclosure, which has been dated at other sites as early as the sixth-seventh century BC, but which here is shown to continue as late as the later Iron Age. Examples include the site at West Whelpington (Jarrett and Evans 1989) where two later Iron Age rectilinear timber palisaded enclosures containing timber round houses were replaced by stone constructions in the second century AD. A Roman rotary quern built into the foundations of a stone house is the main source of dating at this site. Similar rectilinear palisaded structures occur at the site of Belling Law where the first round house at the site has been radiocarbon dated to the third-second century BC, and also at Tower Knowe and Gowanburn river camp (Jobey and Jobey 1988). Here also, earlier timber palisaded rectilinear enclosures were later replaced by a bank and ditch rectilinear enclosure. Several sites continued into the Roman period, such as the nearby settlement at Kennel Hall Knowe, as well as Belling Law and West Whelpington.

Further south, examples of excavated rectilinear settlements include Ingleby Barwick in Cleveland, a site with a possible rectilinear enclosure, which has been dated to the late Iron Age and continues into the Roman period, on the basis of radiocarbon dates and pottery (Heslop 1984). The site of Rock Castle, Gilling West, North Yorkshire, near the well-known late pre-Roman Iron Age site of Stanwick, has a long period of occupation. Radiocarbon dates have placed the occupation from an early first millennium date pre-palisade phase to an earlier Iron age date palisaded enclosure, which was later replaced by a rectilinear ditched enclosure, occurring roughly around the fourth-third century BC, with two circular buildings. Occupation at this site does not appear to continue beyond the first century AD (Fitts *et al.* 1994). A high quality pottery assemblage from a site at Scotch Corner, North Yorkshire, dates it to the early-mid first century AD (Abramson 1985). A number of the special unenclosed, "open" settlements restricted to the south east of Durham and Cleveland lowlands have also been excavated, including the site at Melsonby (Haselgrove *et al.* 1994), only three kilometres north of Scotch Corner, dating from before the Roman occupation to the later first century AD, and the site of Catcote, which on the basis of radiocarbon dates and pottery has a long period of occupation from before the Roman period to the fourth century AD (Long 1988). There is no definable enclosure to this settlement in any phase. The site of Thorpe Thewles also has an unenclosed phase (Heslop 1987). Here a large sub-rectangular enclosure dating from the late third-second century BC is followed by the expansion of the settlement outside the enclosure, and on the basis of the absence of wheel-thrown pottery from the Roman period, corresponds to the earlier, pre-Roman phase of Catcote.

One of the main aims of excavation of many of the sites in the south east Durham and Cleveland lowlands was to examine the relationship of these sites with the unusually large site at Stanwick in North Yorkshire. Here a preliminary phase of occupation in the later Iron Age was replaced by the construction of major earthworks in the first century AD, but this major phase of construction does not appear to have lasted beyond the first century AD (Haselgrove *et al.* 1990). It is particularly interesting that occupation at sites in the vicinity of Stanwick, such as Rock Castle, Scotch Corner and Melsonby, all do not continue occupation beyond the first century AD either. Abramson (1985) has suggested that their decline was closely linked to the decline at Stanwick, and that there was possibly a relationship of interdependence between these smaller sites and Stanwick, which may have served as the location of central authority and centre for distribution of trade items and high quality items found at the smaller sites which were not locally produced. With the decline of Stanwick it is possible that the smaller sites, which were no longer self-sufficient, failed to survive on their own.

b) Field systems and plough marks

Until recently, in the archaeological literature knowledge of field systems dating to the Iron age and Roman period in the north-east was sparse "..there is still surprisingly little evidence for field systems over much of Northern Britain." Cunliffe (1983, 87), although this was most probably due to a lack of survey or close examination, since numerous field-systems have always been recorded on Ordnance Survey maps of the region.

As Gates (1982) has pointed out, subsequent fieldwork and aerial photography has extended the distribution of field systems in the region considerably, and there is little reason to believe that they are any less scarce than in southern Britain. Obviously the distribution pattern reflects this distribution of research and where earthwork survival is relatively good.

A problem with the identification of Iron Age and Roman period field systems lies with the difficulties of dating such structures. Dating field-boundaries relies upon trying to link the field systems, terraces, lynchets or other types of boundary or cultivation with other structures, for example settlement structures, which can be dated. Only two examples exist of fields which can be identified with any certainty near Romano-British settlements in Northumberland (Topping 1989). It is often difficult to distinguish between field boundaries of a medieval, Romano-British or prehistoric date on the basis of structure alone.

A review of field systems has been provided in Halliday (1982), who notes the existence of some evidence for field systems in the Tweed valley, Redesdale and in the Hadrian's Wall area. Gates (1986) presents new evidence for Romano-British fields in Northumberland based on systematic aerial photography, field walking and ground survey. He has attempted to define morphological and size criteria for distinguishing Romano-British from prehistoric field systems. Field systems have also been recorded as associated with a number of excavated sites. For example, a field system consisting of an enclosure plus a possible "trackway" has been found at the late Iron age-first century AD site at Rock Castle (Fitts *et al.* 1994).

Ard or plough marks are known from reasonably reliable Iron Age contexts such as at Belling Law and Fenton hillfort, Northumberland (Jobey 1982). Ard or plough-marks have also been used as evidence for arable agriculture by Gates in the Roman period (1986). Marks have been found in pre-Hadrianic levels underneath more than a dozen forts and associated military structures along the Wall. However, there is no way of telling whether these are prehistoric or Roman period marks, and they may have been created whilst clearing scrub rather than ploughing for arable. Topping (1989) cites several ard mark locations associated with cord-rig cultivation of Iron age or Roman period date in Northumberland and the Borders. Ploughmarks have also been found in the natural boulder clay within the main cropmark enclosure and close to the possible "trackway" at the site of Rock Castle (Fitts *et al.* 1994).

c) Roman military installations

Ferrell's (1992) listing of settlement sites in north-east England includes the Roman period, although there is no attempt to include military installations and settlements in this survey. Clack & Gosling (1976) is the main source for locations of Roman military installations used in this study, given the lack of coverage of this type of site in Ferrell (1992) and Fairless (1989). The recent focus of research interest in this period has been on rural settlement rather than on military sites, in contrast to the former overemphasis of research on this subject, and to downplay the impact of Roman influence, and as a result this type of evidence has not been subject to much recent synthesis. However, the considerable amount of interest in the past in this subject has resulted in a large number of recorded military sites for the region.

"It is this aspect of the study if the region in Roman times that has received the closest and most prolonged attention from archaeologists; this fact..makes it unlikely that , with the exception of one area [the Durham coastal area], many sites remain to be located" (Clack and Gosling 1976, p.34).

d) Burial evidence

Outside Roman military sites, evidence for burials dating to the Iron Age or Roman period is very scarce for the north-east. However, an example of a late Roman period date double inhumation at Hartlepool, Cleveland has been excavated (Daniels *et al.* 1987), dated by the presence of a jet necklace of a type found in fourth-fifth century AD contexts. Unfortunately pottery from this site is undiagnostic, but its similarity to other locally made coarseware common of Iron Age types supports the theory that such pottery continued to be made well into the Roman period. The scarcity of Iron Age and Roman period burials in the north-east is in contrast to areas such as East Yorkshire where inhumations under square-ditched barrows are common, whether as single inhumations or burial grounds, with some more rare burials associated with vehicles or swords (Haselgrove 1984).

e) Artefactual evidence

Few types of artefactual evidence for settlement and land-use from the region for the iron age have been synthesised and studied in any detail. Haselgrove has noted that there is a scarcity of datable artefacts and a general rarity of artefacts on Iron Age settlement sites (1982).

i) Querns

Querns have been used as evidence for settlement and in particular to indicate the presence of cereals. "The large number of querns of varying types is sufficient evidence to show that grain was ground for direct human consumption " (Cunliffe in Chapman & Mytum, p.87).

" As querns are generally heavy objects, the likelihood is that their find locations will be close to their original use locations and hence to some extent are indicators of nearby settlement" (Gwilt 1992 p.9).
However, querns show only that grain was being consumed rather than cultivated in the vicinity of settlements. Few attempts have been made to synthesise the quern find locations from the region. However, Gwilt has undertaken a preliminary review of querns from southern County Durham and Cleveland, and suggested a reclassification of quern types. Saddle querns and rubbers - attributed to the Bronze Age and Iron Age - have been found on palisaded settlements and hillforts. These overlap to some extent with the later iron age and Romano-British beehive and bun querns. Heslop (1987) notes that beehive querns appear around 200 BC. Flat disc rotary querns have also been found in Roman contexts.

ii) Ceramic evidence

The problem of using Iron Age pottery to date sites has already been noted in the discussion of later Bronze Age ceramic evidence. The chronological insensitivity of the Iron Age local pottery of the north-east has been noted by several workers (Gates 1982; Jobey 1982). The lack of distinctive decoration, the rough, handmade nature of the pottery and its usually local manufacture which means that local materials are used, all add to the problems of using this material as a relative dating tool. An additional problem with using Iron Age type pottery is that it appears to have a very long occurrence in north-east England, extending beyond the Roman conquest, and may also stretch back into the later Bronze Age (Fitts *et al.* 1994). Very little ceramic evidence for the Iron Age exists from the region, particularly south of the Tyne (Haselgrove 1982). However, more recent excavations at rectilinear and open sites in south east Durham and Cleveland have produced good ceramic assemblages. A small, but high quality ceramic assemblage has been recovered at Scotch Corner (Abramson 1985) with coarse ware of Iron Age character, as well as Roman material, whilst a medium sized assemblage (some 337 sherds and fragments probably making up twelve vessels) consisting purely of Iron Age type coarse ware has been recovered from Rock Castle (Fitts *et al.* 1994). As discussed above, the use of such pottery may have continued into the Roman period. Similar pottery has been recovered from Thorpe Thewles, Catcote, Stanwick and sites in East Yorkshire. In comparison with Iron Age type coarse ware, there are many types of pottery which can be dated with some accuracy, on the basis of style and decoration, to specific centuries (and even to parts of specific centuries) within the Roman period, and can be used as a more accurate relative dating tool. The majority of Roman dated ceramic assemblages come from Roman military sites, although excavations at rectilinear and open sites dated to the Roman period have produced some pottery of this date. For example, at Scotch Corner, Roman, wheel-made pottery was the sole method used to date the site to the early-mid first century AD. Catcote has a very large assemblage of Roman period pottery, the largest so far recovered from a non-military site in the north-east, and unusually which covers the whole of the Roman period (Long 1988).

iii) Metalwork evidence

Examples of metalwork from excavated settlement contexts for the Iron Age and Roman periods are rare for north-east England, as are artefact finds in general for this period, outside of military contexts (Haselgrove 1984). It is difficult to tell from this lack of evidence whether there really were few portable artefacts, or whether this lack results from a high degree of curation and use of artefacts. The high degree of acidity and erosion in many parts of the area biases against the survival of metalwork. The majority of metalwork finds for this period are chance finds, sometimes unprovenanced, and the possibility of movement of artefacts from their original place of manufacture and use must be taken into consideration. Hoards exist, such as the Stanwick/ Melsonby hoard and occasional deposits in rivers and streams (MacGregor 1976). Gates (1986) notes that iron agricultural tools, including ard-shares, of Romano-British date are confined mostly to military contexts.

f) Carbonised plant remains

Until fairly recently, few sites from the north-east had any studied carbonised plant remains. " The study of Iron Age economy is not particularly well advanced in Northern Britain largely because of the sparseness of relevant environmental, faunal and floral samples. The topic is therefore extremely difficult to approach on anything but a site by site level." (Cunliffe in Chapman and Mytum p.87).

No carbonised plant remains have been studied for the earlier Iron Age, but late Iron Age plant remains have been studied by van der Veen at Coxhoe, County Durham (van der Veen 1983, 1985; Haselgrove 1982), a rectilinear settlement site, and Thorpe Thewles, Cleveland (van der Veen 1985). These assemblages are dominated by spelt wheat (*Triticum spelta*), hulled and six-row barley (*Hordeum* spp.), with emmer wheat (*Triticum monococcum*), which is common on Bronze Age sites, being very rare. At Rock Castle (van der Veen in Fitts *et al.* 1994), the carbonised plant assemblage yielded spelt, hulled barley and by the end of the occupation, bread wheat *(Triticum aestivum/ T. compactum*). Radiocarbon dates for the pit containing a Roman wheel-made vessel with bread wheat date the context to the late Iron Age or early Roman period, making this one of the earliest occurrences of free-threshing wheat in northern England. Free-threshing wheat had before only been found in Roman contexts such as at South Shields (van der Veen 1992) and in Roman period contexts at Catcote (Huntley in Vyner and Daniels 1989).

The associated weed assemblage from Rock Castle suggests that these crops were most probably grown and processed in the local area, as opposed to the grain being imported in from elsewhere. The plant assemblage from Scotch Corner (Huntley in Abramson 1995) contains spelt wheat and hulled barley, and, like Rock Castle, also some bread wheat. At Catcote the plant assemblage consists of spelt, hulled barley, some oats, which could possibly be a weed, and in the Roman levels, bread wheat (Huntley in Vyner and Daniels 1989). It is interesting to note that bread wheat seems to make its earliest appearance at small sites, such as has been noted in southern England, where it makes its first appearance at small, innovative farmsteads such as at Barton Court Farm and Bierton (Jones 1984).

In comparison with these lowland sites, a carbonised plant assemblage from Dubby Sike, in Upper Teesdale, dating to the late Iron Age and Roman period had no crop plants or other edible plants, and instead reflected the composition of the surrounding moorland vegetation (van der Veen in Coggins and Gidney 1988). These analyses go a long way towards filling the gap in understanding of Iron Age and Roman crop cultivation and processing and the implications of these assemblages for later Iron Age land-use will be discussed in Chapter 9. However, the study of carbonised plant material from earlier Iron Age contexts would be useful to investigate the timing of the change from the late Bronze Age dominance of emmer wheat and naked barley to a later Iron Age dominance of spelt wheat and hulled barley in the north-east.

g) Faunal assemblages

An assessment of available faunal assemblages for Iron Age sites in the Tyne-Tees has been provided by Haselgrove (1982); only three sites exist with small samples of more than 1000 bones. This is largely due to soil conditions unconducive to bone survival across much of the region. Such small sample sizes make it difficult to attach any importance to the results, although there is a predominance of cattle in the assemblages. This might, however, be a product of carcass dismemberment, use and waste disposal practices rather than reflecting the actual importance of cattle in the economy.

4.4 The archaeological database for north-east England

4.4.1 Construction of the archaeological database

a) Aims of the database

It was decided to construct an archaeological database for the purposes of this study, in addition to a pollen database, in order to compare the available archaeological evidence for settlement and land-use for each period from the study region with the picture of settlement and land-use reconstructed from pollen evidence. Methods used to compare pollen evidence for settlement and land-use with archaeological evidence are described in Chapter 6 and the results of these methods are presented in Chapter 8.

Since numerous gazetteers and compilations of the available archaeological evidence for the north-east of England already exist, the aim of this database is primarily to bring together the various lists and gazetteers available for each period into one single database, and to bring together into one database evidence for settlement and land-use from all periods from the Mesolithic to the end of the Roman period from the north-east. Secondly, the aim was to create a database which could be easily searched to retrieve data of any category, from any period and from any geographical area of the study region. To this end, the archaeological database, like the pollen database, was created using Paradox for Windows, the relational database characteristics of which would enable querying of data to be facilitated. In addition, by entering the database into the Arc/Info Geographical Information System or GIS (Environmental Systems Research Institute 1993) any combination of sites and findspots, categories and types of evidence, periods of evidence and evidence from different areas of the region can be easily displayed in map form. The use of a GIS also facilitates comparison of archaeological evidence with pollen evidence, by enabling pollen maps and archaeological maps to be easily compared. The precise means of comparison of the archaeological and pollen evidence will be discussed further in Chapter 6.

b) Archaeological data sources

The database is not designed to be a totally complete and up to date listing of all types of archaeological sites and findspots recorded in the archaeological literature and in county sites and monuments records from the Mesolithic period to the end of the Roman period. A literature search was carried out to identify those publications containing lists and gazetteers of archaeological sites and findspots for each archaeological period, and a search was made of all relevant archaeological journals for the north-east for any additional records of sites and findspots not discovered in the above search, particularly of the *Durham Archaeological Journal* (formerly the *Transactions of the Architectural and Archaeological Society of Northumberland and Durham*), *Archaeologia Aeliana* for Northumberland and Tyne and Wear and occasionally County Durham, *Archaeology in the North* for the whole region, and of major national archaeological journals such as the *Proceedings of the Prehistoric Society*, the *British Archaeological Reports*, the *Archaeological Journal* and reports by the Council for British Archaeology. The various sources of evidence used for the construction of the database vary greatly in what types of archaeological evidence they record, ranging from lists of settlement evidence (such as Ferrell 1992), barrow locations (Young 1980), field-systems (Gates 1986), stone axe findspots (Cummins and Harding 1988; Young 1994), pottery (Gibson 1978), metalwork (Burgess 1968), lithic findspots (Wymer 1977; Haselgrove and Healey 1992) or quern findspots (Gwilt 1992). However, some sources cover more than one type of archaeological evidence, most notably Challis and Harding's (1975) and Annable's (1987) gazetteers of metalwork, lithic (Annable only), pottery, burial and settlement evidence, whilst Clack and Gosling (1986) provide a gazetteer of a wide range of different types of archaeological evidence from Mesolithic flint finds to Roman military sites.

Secondly there is variation in the geographical areas covered by each study, from Coggins' (1986) listing of Upper Teesdale evidence, or Young's (1987) gazetteer of Weardale archaeological evidence, the concentration of the Durham Archaeological Survey in the lowlands between the Tyne and Tees (Haselgrove *et al.* 1988) and Gates' (1986) survey of field systems in Northumberland. Some sources cover the whole of northern England, such as Clack and Gosling (1986) and Annable (1987), whilst Challis and Harding (1975) cover part of the region in their study area from the Trent to the Tyne. Ferrell's (1992) study covers exactly the same area as this study; the counties of Northumberland, Tyne and Wear, Durham and Cleveland.

Lastly, each source of evidence varies in the archaeological period covered. Several sources cover more than one period, for example Ferrell's (1992) listing of settlement sites from the Bronze Age to the Roman period (inclusive), Challis and Harding's (1975) listing of evidence from the "later Prehistoric" period, covering the late Bronze Age, Iron Age and Roman period and Annable's (1987) coverage of evidence from the Neolithic to the late Bronze Age. Others, however, are restricted to evidence from one or two archaeological periods, such as Gates' (1986) concentration on Roman period field system evidence and Wymer's (1977), Weyman's (1984) and Haselgrove and Healey's (1992) concentration upon Mesolithic and Neolithic lithic evidence. Obviously, also, sources vary according to how up to date their listings of archaeological evidence are.

c) Types of archaeological evidence entered into the database

The archaeological database is also limited by the type of archaeological evidence it contains. Since the aim of this study is to investigate settlement and land-use, only archaeological evidence which could be used to shed light upon settlement and land-use was chosen to be entered into the database. However, the choice of such evidence was problematic, since archaeologists have often drawn upon a wide range of different types of evidence to reconstruct settlement and land-use, including evidence which at first sight does not appear to be relevant. For example, metalwork findspots may at first sight not appear to be relevant to a discussion of settlement and land-use, but they may be used to indicate activity in the landscape (bearing in mind that as portable objects, they may have been moved considerably). In addition, the nature of available archaeological evidence for reconstructing settlement and land-use varies from period to period. For example, for the Mesolithic, lithic artefact scatters are the main source of archaeological evidence, with only a few excavated sites with faunal evidence or evidence of structures such as hearths. Also, for the earlier Bronze Age structural evidence is dominated by barrows and cairns, particularly in County Durham, (although in Northumberland the number of known settlement sites has increased), whereas for the late Bronze Age and Iron Age settlement evidence is more abundant. Consequently, for periods where settlement evidence is scarce, other types of evidence such as burial structures and artefact scatters have to be relied upon to reconstruct settlement and land-use. The types of evidence available for reconstructing settlement and land-use for each archaeological period from the Mesolithic to the end of the Roman period have already been discussed in detail in the first part of this chapter and the dating evidence used to assign different types of evidence to each period.

d) Structure of the archaeological database

Unlike the pollen database, which is made up of a large number of interrelated tables containing a wide range of information about each pollen core and site, for the archaeological database it was decided to have a far simpler structure, with only one table. This is because, unlike the pollen database which consists of relatively few pollen sites but considerable numbers of different types of information about each site (i.e.

relatively few rows but many columns), the archaeological database consists of many sites and findspots but comparatively few types of information to be entered about each site and findspot (i.e. many rows but relatively few columns). As a result, one large table was created, with the following columns: easting, northing, site name, category, type and period. These columns will be explained in more detail below.

i) Grid Reference ("northing" and "easting" columns)

In keeping with the entry of pollen data, the Grid Reference of each archaeological site location is entered into the northing and easting columns, given fully as twelve figures (e.g. 3868000 5462000 rather than NY 868 462). This grid reference describes, if the entry is an artefact, the location of the find spot of an artefact, or a group/assemblage of artefacts. This can be problematic since artefacts are by their nature moveable objects and the find spot could be well away from the original point(s) of manufacture, use and discard, or the find might be unprovenanced. In these cases, the grid reference of an artefact cannot be used to tell us much about distribution of past activity in the landscape. A further point to note is that this database does not have a single entry for every single artefact; some entries are for groups of artefacts, or whole assemblages, whilst others are for single finds. However, this is made clear in the "type" column, where notes about the type of archaeological evidence is stored. If the entry is a settlement site, monument, burial or landscape feature such as a cairnfield or field system, the grid reference for the centre of that site. For entries such as Roman roads, the grid reference of the start and finish of a surviving road section is noted.

ii) Major category and type of archaeological evidence ("category" and "type" columns)

Next, the category of archaeological evidence for each entry is noted. By "category" it is meant the general class of archaeological evidence into which the entry falls. Categories are as follows. Artefact categories include lithic artefacts (stone and flint artefacts, whether made by knapping or pecking/grinding, or both, including debitage - waste - produced during manufacture) , pottery, querns and metalwork. Non-artefact (structural) categories include settlement evidence, burial structures, other monuments (including henges, stone circles, standing stones and rock art), landscape features (including cairnfields, boundaries and field systems), military sites (Roman, including camps, forts, signal stations and milecastles) and communications sites (including evidence such as roads and bridges). Each entry is then described in more detail in the "type" column. For example, types in the category "settlement" include "curvilinear", "rectilinear", "enclosed" and "open", describing the form of enclosure of the settlement, if present. Types in the "pottery" category include types such as "Grimston Ware", "Beaker", "Food Vessel" and "Urn".

iii) Period assigned to each entry ("period" column)

Lastly, each entry is assigned to an archaeological period, or to several periods, where that is not possible. For example, an entry describing a find of Grimston Ware pottery would be described as "ENEO", short for "early Neolithic", since all dated contexts with Grimston Ware pottery from the study region have been dated to the early Neolithic (i.e. before the mid third millennium BC). More details about the dates assigned to different types of artefact or structure, on the basis of radiocarbon dating or dating on the basis of stylistic/ structural similarities with dated sites or artefacts, have been provided in the first half of this chapter. Radiocarbon dates and calibrated midpoint dates for a range of examples of artefacts and structures for each period are provided in Tables 4.2 to 4.7.

In the database Mesolithic finds or sites are listed as "MESO", Neolithic as "NEO" (or as ENEO or LNEO if a site or findspot can be dated more precisely), Bronze Age as "BA" (or "EBA", "MBA" or "LBA" for the early Bronze Age, middle Bronze Age or late Bronze Age respectively), Iron Age as "IA" (or "EIA" and "LIA") and Roman period as "RO". Where an artefact type or settlement type cannot be restricted to any one period, a combination of periods can be entered, such as "LBA, IA, RO" which is entered for several curvilinear sites that cannot be dated any more precisely. The use of these abbreviations facilitates searching for entries by period, since for example a search for all entries dating to the Neolithic, whether "ENEO", "LNEO" or for example "NEO, BA" would be picked up by querying for "..NEO.." using Paradox for Windows.

4.4.2 Description of the database

The first part of this section provides a break-down of the different types of archaeological evidence entered into the database, the numbers of entries of each category and type, and other summary statistics. A note will also be made of the numbers of entries of each category and type assigned to each archaeological period, with a brief explanation summarizing the reasons behind dating each type of archaeological evidence. It must be noted that because certain types of archaeological evidence occur in more than one period, or cannot be dated with any accuracy to one archaeological period alone, these types of evidence will be recorded as occurring in both periods. As a result, if a tally is made of the number of entries in each period, if the number of entries in all the periods is added together, it will exceed the total number of entries, since some entries have been counted more than once, since they date to more than one period. An example of this is the "open" (unenclosed) settlement type, which is assigned an early and middle Bronze Age date, and the "curvilinear" settlement type which has examples dated to the late Bronze Age and Iron Age, and in some cases, beyond. A problem with this is that counting open settlements twice, once for the early Bronze Age and once for the middle Bronze Age, will tend to overestimate the actual numbers of open settlements in use in the early Bronze Age or the middle Bronze Age; not all the sites will have been occupied in both periods. However, the lack of sites which can be dated more accurately by association with artefacts and radiocarbon dating means that this crude system has to be used.

In the second part of the section a description of the distribution patterns of the different types of archaeological evidence available for each period will be made.

a) A summary of entries in the archaeological database (Table 4.5)

Table 4.5 gives an overview of the total number of entries in the archaeological database, divided by category. In total there are some 3346 entries in the archaeological database, including a wide range of different types of archaeological evidence which can be used to shed light upon settlement and land-use, and ranging in date from the earlier Mesolithic (circa 8000 cal. BC) to the end of the Roman period (circa cal. AD 500).

To give a picture of the composition of the archaeological database, if we look at the entries from all the periods together, there are some 984 artefacts in total (29.4% of the total number of entries), whilst the majority of entries (some 2362 entries) fall into the non-artefact group (which includes site categories such as settlements, burials, monuments, landscape features and military installations), making up 70.6% of the total number of entries.

The artefacts fall into the following categories: lithics, which make up most of the artefact entries (705 lithic entries, making up 21% of the total number of entries, 71.6% of the total number of artefacts), pottery (42 entries, 1.2% of the total entries, 4.2% of artefacts), metalwork (178 entries, 5.3% of total entries, 18% of artefacts) and querns (59 entries, 1.7% of the total, 5.9% of artefacts.)

The sites fall into the following categories: settlement sites, which have the largest number of entries of any category of archaeological evidence in the database (1285 entries, 38.4% of total entries, 54% of sites), burials (358 entries, 10.6% of total entries, 15% of sites), landscape features (cairnfields and field systems) (242 entries, 7.2% of total entries, 10.2% of sites), monuments (177 entries, 5.3% of total entries, 7.4% of sites), military installations (236 entries, 7% of total entries, 10% of sites), industrial sites (12 entries, 0.3% of total entries, 0.5% of sites), religious sites (10 entries, 0.2% of total entries, 0.4% of sites) and other sites including roads (42 entries, 1.2% of total entries, 1.7% of sites).

i) The Mesolithic (Table 4.6)

A detailed break-down of the entries for the Mesolithic, by category and type is presented in Table 4.6. There are, in total, 302 entries for the Mesolithic (9% of the total number of entries), consisting entirely of lithic artefacts, either in the form of single flint finds or flint scatters. Virtually all the entries have been assigned to the later Mesolithic period (circa 6000 - 4000 cal. BC) on the basis of typology, whilst only two artefact finds have been assigned to an earlier Mesolithic date (circa 8000 - 6000 cal. BC).

ii) The Neolithic (Table 4.6)

For the Neolithic period, there are 446 entries (13.3% of the total number of entries), of which the majority (336, 75.3% of Neolithic entries) are, like the Mesolithic, lithics. A detailed break-down of the different types of lithics for the Neolithic is given in Table 4.6. A large proportion of the lithic entries for the Neolithic consist of flint or stone axes (192 entries, 43% of all Neolithic entries), with lithic scatters and single finds of diagnostic Neolithic flint artefacts, such as leaf arrowheads, oblique arrowheads and transverse arrowheads making up the remainder of lithics attributed to the Neolithic. More detailed discussion of dating of lithics and diagnostic types has already been given in the first part of this chapter. Monuments of Neolithic date are the next largest category of entries for this period (70 entries, 15.6% of Neolithic entries), made up of 13 henges, 32 standing stones (or groups of standing stones) and 25 stone circles. These have been assigned a later Neolithic date on the basis of excavations and associated artefacts (as discussed earlier in the chapter), i.e. a date in the third millennium BC, corresponding to the period 2800 - 2300 cal. BC used for mapping the pollen in this study. There are only 24 entries for burial sites of Neolithic date (5.3% of Neolithic entries), low when compared to the large number of long barrow sites further south in Britain. There are also only 16 entries for pottery of Neolithic date in the database (3.5% of Neolithic entries), mostly assemblages from a small number of sites which have been excavated. Only three assemblages in the database can be assigned to the earlier Neolithic (earlier than the third millennium BC, corresponding to the period 3800 - 3300 cal. BC used for pollen mapping), and these are Grimston Ware assemblages. The rest are later Neolithic, with four Peterborough Ware assemblages, two Grooved Ware assemblages and seven other indeterminate entries for Neolithic pottery.

iii) The Bronze Age and earliest Iron Age (Tables 4.7, 4.8 and 4.9)

Tables 4.7 to 4.9 give a break-down of the numbers of entries that are attributed to the early Bronze Age, middle Bronze Age and late Bronze Age respectively into the archaeological database. A far larger number of entries (1674, 50% of total entries in the database) have been assigned a Bronze Age date (the second millennium BC and early first millennium BC, and corresponding to the three pollen mapping periods, 2000 - 1500 cal. BC, 1500 - 1000 cal. BC and 1000 - 500 cal. BC). The majority of these entries are settlement sites (739 entries, 44% of Bronze Age entries), made up of 176 "open" settlements and 563 curvilinear settlements. These "open" settlements exclude the small number of large unenclosed sites which appeared in the pre-Roman Iron Age in the south east of the region such as at Catcote, and for the most part can be assigned to the early and middle Bronze Age. However, some open sites, particularly in Northumberland, have been demonstrated to continue in use into the first millennium BC, and it is therefore likely that the actual number of Bronze Age open sites is somewhat less than the number entered. The second type of settlement assigned to the Bronze Age, "curvilinear" settlement, is assigned only to the late Bronze Age, as discussed in the earlier part of the chapter. However, radiocarbon dates and artefactual evidence show that many curvilinear sites continue in use throughout the first millennium BC and in some cases, later than this. It is therefore likely that not all these curvilinear sites belong to the late Bronze Age.

Landscape features also make up a sizeable proportion of entries for the Bronze Age (242 entries, 14% of Bronze Age entries.) These are made up of cairnfields (119 entries) and field systems (123 entries). As discussed earlier in the chapter, the majority of cairnfields are assigned a Bronze Age date, but field systems are difficult to date, except in cases where there is a definite stratigraphic sequence which has been dated. As a result, field systems could date from any time from the Bronze Age onwards, and it is possible that some examples may not be prehistoric, and in fact are medieval in date. Burial sites attributed to the Bronze Age are represented by 310 entries (18.5% of Bronze Age entries), the majority of which are most likely to be first millennium in date, and most likely to be early Bronze Age or Beaker barrows and cists. A further source of evidence for activity in the landscape, rock art, the majority of cases being cup marked or cup and ring marked stones (although there are some incised stones and one example of zoomorphic depictions at Goatscrag, Northumberland), is represented by 107 entries (6.3% of Bronze Age entries). Despite the difficulties of dating such features, it is generally accepted on the basis of examples in stratified situations or associated with artefactual and structural evidence, that they are a Bronze Age phenomenon.

Of the artefactual evidence for the Bronze Age, there are 67 lithic entries (4% of Bronze Age entries) which have been dated on typological grounds to the Bronze Age, of which 61 are typologically early Bronze Age, and six dated to the middle Bronze Age. More lithic assemblages may actually be of Bronze Age date than these, but if typologically distinctive types are absent, it may be difficult to distinguish assemblages from ones of Mesolithic and Neolithic date. Some 20 pottery finds and assemblages have been assigned to the Bronze Age, mostly to the second millennium BC (early and middle Bronze Age) on typological grounds. As discussed earlier in the chapter, few examples of late Bronze Age pottery are known, and those examples which do exist are difficult to distinguish from the coarse pottery of the Iron Age, often undecorated and as a result difficult to date.

The pottery entries break down into five Beaker assemblages, three Food Vessel entries, five Collared Urn entries, three Bucket Urn entries, three indeterminate urn entries and one other indeterminate Bronze Age pottery entry. There are also eleven entries for saddle querns (0.6% of Bronze Age entries), which have been found on open sites dated to the second millennium BC (such as at Forcegarth Pasture, Fairless and Coggins 1980, 1986), although they do also occur in later contexts. Metalwork, consisting both of single finds, multiple finds and hoards is represented by 178 entries (10.6% of Bronze Age entries), of which 26 entries have been dated to the early Bronze Age from the presence of typologically distinct forms, 61 to the middle Bronze Age and 91 to the late Bronze Age. The early Bronze Age metalwork entries include types such as flat axes (19 entries, including one hoard), two moulds for flat axes, two flanged axes, a dagger, tanged spearhead and halberd. The middle Bronze Age metalwork entries include seventeen axes, thirteen spearheads, eight rapiers, five palstaves and small numbers of flanged axes, shields and gold finds. There are twenty recorded hoards of late Bronze Age metalwork, thirty-one entries for socketed axes, nineteen spearheads, seven swords and small numbers of knives, rapiers, flanged axes and celts.

iv) The Iron Age (Table 4.10)

A total of 1258 entries (37.5% of the total entries in the database) have been assigned to the Iron Age period, corresponding to circa. 500 cal. BC - cal. AD 70 for the purposes of pollen mapping. The majority of these are settlement sites (1086 entries, 86.3% of Iron Age entries), comprising of curvilinear sites (563 entries), enclosed sites (44 entries), rectilinear sites (477 entries) and the open sites characteristic of the Pre-Roman Iron Age in south east Durham and Cleveland (two entries.) As has been mentioned in the previous section, curvilinear sites continue into this period. Rectilinear sites date from the Iron Age, but some continue into the subsequent, Roman period. Enclosed sites cover those sites in Northumberland with curvilinear enclosures, but sharing many internal features with those of rectilinear sites. Only five burial entries have been made into the database for the Iron Age (0.4% of Iron Age sites). Many of the field systems already mentioned (123 entries, making up 9.7% of Iron Age entries) may be of Iron Age date, although given the lack of dating evidence for this period, they could be placed in any period.

Of the artefactual evidence assigned to the Iron Age, there are six entries for pottery (0.5% of Iron Age entries) and 38 for querns (3% of Iron Age entries), of which 27 are beehive querns, which have been found in later Iron Age and Roman period contexts, and the remainder of which are saddle querns, which still occur on sites dating to this period. The small number of pottery entries is at least partly explainable by the coarse, difficult to identify nature of the pottery, and also its susceptibility to destruction by later ploughing.

v) The Roman period (Table 4.11)

There are 1036 entries for the Roman period (30.9% of total entries in the database), corresponding to the period circa. AD 70 - 500 used for pollen mapping. The majority of these, once again, are settlement sites (546 entries, making up 52.7% of all Roman period entries), with rectilinear (477 entries), enclosed (44 entries) and some open sites (two entries) continuing into this period. A problem is that not all such sites did continue into the Roman period, but with a lack of dating at most sites it is impossible to gain an accurate idea of numbers involved. There are 236 entries for Roman military sites (22.7% of Roman period entries), comprising 96 turrets, 49 camps, 23 forts and seven fortlets, 47 milecastles, five signal towers and nine bath houses. In addition, 10 temples are recorded associated with Roman installations (0.9% of Roman period entries). There is a range of other site types including 16 entries for Roman roads, seven milestones and 10 bridges, and 11 industrial sites, including quarries, a lime kiln, lead workings, smelting sites and a coal working. Nineteen burial sites are recorded for the Roman period, many of which are associated with military installations. Of the artefactual evidence recorded in the database for the Roman period, some 48 querns are recorded, of which disc and rotary querns and millstones are only recorded on Roman period sites (millstones in the later part of the Roman period), whilst beehive querns appear in the later Iron Age and continue into this period.

b) A discussion of the distributions of different categories of archaeological evidence in the database

Figures 4.3 to 4.7 show the distributions of different categories of archaeological evidence entered into the database across the north-east of England, period by period. Discussion of archaeological distribution maps must be undertaken with caution, bearing in mind that site distribution is very much a product of research interests, differential destruction and survey methods. The following section will identify patterning in the distributions of different categories of archaeological data in each period, and relate it to the known concentrations of research for each period, and to the sources used to compile the archaeological database. No attempt here is made to interpret distribution patterns in terms of settlement and land-use. This will be discussed in later chapters.

i) The Mesolithic

Figure 4.3 shows the distribution of lithic artefact scatters or single finds across the north-east of England that have been attributed to the Mesolithic. The distribution pattern clearly shows the influence of different research interests in the region, such as the marked concentration of Mesolithic lithic find spots along the coast, up the valleys of the Wear and the Tees, whilst the areas studied in the lowlands between the Tyne and Tees as part of the Durham Archaeological Survey (Haselgrove *et al.* 1988) are clearly visible. The number of entries for the Mesolithic north of the Tyne is very low, being confined almost entirely to the coastal strip and northern Northumberland. Considering the amount of flint find spots from the upper valleys of the Northern Pennines, it seems unlikely that the absence of lithics from the Northumberland uplands is due to an absence of Mesolithic activity in this area. It seems more likely that the absence is due to a lack of survey for lithics in this area, partly due to the paucity of ploughed land in the uplands hindering field walking, but also to a traditional concentration of research interest along the coastal lowlands. In addition there have been more survey projects undertaken in County Durham compared to Northumberland.

ii) The Neolithic

Figure 4.4, showing the distribution of different categories of evidence assigned to the Neolithic, shows a clear concentration of standing stones and stone circles or henges north of the Tyne, with only one example south of the Tyne in Upper Teesdale. There is also a notable absence of such monuments in the lowlands of the study area, although standing stones tend to occur at lower elevations than stone circles/ henges, which can be found at the highest elevations in the region. Given the particular visibility of such types of monument, it seems unlikely that the absence of such structures in the lowlands or south of the Tyne is due solely to a failure to record them. Despite considerable survey in Upper Teesdale, for example, (Coggins 1986) only one possible stone circle has come to light. Particular concentrations of monuments occur in the valleys of the North Tyne and Rede (stone circles), the upper Blyth valley (a concentration of standing stones), the Coquet (stone circles and standing stones) and a very dense cluster in the Till valley in Northern Northumberland, which corresponds to the Milfield Basin complex of Neolithic monuments near Wooler.

Burial sites appear to occur at a wide range of different elevations, occurring in lowland Weardale and near Hartlepool as well as in Upper Weardale and Teesdale and further north in the upper reaches of the North Tyne and Rede and in the Till and Aln valleys in Northern Northumberland. The infrequent pottery find spots for the Neolithic tend to occur with concentrations of other types of sites, such as near the burial site at Hartlepool, in lower Weardale with the dense concentration of stone/ flint axe find spots and burial sites, in the Rede valley with burial sites and stone/ flint axes, in the Aln valley with standing stones, flint scatters and stone axe finds, and in the Milfield Basin area, which has the largest concentration of pottery find spots in the north-east. Locations of stone/ flint axe find spots are quite evenly distributed across the region, although few are located at high elevations (with the exception of Upper Teesdale). This might reflect lack of survey, or lack of field walking in upland areas owing to the scarcity of ploughed land. The large concentration in the well surveyed Upper Teesdale and Weardale (where considerable research by Young has produced a dense concentration of stone/ flint axe finds as well as lithic finds in this valley), appears to suggest that more survey in upper valleys to the north might reveal a greater concentration of such artefacts. The concentration of research in the entire Wear valley is apparent from the continuous distribution of stone/flint axe finds throughout the valley, including around the concentration of burial sites in lower Weardale. The distribution of stone/ flint axe find spots is also fairly continuous in the Tyne valley and concentrations occur in the Coquet, Aln and Till in areas where Neolithic monuments abound, and there has been considerable survey and excavation work.

iii) The Bronze Age and earliest Iron Age (Figures 4.5 to 4.7)

From figure 4.5, the distribution map for the early Bronze Age period, the marked concentration of sites, particularly open settlement sites, burial sites, cairn fields and field systems, in Northumberland is apparent. This is particularly marked in the Breamish valley, upper Coquet, upper Aln and Till valley, in northern Northumberland, where concentrations of open settlement in particular are very dense, whilst further south in the Rede and North Tyne valleys there are large numbers of field systems and cairnfields in particular. There is a marked lack of sites in lowland Northumberland in comparison, with only occasional lithic or metalwork finds. South of the Tyne particularly marked concentrations of Bronze Age sites occur in Upper Teesdale, where there are several early Bronze Age burial sites, open settlements, cairnfields and field systems, with lithic finds dating to this period and a couple of pottery find spots. Field systems and lithics are concentrated in Weardale, whilst on the East Durham Plateau there is a grouping of early Bronze Age burial sites.

The large numbers of early Bronze Age barrows, cairnfields, field systems and open settlement sites in the North York Moors is picked up in the south east corner of the region by the concentration of sites on Eston Nab. The distribution of early Bronze Age metalwork find spots is fairly even across the region, with sites occurring in the river valleys in the lowlands, such as in the Tyne valley, the Aln and Wansbeck, and in Weardale, but also at sites at higher elevations such as in Upper Teesdale and Upper Weardale and in the Till valley.

The archaeological evidence for the middle Bronze Age (figure 4.6) is identical to the early Bronze Age for open settlements, field systems and cairnfields, since it is not possible on the basis of dating evidence to date these types of sites more precisely. However, artefactual evidence can be attributed to this period. The few lithic scatters and single finds that can be dated to this period occur along the Durham lowlands and in Weardale, and reflect the existence of survey projects such as the Durham Archaeological Survey (Haselgrove *et al.* 1988) and Young's work on lithics in Weardale, where detailed examination of the assemblages would permit identification of diagnostic lithics which could give a middle Bronze Age date. No doubt assemblages exist from the rest of the region which have a similar date, but due to the lack of diagnostic lithics, or the lack of detailed survey or lithic analyses, these have failed to come to light. Metalwork find spots come from across the region, as for the early Bronze Age, from both lowland and upland contexts, with concentrations along the Tyne, North Tyne, Wansbeck, Coquet, Aln and Till in Northumberland, and along the Wear in particular to the south.

The distribution map for the late Bronze Age (Figure 4.7) clearly shows that the earlier concentration of recorded sites in Northern Northumberland continues in this period in the distribution of curvilinear settlement sites, which are represented in large numbers in the valleys of the Breamish, Till, Tweed, Glen, Aln and Coquet and throughout the lowlands of Northern Northumberland. South of the Wansbeck the distribution of curvilinear sites thins out considerably, with a much sparser, but even distribution between the Wansbeck and the Tyne, ranging from the lowlands to high elevations in the uplands of the Border Hills above Kielder Water. South of the Tyne the distribution of curvilinear sites is on a similar level of density as southern Northumberland in the Wear and Tees lowlands between the Pennines and the East Durham Plateau. There are large concentrations on a level only seen in northern Northumberland in Upper Teesdale, which might have resulted from the intensive survey carried out in this area (Coggins

1986). Despite the less dense distribution of curvilinear sites in southern Northumberland and lowland County Durham, the distribution of late Bronze Age metalwork finds is fairly even across the region, with a large number of finds in the Tyne valley, as well as to the north in the valleys of the Aln, Coquet and in lowland northern Northumberland, and to the south in the Tees valley.

iv) The Iron Age

The distribution map for the Iron Age period (Figure 4.8) clearly shows the relationship between recorded curvilinear sites and rectilinear site locations. With rectilinear sites, the greatest concentrations appear to occur in the Tyne valley extending all the way from the coast to the North Tyne valley (although many of these are small in size and may be Roman in date rather than Iron Age), and further south in the corridor of the Wear lowlands between the North Pennines and East Durham Plateau and in the middle stretch of the Tees around Darlington. Smaller numbers of rectilinear sites are scattered in the Northern Pennines and in northern Northumberland, although there is a dense concentration around the edge of the Cheviots in the valleys of the Breamish and Till, in areas of a dense concentration of curvilinear and enclosed sites. The burials recorded for the Iron Age all lie in the Durham lowlands, and quern sites were only recorded for County Durham, and show a distribution ranging from the highest elevations in Upper Teesdale to the coast. The small number of recorded Iron Age date pottery find spots in the database are recorded in the Cleveland Hills, mostly in the Eston Nab area.

v) The Roman period

The distribution map for the Roman period (Figure 4.9) clearly shows the location of Hadrian's Wall in terms of the dense distribution of milecastles and turrets along the Wall, and the occasional location of forts or fortlets along the Wall or in the vicinity, and of camps. A notable concentration of camps and forts up the North Tyne and Redesdale is also apparent, following the line of a Roman road, as is the concentration of signal towers and forts in the corridor of the Wear lowlands and across the Stainmore Gap.

Part II

Methods

Evaluation of different methods for using pollen and a combination of pollen and archaeological evidence to investigate settlement and land-use

5

Methods I:

Pollen-based approaches for identifying land-use.

An evaluation of three commonly used methods, the indicator approach, the index approach and the comparative approach, and a review of pollen mapping methods used to present the results of these approaches

5.1 Introduction

The following two chapters will investigate methods for reconstructing settlement and land-use using the pollen and archaeological datasets discussed in Chapters 3 and 4. Chapter 5 will investigate purely pollen-based approaches, and evaluates three commonly used methods for identifying human activity from pollen data: the anthropogenic indicator approach, the use of arable:pastoral and arable:agricultural indices which builds upon the indicator approach, and lastly the comparative approach which uses modern observations of relationships between pollen-rain, vegetation and land-use to shed light on past human activity in the landscape. The aim of evaluating these different pollen-based approaches is to choose appropriate methods to use in Part III; to use in the reconstruction of settlement and land-use for north-east England from the Mesolithic to the end of the Roman period. Lastly, chapter 5 will review the different methods available for mapping pollen data, for presenting the results of these pollen-based approaches. The following chapter, chapter 6, will propose and evaluate combined approaches which draw on both pollen data and archaeological types of evidence.

This chapter divides into two main sections. The first section looks at three different pollen-based methods used in the pollen literature for shedding light upon settlement and land-use: the indicator approach, the index approach and the comparative approach, with the aim of choosing suitable approaches to use in Part III. These three different approaches will be evaluated by using pollen data from recent and modern levels of cores, where the local land-use is already known. The problems and potential of each approach will be discussed and suggestions made about the applicability of each of these methods to identify land-use in the past. The second section of this chapter states which of the above methods will be used in Part III of this thesis, and describes the method of pollen mapping used for presenting the results of these methods in Part III. A review of various pollen mapping methods used in the pollen literature will be made and an evaluation of the suitability of different methods will be undertaken, with the aim of choosing a suitable method to use in this study.

5.2 Section I

An evaluation of three pollen-based methods for reconstructing settlement and land-use: the indicator approach, the index approach and the comparative approach

A review of pollen-based approaches used in the pollen literature to reconstruct past settlement and land-use, and a discussion of their potential and drawbacks has been provided in Maguire (1983, Maguire *et al.* 1983). Until recently most attempts to use pollen to reconstruct settlement and land-use have been on the spatial level of the single pollen core, or small groups of cores (Roberts *et al.* 1973; Turner 1964; Donaldson 1973; Donaldson and Turner 1977). There have been few attempts to look at regional patterns in land-use using these methods, although Fenton-Thomas (1992) and Ferrell (1992) have produced basic maps and analyses for the north-east of England. Bradley (1978) has produced maps of arable:pastoral ratios for selected sites across Britain. The value of producing maps of indicators and ratios has been questioned by Wilson (1983); the direct comparison of scores from sites with diverse catchment areas can be misleading. However, if the effects of differing site catchment areas are taken into account and if results from a high density of cores across a region the size of north-east England are used, some idea of the spatial trends in land-use across a region can be gained.

All these commonly used palynological approaches rely on a) palynological evidence alone to identify land-use and b) the uniformitarian assumption that modern day observations about the vegetation associated with different types of land-use can be used to identify past land-use from pollen data. It will be argued here that whilst some purely palynological approaches do provide useful insights into the nature of land-use, the picture provided is considerably improved if other types of evidence are used in combination with pollen data. Secondly, whilst modern day observations are very valuable for understanding the relationships between pollen, vegetation and land-use, such observations cannot be expected to cover the full range of types of land-use and conditions that may have existed in the past. This second reason also argues for the use of complementary archaeological evidence when identifying land-use from pollen.

5.2.1 Indicator approaches

a) Background: definitions and review of previous uses of anthropogenic indicators

A comprehensive review of the use of certain pollen types as anthropogenic indicators has been provided by Behre (1981,1986) and by Maguire (1983) in a series of papers discussing various aspects of the use of indicator taxa. Their use is discussed with reference to the role of human activity in European vegetation history in Behre (1988).

Behre (1981) defined the indicator approach as follows

> "In this approach the indicator value of a small number of selected pollen types is of primary importance.." (p. 226)

Building upon this definition, Maguire, in his review (1983) adds

> "This approach involves the extension backwards in time of known sociological and ecological preferences of individual taxa. It explicitly uses the principle of uniformitarianism assuming the preferences of the taxa in question and their response to competition have not changed through time." (p.11)

The indicator approach involves the use of a small number of individual pollen types to "indicate" the presence of agriculture, or particular types of land-use, such as arable or pastoral regimes. The choice of indicator types to use is made upon the basis of often limited modern day observations of their common occurrence with particular types of land-use or with human activity in general. The uniformitarian assumption is made that these indicator types, when identified in the pollen record, can be used to identify the presence and nature of human activity in the past.

In one of the earliest uses of pollen taxa to indicate human activity, Iversen (1941, 1949) distinguished a group of pollen taxa which reflect human occupation and economy. The systematic use of such indicator taxa to identify presence and nature of human activity was initiated by the work of Steckhan (1961), Turner (1964) and Lange (1976).

In this section the value of different commonly used indicator types for indicating particular types of land-use will be investigated, with special reference to the ecological tolerances and modern distributions of these species in north-east England. Comparisons of their modern distributions will be made with the known pattern of modern land-use. Pollen data from modern and recent levels of pollen cores from the region will then be extracted and mapped. The picture of modern land-use reconstructed using these indicator types will be compared to the known patterns of land-use derived from satellite images.

Indicator types can be divided, following Behre (1981) into "anthropochores" - those taxa originally not native to an area and introduced as a result of human activity, and "apophytes" - those taxa which are native to an area but which are favoured and spread by human activity, and which colonise newly established biotopes. The value of these two main types of plants as indicators will be discussed in turn.

b) Cultivated and introduced types ("anthropochores")

In this section, first of all, a review of different cultivated and introduced types will be made, and an evaluation of the usefulness of different types as anthropogenic indicators will be made. In the second part of this section, a map of modern *Cerealia* (cereal) pollen (the cultivated type most commonly used as an anthropogenic indicator) will be compared with a map of the present day land cover of arable land.

i) A review of cultivated and introduced types used as anthropogenic indicators

Originally non-native and introduced plants include many crop plants, and these are commonly viewed as the best indicators of human activity and cultivation. Cereals are the most widely used types in this respect, and to a lesser extent other types known today or from historical records to have been cultivated, for example *Cannabis sativa* (hemp) and *Humulus lupulus* (hop). The value of such types as indicators rests upon the assumption that they were not present prior to human activity in an area. However, the indicator value of such types is problematic for a number of reasons. Firstly problems exist with identifying many of these pollen types to a sufficiently detailed taxonomic level to have indicator value. Cereals in particular are difficult to distinguish from general Gramineae (grass) pollen, a group which occurs across a wide range of ecological types. Edwards (1989) has comprehensively reviewed the problems of detection of *Cerealia*-type pollen, with particular reference to the identification of the earliest occurrences of cereal cultivation in Britain (Edwards and Hirons 1984). According to Behre (1981) the pollen of *Secale* (rye) is most easily identified of the cereal pollen grains, with *Avena* (oats), *Hordeum* (barley) and *Triticum* (wheat) being more difficult to identify. Other crop types such as *Linum usitatissimum* (flax) and *Fagopyrum* (buckwheat) have distinctive pollen grains, whilst *Cannabis* and *Humulus* can be difficult to distinguish. Other possibly cultivated crops cannot be identified beyond family level, which can prove difficult if that family has a wide range of ecological tolerances. For example, *Pisum* spp. (pea) may be identified from other members of the Leguminosae family, but commonly tend to be grouped together as Leguminosae. *Camelina sativa* (gold of pleasure), another possible cultivar, can only be identified as Cruciferae. Even though these pollen types may be identified with careful use of high resolution miscroscopy, such work is only carried out when the research aims of the pollen work is to reconstruct human activity. In the majority of cases, pollen tends usually to be identified to *Cerealia*-type at best, or grouped with Gramineae, and other possible crop types are also recorded at family level. This proves a drawback when using pollen data provided by other workers with different research aims.

A further problem with the use of possible cultivars as indicators, is that many of the plant taxa now grown as crop types may not have been in the past, or may have grown as weeds of other crops (Maguire 1983). For example, Godwin (1975) suggests that *Secale cereale* first occurred as a weed before it became a crop plant. Jones (1983) has also suggested that the modern clear distinction between crops and weeds may not necessarily have existed in the past.

The overall low production and dispersal of cereal pollen also contributes to problems with its use as an indicator: the absence of cereal pollen in a sample may not necessarily indicate absence of cereal cultivation. However, *Secale*, which is not self-fertile (allogamous), has relatively high pollen productivity and dispersal when compared to *Avena*, *Hordeum* and *Triticum*, which, being self-fertile (autogamous) disperse poorly, since the pollen tends to remain in the hulls. Work on cereal pollen dispersal and transport (Federova 1956; Vuorela 1973; Robinson and Hubbard 1977; Bower 1992) has demonstrated that owing to its poor dispersal, when cereal pollen is found in large quantities this usually either indicates immediately close by cultivation on a large scale, or indicates the very close presence of crop processing activities. Very high *Cerealia*-type pollen values (of around 60% total tree pollen) have been recorded in a waterlogged pit, and are attributed to the transport of pollen on cereal fragments and chaff.

Since pollen levels of *Cerealia* tend to drop off very rapidly from the source, a small change in location of a pollen core can have often dramatic effects on the cereal pollen values. Pollen studies at neolithic lake-settlements have demonstrated that levels of *Cerealia* pollen can fluctuate from 114 % of total tree pollen within the settlement to 0.8% only 13 metres outside (Troels-Smith 1955). Such results are common and show the difficulty of reconstructing the pattern of cereal cultivation since values are so dependent upon the location of the sampling site. This problem is particularly marked if pollen data are being used from cores not taken to investigate agriculture. There is a need for more work to be focused upon sampling settlement sites rather than hill peat where *Cerealia* pollen is, at best, only represented in very small quantities.

To sum up, the pollen of cultivated species is a definite indicator of human activity, but has to be used with caution when statements about the amount of agricultural activity are made. The absence of cereal pollen does not necessarily indicate the absence of agriculture. The values of cereal pollen found at a core/sampling site depend heavily on the site's location with respect to crop fields and crop processing activities.

ii) A comparison of the distribution of modern/ recent *Cerealia* pollen from north east England with modern land cover of arable land.

To investigate the value of cereal pollen as an indicator of agricultural activity, cereal pollen values from recent and modern levels from pollen cores in the NEEPD will be examined, compared between sites, and compared with the known modern distribution pattern of cereal agriculture in the study region.

Some 33 cores have cereal pollen recorded in modern/recent levels (i.e. for the last 500 years), out of some 57 cores which have cereal recorded for all the time periods. Other cores may have cereal pollen, but it was not distinguished from Gramineae according to the research aims of the pollen analyst. In the majority of cases cereals are recorded as "*Cerealia*-type", or Gramineae > 35 µm (Tipping, unpublished), allowing for the possibility of inclusion of large Gramineae grains. A small proportion of cores (eleven) have cereal grains identified to genus level (Davies 1978; Davies and Turner 1979; Tipping, unpublished).

Cereal pollen values have been extracted from levels dated to the last 500 years. Table 5.1 lists those pollen sites which have cereal pollen recorded at any point in their sequences, the level of taxonomic identification of the cereal pollen (for example, whether cereal is identified as *Cerealia*-type, *Cerealia*, Gramineae > 35µm, or to the genus level, for example *Avena, Hordeum, Triticum*, or even to species level, for example *Triticum monococcum*). Table 5.2 gives values for *Cerealia*-type pollen identified in levels dating to the last 500 years from the region, together with a measure of agricultural land potential (adopting the grading system for classifying land used by the Department of Agriculture, Fisheries and Food). Figure 5.1 plots the distribution of modern occurrences of cereal pollen at each site. For the purposes of this chapter, this is a simple plot map showing cereal pollen values at each pollen site as a percentage of total dry land pollen. Subjectively drawn contours have been added to highlight those areas of the region with pollen cores with the highest *Cerealia* values. A thorough review of pollen mapping techniques used to display information from large numbers of pollen sites, and the mapping techniques used in this study will be given in the second part of this chapter.

If we look at the pattern of distribution of modern and recent *Cerealia* pollen, it is unsurprising that many of the noted occurrences are in the lowlands, where today cereal agriculture is most prevalent. Core sites in the uplands with noted *Cerealia* pollen are located in the valley bottoms or sides (for example, Bollihope Bog and Steward Shield Meadow in Weardale), around the Cleveland Hills (Ewe Crag, Tranmire Slack), valleys in the Cheviots (Mow Law, Quarry Knowe), and in upper Teesdale (Cronkley Pastures, Dufton Moss, Fox Earth Gill.) The occurrences on these upland sites may represent small scale cultivation in the valley bottoms, or where the sites are on hilltops and plateaux with large pollen catchment areas, could represent cereal pollen blown up from agricultural areas at lower altitudes. An example of this is at the Cross Fell sites where sporadic small occurrences of Cerealia pollen have been attributed by Turner (1984) to wind transport from the Eden valley to the west.

As has already been noted, *Cerealia* pollen values cannot be directly translated into statements about the quantity of cereal agriculture at a site without considering site catchment area and patterning in other taxa. However, if we look at those sites with the highest percentages of *Cerealia* pollen, it is evident that most of these are lowland sites, today surrounded by agricultural land. From Table 5.2 it can be seen that many of the sites with the highest cereal percentages are Grade 3 or 4. Those sites which are Grade 5 are either on plateaux above Grade 3 or 4 land - sites with large pollen catchments which would include cereal pollen from agricultural land at lower altitudes - or lake and coastal sites which also have larger catchment areas and could have low levels of cereal pollen from further away.

If the pattern of recent cereal pollen distribution is compared with the map of the land coverage of arable land across the region presented in Chapter 2 (Figure 2.1), an idea of the value of cereal pollen to indicate arable agriculture can be gained. The map of modern and recent cereal pollen distribution agrees quite well with this map, showing a concentration of cereal cultivation in the lowlands, with the exception of the coastal strip, and along the river valleys.

iii) Conclusions

Cereals tend to have poor pollen production and dispersal which makes their occurrence in pollen diagrams difficult to interpret. The presence of cereal pollen in a core does indicate presence of agricultural activity, but it is difficult to assess the amount of agricultural activity from pollen values. Comparing values between sites is difficult, because of different site catchment sizes and the effects of other vegetation types on the cereal pollen percentages.

c) Other indicator types: taxa favoured and spread by human activity ("apophytes")

Apart from crop plants, there are several taxa which have commonly been used as indicator types of different types of land-use, or as general indicators of human activity. The indicator value of a taxon depends upon a) the degree to which that taxon is confined to a particular plant community, for example hay meadows, cereal crops and b) the level of taxonomic detail to which its pollen can be identified. As Behre (1981) has indicated, of the numerous species which could be useful indicators of human activity, not all can be identified by pollen analysis. Many can only be identified to the family or genus level. For example, the Gramineae family includes grasses from a wide range of plant communities, but it is very difficult to distinguish their pollen to a level below that of the family and this significantly reduces the value of Gramineae pollen to indicate specific types of plant community.

Appendix B assesses the indicator value of each commonly used anthropogenic indicator. For each taxon there is a list of the most common species found in north-east England, their ecological tolerances, modern distribution and abundance. An assessment is made of the indicator value of each type by considering a) how far each type is confined to particular types of land-use and b) how far individual species in a genus or family conflict in their ecological tolerance. In the following section, maps of recent pollen values of a selection of common indicator types will be presented and discussed in the light of the conclusions about the value of each as an indicator type in Appendix B.

Figures 5.2 to 5.13 plot modern/ recent pollen values for each indicator type discussed in Appendix B, with the exception of the rarer indicator types such as *Knautia* and *Fagopyrum* which are not recorded by many pollen workers. These maps are produced in the same way as the *Cerealia* map already discussed. The maps are of the following commonly recorded pollen types which are used in the pollen literature as indicators of arable, pastoral or general anthropogenic activity: Gramineae, *Artemisia*, Caryophyllaceae, *Centaurea*, Chenopodiaceae, Compositae, Cruciferae, Leguminosae, *Plantago*, *Polygonum*, Ranunculaceae and *Rumex*. Each map is compared with the known modern coverage of arable land (Figure 2.1), urbanised and industrialised areas (Figure 2.2) and grassland (Figures 2.3 and 2.4), and also with the maps for dwarf shrub moorland and woodland to assess the value of each type for indicating arable or pastoral activity, or disturbance in general, or whether they occur in other, semi-natural types of vegetation, such as moorland or woodland.

Gramineae pollen (Figure 5.2) occurs at its highest values in the north of the region, at sites near the Tweed valley and at Edlingham in the northern Northumberland lowlands, where a value of up to 68% tdlp occurs. Lower values between 20-40% tdlp occur across most of the lowlands of the region, whilst much lower values occur over much of the uplands, with the exception of sites at the highest elevations. The areas with the highest grass pollen levels correspond well with the areas with the highest arable land cover, in northern Northumberland and in the lowlands, although a high proportion of the area covered by higher grass pollen levels also has a good land coverage of pasture. Grass pollen values on land covered by rough grassland and dwarf shrub moorland vegetation is much lower. It therefore appears that Gramineae cannot be used as an indicator purely of pasture, as very high grass pollen occurs in arable dominated areas also. This is not surprising considering that this is a very large family containing taxa found in a wide range of environments.

Areas with the highest values for recent *Artemisia* pollen (Figure 5.3) tend to be those with a high land coverage of rough grassland and dwarf shrub moorland, in the uplands of Northumberland, the Northern Pennines and the Cleveland Hills. This is puzzling when considered in the light of the ecological account in Appendix B, since according to Graham (1988) and Swan (1993) it is seldom found in the uplands, occurring most often in disturbed situations such as waste ground and field borders. However, it is possible that the lower values in the lowlands are because *Artemisia* is rarely found in damp grazed situations, and pollen cores from lowland sites tend to be from such situations where *Artemisia* would be absent. Its presence in the uplands may be due to its pollen being blown from disturbed, open areas in the vicinity.

The map of Caryophyllaceae pollen (Figure 5.4) does not appear to show any strong spatial trends in distribution, with high concentrations in the East Durham Plateau area and in the western Tyne Corridor as well as in upper Teesdale and northern Northumberland. This appears to support the conclusion from Appendix B that Caryophyllaceae is a poor arable indicator, with its wide range of species occurring in a wide variety of habitats, including both well drained land and damp grassland.

The map of *Centaurea* pollen (Figure 5.5) distribution shows that the highest values occur in the north of Northumberland at sites near the Tweed valley and at sites in south east Durham, which would be consistent with the use of *Centaurea* as an arable indicator, since these areas have some of the highest arable land cover across the region. However *Centaurea* pollen also occur at some of its highest values at sites today dominated by rough grassland, in the Cleveland Hills, in the Derwent valley and in central Northumberland at Steng Moss. It is most likely that *Centaurea nigra* is responsible for the pollen at these sites, since this occurs in a wide range of grassland environments including rough grassland, and does ascend into upland valleys. This calls into question the arable interpretation of *Centaurea* unless *C. cyanus* (the only taxon which occurs almost entirely in arable situations) can be identified.

The occurrence of high values of Chenopodiaceae pollen (Figure 5.6) in the lowlands appears to support its use as an arable indicator, although the common occurrence of members of this family in disturbed habitats as a whole suggests it is more valuable as a general indicator of disturbance activity (with the exception of along the coast, where it occurs in natural/semi-natural coastal communities). Concentrations of Chenopodiaceae pollen in the uplands, such as in the Northern Pennines, can most likely be accounted for by *Chenopodium album* and *Atriplex patula*, although both are seldom found on grazed land, and are instead indicators of disturbance.

The distribution of areas with the highest values for Compositae pollen (Figure 5.7) corresponds well with those areas under arable land, such as in the Durham lowlands and lower Weardale and northern Northumberland, which supports its use as an arable indicator in these areas, although many Compositae also occur on disturbed land in general. However, its occurrence in other areas such as the Cleveland Hills, the western Tyne Corridor and the Northern Pennines suggests that members of the Compositae occurring in pasture and meadow (the Type A taxa described in Appendix B) are accounting for the pollen in these areas.

Like Compositae, areas with the highest Cruciferae pollen (Figure 5.8) values occur in arable areas such as Eastern Durham and northern Northumberland, but also occur in Upper Teesdale, Weardale and across Northumberland. Most of these areas have habitats that are dry, rocky, often calcareous, with shallow soils or which are disturbed found on rocky outcrops, walls, shallow soils in the uplands on limestone and whin, and on the Magnesian Limestone. However, in other areas Cruciferae may occur in damp meadows and woodland, and so it is not an unambiguous indicator of disturbance.

The occurrence of Leguminosae pollen (Figure 5.9) in the East Durham Plateau area and in the uplands may represent the occurrence of types on short turf on limestone or sandy soils. The concentration of Leguminosae in northern Northumberland may reflect its occurrence in meadows and pasture in this area, but also possibly its occurrence in arable land which dominates the land cover in this area, in which case it is most likely to be *Vicia*. Leguminosae are, from the conclusion in Appendix B, most likely to represent grassland rather than arable or disturbed land.

Plantago pollen (Figure 5.10) occurs widely and abundantly (compared to other herb pollen types) across the region, with the exception of sites in some lowland areas such as in the Durham lowlands outside of the East Durham Plateau and in Northern Northumberland. At the majority of pollen sites with *Plantago* values exceeding 1% total dry land pollen, the *Plantago* pollen is made up almost entirely of *Plantago lanceolata* pollen, and according to the ecological account in Appendix B, this is most likely to indicate meadow or pasture. However, along the coast *Plantago* is more likely to be represented by one of the coastal species, whilst *P. major* will occur in disturbed habitats including arable land, and *P. media* is a good indicator of limestone.

The scattered occurrence of *Polygonum* pollen (Figure 5.11) in upland areas most probably represents the Type D *Polygonum* species discussed in Appendix B which occur on upland grassland, whilst the concentration of *Polygonum* in the northern Northumberland lowlands more likely represents Type B or C *Polygonum* found on waste or cultivated ground. Away from upland and wet situations, *Polygonum* is useful as a disturbance indicator and arable indicator.

Like the distribution of *Plantago* pollen, sites with high Ranunculaceae pollen (Figure 5.12) are evenly distributed across the region, with the exception of the lowlands (apart from the East Durham Plateau. Concentrations of Ranunculaceae occur in areas with high land coverage of meadow or pasture. This supports the conclusion in Appendix B that away from wooded areas or waterways, it is a reliable indicator of grassland.

Like the distributions for *Plantago* and Ranunculaceae pollen, high values for *Rumex* pollen (Figure 5.13) occur across much of the region, with the exception of some lowland areas, although *Rumex* is more abundant in lowland areas than the other two types. In areas with acidic soils, predominantly in the uplands, the dominance of *R. acetosa* and *R. acetosella* on grazed grassland make *Rumex* a reliable pastoral indicator. However, in areas not on acidic soils, *Rumex* species occurring in disturbed habitats including cultivated land, as well as on pasture, can occur. This makes the use of *Rumex* as a pastoral indicator in these areas problematic. On the whole, it is a good general anthropogenic indicator, although its specific use as a pastoral indicator holds out best in acidic areas.

To summarize, the indicator types discussed above tend to fall into three types of distribution pattern; those that occur mostly in grassland including meadow and pasture (*Plantago*, Ranunculus and *Rumex*), those which on the whole are more indicative of disturbance, including waste land, settled land, trackways and cultivated land or on shallow, dry soils (including *Artemisia* and Chenopodiaceae), and lastly those which cannot be assigned to one group or the other, because these pollen types include species found on grassland, disturbed land and also in a range of natural and semi-natural habitats. These less valuable indicators are as follows: Caryophyllaceae includes taxa which occur both in disturbed habitats and in meadow and pasture, and cannot therefore be used as a reliable arable indicator. Cruciferae includes types found in a wide range of natural habitats either in dry conditions (which may include disturbed and arable situations) or damp conditions (which may include damp pasture). Compositae is a very large family including a wide range of species occurring in a wide range of different habitats, including both pasture and grassland and disturbed and cultivated ground. Even those pollen types in the first two categories above which tend to occur in either grassland or disturbed/ cultivated habitats, there are always exceptions, and when interpreting certain types (for example *Rumex*) it is important to bear in mind the local bedrock and edaphic conditions when interpreting them as arable or pastoral indicators, or as naturally occurring types.

d) Conclusions : the value of using individual indicator taxa

Reliance on a single pollen type to "indicate" a type of land-use is precarious when that pollen type is a low pollen producer and disperser, as are the majority of herb pollen types used as anthropogenic indicators. Conclusions about land-use are more reliable when a whole suite of pollen types rather than an individual pollen indicator type are used to reconstruct land-use. The second type of pollen-based approach covered in this chapter, the index approach, goes beyond the use of individual indicator types, and instead relies upon relative proportions of groups of pollen taxa to indicate land-use.

5.2.2 The index approach: use of arable:pastoral and arable:agricultural indices

In this section, the value of different arable:pastoral and agricultural:arable indices will be assessed. Ratios will be calculated for these indices from modern pollen data from core sites in north-east England. The results of different indices will be compared, and evaluated against the known pattern of modern land-use.

a) The index approach: background and previous applications

The index approach (termed the "statistical" approach by Maguire 1983), attempts by means of a ratio of arable:pastoral, or arable:agricultural pollen indicators to determine the levels of arable and pastoral, or arable and general agricultural farming around a site. This approach obviously builds heavily upon the indicator approach, but differs in that it relies upon a wider range of types to characterise a type of land-use, and by accepting that few types have so narrow ecological tolerances as to be found exclusively in arable or pastoral habitats.

As with the simple indicator approach, the choice of indicator types to include in the ratios is based upon modern observations of their occurrence with particular types of land-use, and particularly which species tend to occurr together in these habitats. Table 5.3 lists the main arable:pastoral indices that have been used by various workers to characterise arable and pastoral regimes from pollen data, and lists the taxa used by each worker in their index. Fenton-Thomas (1992) uses an arable:agricultural index instead, using the valid argument that since few taxa exist that are found exclusively in pastoral situations (as opposed to arable), it is more suitable to use an index of general agricultural types versus types specifically associated with arable agriculture.

The index approach can potentially be very valuable if the choice of taxa to include is based upon careful observation of plant communities associated with different types of land use in different environments, plus a detailed study of how these communities are represented in the pollen rain. However, the construction of most of the commonly used indices has been based on very limited modern observations. Turner (1964) states that her ratio was created upon the basis of the examination of only 21 modern samples, although she has pointed out that the ratio was devised only to identify general trends. Also there is some contradiction between the different indices over which taxa indicate arable as opposed to pastoral. For example, as is shown in Appendix B, the genus *Rumex* (dock) has a wide range of ecological tolerances and this can lead to problems with its use in the indices. Riezebos and Slotboom (1978) use *Rumex* as an arable indicator, whilst Donaldson and Turner (1977) use *Rumex acetosa/ acetosella*-type as a pastoral indicator. As has been demonstrated in the previous section, the ecological requirements of many of the major indicator types are in fact much more complex.

A third problem with the use of arable:pastoral indices is that clear cut distinctions between arable and pastoral may not exist in reality, and cannot be assumed to have existed in the past. For example in many parts of the Durham lowlands today a mixed farming regime exists with stock rearing and fattening, with cultivation of fodder crops and barley (Jarvis *et al.* 1984). Around a core taken in this area we would find a combination of arable crops, fallow land and pasture, and if traditional arable:pastoral indices were used, they would be biased by whichever field type was closest to the coring site. The problem is further complicated by crop rotation, which may bring land under pasture some years and under crops in others, and weeds associated with the one may continue to grow with the other. However, since pollen samples integrate spans of years rather than reflecting a single year, it is likely that a pollen sample would reflect the range of types of land-use carried out during crop rotation. These problems are further compounded if we apply these indices to the past where the present day distinction between arable and pastoral may not apply at all.

Changing levels of agricultural technology will also affect the plant communities associated with different types of land-use. Factors such as depth of ploughing, time of harvest, drainage conditions, rotation, use of fertilizers and weed killers, amongst others, will all affect species composition.

Behre (1981) cautions against the use of arable:pastoral indices to compare core sites from different types of environment. For example, the absence of *Plantago lanceolata* (ribwort plantain) in heathlands or the varying *Rumex* species present depending upon local conditions, may result in an index which doesn't reflect the real proportions of arable *versus* pastoral. This has implications for the current study, as here we are comparing sites from a wide range of different environments. Where arable:pastoral indices are used to compare different areas, the local conditions should always be taken into careful consideration when interpreting the results.

Fenton-Thomas (1992) has argued that distinct pastoral indicators do not exist, and therefore proposed an agricultural:arable index, which would give an idea of the amount of arable agriculture in an area as opposed to general agricultural activity.

b) Evaluating different arable:pastoral indices using modern pollen data from north-east England

Bearing in mind these problems, the different arable:pastoral indices will be compared and evaluated using recent pollen data and land-use information from the north-east. A similar comparison of different indices has been carried out on a far smaller scale by Maguire *et al.* (1983) for pollen cores from Holne Moor, Dartmoor. Values for arable:pastoral indices and Fenton-Thomas' (1992) agricultural:arable index were calculated for each pollen core with levels dated to the last 500 years. Where more than one level existed per core for this period, values were averaged over the whole period. Arable:pastoral indices were calculated by expressing the pastoral taxa at a site as a percentage of the arable taxa. The selection of pastoral and arable taxa to use in this calculation depends on the particular index being used (see Table 5.3 for a list of taxa used for each index). With the arable:pastoral indices, results below 50% are generally held to indicate arable agriculture, whereas those above 50% are held to indicate pastoral regimes. With Fenton-Thomas' agricultural:arable index, arable taxa are expressed as a percentage of overall agricultural taxa, and high results indicate arable agriculture.

The resultant values should be treated with caution: local conditions and site catchment need to be considered when interpreting the results. Since taxa have been identified to a greater level of detail at some core sites, this will also affect the results to some extent. For example, failure to distinguish *Cerealia* from other Gramineae automatically invalidates the use of Riezebos and Slotboom's (1978) and Kramm's (1978) indices, since both rely on *Cerealia* alone to distinguish arable from pastoral.

The results are displayed in two ways: firstly as a plot comparing all the indices together (Figs. 5.14 and 5.15), and secondly as maps showing the results for each index at all the sites (Figs. 5.16 to 5.19). Maps are only produced for the arable: pastoral indices by Brown, Donaldson and Turner, and Turner and the agricultural: arable index by Fenton-

Thomas, and not for the arable: pastoral indices by Kramm, Steckhan, Lange, Riezebos and Slotboom, since for these indices the scores for all the sites in the region are above 80%, and therefore there is almost no variation between sites. Figure 5.14 plots the scores for the seven arable:pastoral indices for each site, and Figure 5.15 plots the results for Fenton-Thomas' agricultural:arable index.

i) Results I: Comparing the indices together

An initial examination of the plots and maps shows that the indications provided by the different indices do not always agree; there is often a wide divergence between the scores of different methods. The trends between the sites, however, tend to be similar, with certain sites having the lowest scores for all the indices, and others having the highest. The indices fall into two groups: those with scores consistently high (pastoral) for virtually all the sites, and those which have a mixture of both arable and pastoral scores. It will be shown here that the former group have little value for distinguishing land-use, whereas the latter group distinguish quite well between arable and pastoral areas.

Turner's index (Fig. 5.16) consistently has the lowest (i.e. the most 'arable') scores of all the indices, with the exception of a couple of sites. This consistently low scoring is due to the taxa used to calculate the index: only *Plantago* is used to differentiate pastoral from arable, and a comparatively large number of taxa that can occur in quite large values are used on the arable side (including Compositae, Cruciferae and Chenopodiaceae). In the recent levels the 'arable' side will exceed the value of *Plantago* alone, therefore the index will tend always to be below 50%.

Donaldson and Turner's (1979) index (Fig. 5.17) in most cases have the second but lowest scores, with the exception of Akeld Steads and Fox Earth Gill where it is third from lowest, Mickle Fell (fourth from lowest) and Hartlepool Bay 6 where it has the highest scores of all the ratios. At both Cranberry Bog and Cronkley Pastures this index has the lowest scores.

The consistently low scores of Donaldson and Turner behave in many ways similarly to those of Brown's (1978) index (Fig. 5.18). Scores for Brown's index are consistently third lowest or occur jointly with Donaldson and Turner's index scores, except at Akeld Steads where it comes second lowest, and at Mickle Fell, The Lough and Trickley Wood, where it has some of the highest scores. Both indices have *Plantago*, *Rumex* and *Ranunculus* on the pastoral side, and include Compositae on the arable side. The often large scores for Compositae in these recent levels tend to make the scores quite low (arable). The inclusion of Compositae accounts for the differences between these two indices and that of Roberts *et al.* (1973), which overall tends to have higher, more 'pastoral' scores owing to the omission of Compositae and inclusion of some taxa that only tend to be represented in small amounts, if at all (for example, *Centaurium* and *Centaurea cyanus*.)

The scores for Roberts *et al.* (1973) are more variable (Fig. 5.19). For some cores it has very low scores, such as at Tranmire Slack and Black Lough and at Cross Fell West and Hartlepool Bay 6. Scores for this index rarely occur below 60% and the highest scores rarely exceed 90%, and only then when no taxa are present except *Plantago* and other 'pastoral' types.

If we compare the maps of the above indices, it is apparent that the distribution patterns of arable and pastoral agree closely. The maps for the second group of indices, however, show no distinction between arable and pastoral areas. These indices have consistently high scores mostly over 90% (Steckhan (1961) and Lange (1975), Kramm (1978) and Riezebos and Slotboom (1978)) and consistently give a 'pastoral' reading for all the sites. This sheds some doubt on the usefulness of such ratios for distinguishing arable from pastoral. Steckhan's, Lange's and Kramm's indices often score at 100%. This is because both indices rely on the presence/identification of *Cerealia* pollen to identify the presence of arable. When using pollen data from a large number of different workers, there will inevitably be differences in the level to which *Cerealia* pollen is identified: some do not distinguish it from Gramineae as a whole.

With Steckhan's and Lange's indices, where cereal values are less than *Plantago*, scores are greater than 50%, and where greater than *Plantago*, scores are less than 50%. In only two cases are there low scores for this ratio: at Mordon Carr where it is extremely low (10%) and at Edlingham (45%). Both sites have relatively high *Cerealia* pollen values. For Kramm, in no case are the scores less than 80%. This is because the ratio of Gramineae to Gramineae plus *Cerealia* is used to distinguish pastoral from arable. At all sites the values for Gramineae far exceed those for *Cerealia*, so much so that changes in the value of *Cerealia* do not have any real effect on the resultant scores. It is possible that for earlier time periods the dominance of Gramineae would not occur, and this ratio might be more useful. Like Steckhan and Lange, this index is very dependent on the identification of *Cerealia* pollen.

In many respects Riezebos and Slotboom's index behaves similarly to Kramm's; the persistently high Gramineae at all sites means that all other taxa in the calculation are always insignificant in comparison. However, unlike Kramm, it relies on a wider range of taxa than just Gramineae and *Cerealia*, which accounts for its overall slightly lower scores than Kramm. Despite this, scores do not fall below 80%, and rarely below 90%. The scores for Fenton-Thomas' (1992) agricultural:arable index, although they run inversely to the other indices, tend to agree with the first group of arable:pastoral indices. The pattern of distribution of arable is very similar to the maps for Brown, Donaldson & Turner and Turner. Sites with high ('arable') scores (like Edlingham and Mordon Carr) tend to have low ('arable') scores for these arable:pastoral indices. Fenton-Thomas' ratio shows a good spread of scores between sites, unlike other methods where sites are difficult to differentiate on the basis of their scores.

ii) Results II: Comparing the results with the known pattern of modern land cover

Using the maps of modern land cover of arable land and grassland across north-east England (Figures 2.1, 2.3 and 2.4) as a rough indication of the distribution of arable and pastoral activity, the maps for each index can be compared to guage how well each index identifies arable and pastoral.

The maps of Fenton-Thomas, Brown, Donaldson and Turner and Turner agree closely with the modern pattern of arable activity shown in Fig. 2.1. Arable values are concentrated in the lowlands and river valleys, with the exception of the coastal strip. The high values along the Tweed are not picked up well, but this is due to a lack of pollen sites in this area, but the sites on the fringe of the Tweed valley (Yetholm Loch, Din Moss, Linton Loch, do show more arable scores than those sites up on the Cheviots. The highly contrasting scores for the close by sites of Edlingham and Black Lough can be explained by the location of Black Lough on the strip of Fell Sandstone moorlands to the east of the valley in which Edlingham is located. Those sites with consistently arable scores tend to be found on the higher Agricultural Land Classification Grade land. According to Table 5.4, 72% of the pollen sites on Grade 3 land have arable scores, 37% of sites on Grade 4 land, and only 14% of sites on Grade 5 land. Table 5.5 details the pollen sites on each Grade of land and lists the indices which have arable scores for these sites.

The maps of land cover of grassland and rough grassland shows that the majority of meadow and mown and grazed grassland is in the foothills of the Pennines, and the valley bottoms with sporadic occurrences in the lowlands, whilst in the higher uplands rough grazing is more common. The maps for the indices have pastoral scores concentrated in the uplands, but there is no way using these of distinguishing between meadow and rough grassland using these indices. The majority of pollen sites with pastoral scores tend to occur on Grade 5 land, which is highly unsuitable for arable agriculture owing to topography and soils.

There are a couple of exceptions to the general pattern which can be explained. Mickle Fell, an upland site, has an arable score from Turner's index (and even then it is relatively high at 45%) but has pastoral scores for all the other indices. The low score for Turner is due to relatively low values for *Plantago* at this site. Similarly the arable score for Turner for coastal Hartlepool Bay 6 can be explained by low *Plantago*, and also a large catchment area for the site, which could include arable from further inland. Yetholm Loch's low scores for Turner could be accounted for its status as a lake site, which tends to have a larger catchment area. The site could be picking up arable activity in the Tweed valley. Coom Rigg A has arable values for several indices, whereas nearby Coom Rigg B has consistent pastoral scores. This is due to low *Plantago* and Rumex at the A site, and high Compositae, which would explain its low scores for Turner, Brown and Donaldson and Turner.

In summary, the indices of Turner, Turner and Donaldson, Brown, Roberts *et. al.* and Fenton-Thomas distinguish the differences between pollen sites the best of all the indexes used in the pollen literature. These indices, when compared with known modern land-use, do actually provide a good basic indicator of the type of land-use found at a site, and correspond well with the land-use potential predicted for each site. These indices cannot, however, give more detailed information about land-use, such as the distribution of meadow as opposed to rough grazing, and cannot identify mixed agricultural regimes. Steckhan and Lange, Kramm and Riezebos and Slotboom give consistent pastoral scores for all the sites: the dependence upon *Cerealia* pollen, and swamping effect of Gramineae in these indices lead to consistently high scores. It is possible that these indices may be more useful in earlier periods where the dominance of Gramineae pollen is not so marked or does not exist.

c) Conclusions: the value of arable:pastoral and arable:agricultural indices

It has been demonstrated that commonly used arable:pastoral indices have to be used with caution. They have been constructed in many cases on the basis of very limited modern observations, observations which have tended to be applied to a wide range of environments and time periods. The simple distinction between arable and pastoral overlooks the wide range of factors (agricultural, technological, edaphic) which can affect the plant communities associated with different types of land use. There is a great need for detailed work on the effects of different factors on plant communities and the associated pollen rain. Instead of characterising different types of land use by named indicator species, it might be more useful to characterise them by type of plant - nitrophilous, trample-resistant, occurring on disturbed ground, nutrient-poor ground, or on poorly drained land. This might increase the applicability of such ratios to the past, where the exact species may not have been the same, or to different environments. The distinction between arable and pastoral may as yet, in the absence of sound research into modern land use-vegetation-pollen relationships, be questionable when applied to the past. It is, however, still a useful investigative tool; a starting point for suggesting likely land use, which can then be modified in the light of other types of evidence.

5.2.3 The comparative approach

a) Definition of the comparative approach

In the last section it was discussed how the lack of detailed analyses of the pollen rain of modern agricultural communities has led to a simplistic characterisation of different types of land use by a limited range of pollen types. The need for such work is great if we are to understand the relationship between land use, vegetation and pollen.

The comparative approach involves the characterisation of the pollen rain of modern agricultural communities, usually using surface samples from pollen traps or moss polsters. It aims to understand the complex taphonomic relationship between pollen taxa and plant species, and between plant species and land-use, so that ultimately land use can be 'read off' the fossil pollen record. Like the previous approaches, this method uses the uniformitarianism principle.

A major drawback of such an approach is that studies of modern agricultural communities cannot be expected to represent the range of agricultural regimes that may have existed in the past. As has already been discussed, modern agriculture has quite clear distinctions between arable and pastoral which may not have existed in the past. Also, the range of plant taxa associated with modern land-use has been severely restricted by the use of pesticides, reseeding and monoculture cropping. Different agricultural techniques would also provide situations not found in the present; for example, the use of the mouldboard plough would result in a new weed flora with fewer perennials and more annuals, due to the greater depth of ploughing (Behre 1981). Some of these problems might be overcome by examining pollen spectra from experiments attempting to model ancient agriculture or at agricultural research centres where different factors affecting plant growth and weed flora composition can be carefully controlled and measured.

The comparative approach is advantageous in that it is the only approach so far discussed which looks at a wide range of pollen taxa rather than individual taxa or small groups to identify land use. Also, by studying the modern pollen rain it deals with many of the problems of sampling, preparation and identification that affect fossil pollen samples.

It is surprising that so few studies have been carried out into characterising modern agricultural communities. Modern surface pollen sampling has been carried out to look at other issues, such as investigating the pattern of fall off in pollen rain with increasing distance from woodland (Andersen 1970; Janssen 1966; Tinsley and Smith 1974; Tauber 1965, 1967; Tyldesley 1973), or characterising the pollen rain of different plant communities. Examples include Caseldine (1981), Caseldine and Gordon (1978), Randall *et al.* (1986) and Turner (1964) in Scotland, Rymer (1973) in Iceland, Birks (1973), Ritchie (1974), Ritchie and Lichti-Federovitch (1967) and Lichti-Federovitch and Ritchie (1968) in arctic and sub-arctic environments, Davies and Goodlet (1960), Janssen (1967), Maher (1963), Potter and Rowley (1960) and Webb (1974) across North America, Stevenson (1985) in south west Spain, Bottema and Barkoudah (1979) in Syria and Lebanon and Wright *et al.* (1967) in Western Iran.

A small number of studies relevant to the characterisation of modern agricultural communties have been carried out by Berglund *et al.* (1986) in southern Sweden, Potter and Rowley (1960) in New Mexico, Heim (1962) in Belgium, Turner (1964) in Ayrshire, Vuorela (1973) in Finland, and by Caseldine (1981) on Bankhead Moss in Fife. Vuorela's (1970, 1972, 1973, 1975) studies in particular specifically address the issue of pollen rain around cultivated fields. Such studies, whilst useful, are still very small in number, and there is a great need for more studies from a wider range of environments and different types of agricultural regime.

It was initially proposed as part of the current study to carry out a comparative field-study investigating the relationships between pollen-rain, vegetation and modern land-use in the Northern Pennines, so that insights from this could be used to aid reconstructing past settlement and land use. However, given the virtual absence of other work of this type, it was felt that the scale of such a study needed to get sufficient information, including pollen preparation and analysis, would be too great to be incorporated into the current study. A full description of the proposed study is given in Chapter 10 in the section on prospects for further work. This study would investigate the fall off in pollen rain with increasing distance from agricultural fields, and attempt to characterise pollen and vegetation communities of different types of land use. Particular emphasis would be laid on investigating the effects of different factors such as ploughing, manuring, reseeding, rotation of crops, and grazing on the vegetation and pollen rain.

b) Investigating relationships between land-use, vegetation and pollen rain from vegetation survey data

In the absence of such work, some suggestions about possible relationships between land-use, vegetation and pollen can be made by using information from modern vegetation surveys, and inferring the likely pollen rain to be associated with the vegetation, based on the pollen productivity and dispersal of each species, and the taxonomic level to which each species can be identified. Published vegetation survey data from a range of environments across County Durham were obtained from Graham (1988).

Table 5.6 lists a range of different types of modern land-use found across north-east England, ranging from arable fields to road verges, unimproved upland meadows to peat moorland. For each land-use type,a typical associated vegetation community for both the uplands and lowlands of the region is given, with information on species composition, and estimations of abundance of these species (using the 1 to 10 Domin rating of cover/ abundance of a vegetation survey quadrat). For each vegetation community, the likely pollen rain associated with it was estimated, based upon information about the pollen productivity and dispersal of each species, and the taxonomic level to which each pollen type will be usually identified. Abundance of the different pollen types is expressed on a 1-5 scale. This estimated pollen rain information is displayed in Table 5.7, along the lines of the table by Behre (1981), which suggests the likely pollen rain for eight types of land-use found across northern Europe.

The table is not designed to cover the full range of environments and conditions in which each type of land use can be found, but just aims to give some initial guidelines. Such an approach relies on examining the patterns of abundance of a whole range of pollen types, instead of relying on small groups of taxa or individual taxa. It also recognises that any given pollen type can occur in a wide range of types of land use, but it is the abundance of that type and its association with other taxa that is more indicative of particular types of land use.

The value of this table can be checked by using it to help identify land-use from modern and recent pollen levels in cores in the NEEPD. For each core, the entire range of non-tree taxa was examined and given a rating on a 1-5 scale. The scores were then compared with the pollen scores from the table to suggest the most likely corresponding land-use type. The scores were then compared with the known land-use around each core-site and with information on agricultural land potential for each site.

To aid comparison, the ordination program DECORANA (Hill 1979; Kent and Coker 1992) was used to plot pollen cores according to how similar they are in comparison to the estimated pollen rain for the different land-use types. Figure 5.21, first of all, plots the DECORANA scores for the 14 land-use types on the first and second axes. These show the first and second most important axes of variation in the data. On the left of the plot (low on the first axis) are land-use types on base-rich, limestone soils, or on waste ground, rubble and ballast, whilst on the right (high on the first axis) are types found on base-poor, acidic soils and peat. The first axis therefore represents a base-rich to base-poor gradient. The second axis, from bottom to top, separates land-use types in wet and damp conditions, from those on drier soils. The combination of these two axes of base-rich to base-poor and wet to dry covers a wide range of land-use types ranging from damp limestone road verges and meadows to drier base-rich ballast communities and field-stubble, to acid wet mire and blanket mire, and to drier *Calluna* moorland. Neutral grasslands, trackways and other trampled ground fall in the middle of both axes.

If the DECORANA scores for the pollen cores are now added to this picture (Figure 5.22), it can be seen how the pollen cores group with respect to the land-use types, and to each other. It is immediately obvious that the pollen cores do not spread out well into the different land-use categories, instead grouping between blanket mire, grazed moorland, acidic grassland and fen-meadow. There are several reasons why this might be the case. Firstly, this might be because the vegetation around all of the pollen cores is restricted to fen-meadow, blanket mire, grazed moorland and acid grassland, and few pollen cores are taken from base-rich environments or dry conditions. Alternatively, if cores are taken from limestone areas, they will be taken from areas of blanket peat, or wet hollows, where pollen will preserve, thus biasing the cores towards the wetter, more acidic side of the plot. So, even if a pollen core site is surrounded by limestone pasture, the vegetation on the exact spot of the coring will be unrepresentative. Another reason is that pollen cores can represent pollen from a wide range of surrounding environments, and that this might make it less simple to compare pollen data with estimated pollen rain derived from single vegetation survey quadrats. It is therefore evident that there is a great need for more surface sampling work to understand how the vegetation associated with different types of land-use in different types of environment, and the vegetation surrounding it, is reflected in the pollen rain.

5.2.4 Conclusions: the value of the indicator approach, index approach and comparative approach for investigating past settlement and land-use

This review of solely pollen-based methods for reconstructing land-use has evaluated the potential of the indicator approach, the use of arable:pastoral indices, and the comparative approach, by testing them with data where the land use is already known - with recent pollen samples from the tops of cores in the north-east. These studies have shown that relying on individual indicator species alone is inadequate, although comparing distribution maps of individual indicator species can be of great use in understanding the distributions of pollen types associated with human activity. With the index approach, the study of a range of arable:pastoral indices has shown that there is a wide divergence between the results of different indices, and that certain indices are unsuitable for identifying land-use on account of the taxa chosen and their effects on the results. Certain arable:pastoral indices and Fenton-Thomas' agricultural: arable index, however, do seem to correspond well with the known pattern of modern land-use. Since Fenton-Thomas's (1992) index also correctly allows for the fact that there are no types strictly associated with pasture, and instead uses a general group of agricultural taxa, this index has been chosen as the index to use in Part III. As for the comparative approach, this approach is very new and a lot more field work remains to be done before this approach can be applied to reconstructing past settlement and land-use in a range of different environments. However, despite the considerable amount of research that needs to be done before this approach can be useful, it does has great potential for understanding the relationships between land-use, vegetation and the pollen rain.

A drawback with all the above pollen-based approaches is that they rely solely upon the uniformitarian assumption that modern observations can be applied to the past, and do not draw upon other types of evidence to support their statements. It is clear that such modern observations can provide very useful insights, but cannot be expected to cover the full range of land-use types and environmental conditions that may have existed in the past. However, they provide a good starting point, particularly when augmented by other forms of evidence for land-use, such as archaeological evidence. Such as multi-disciplinary, "combined" approach has been advocated by Maguire (1983) as providing one of the most promising avenues for future research. "Combined" pollen and archaeological approaches for shedding light upon past settlement and land-use will be investigated in Chapter 6.

5.3 Section II: The pollen-based methods used in this study and a review of pollen mapping techniques

As a result of the above evaluation of different approaches it was decided to use the following pollen-based methods to investigate settlement and land-use in north-east England from the Mesolithic to the end of the Roman period in Part III. Firstly, summary maps of trees, shrubs, herbs and dwarf shrubs, expressed as a percentage of total dry land pollen, would be presented to give an overall picture of tree and shrub cover in each period, and the extent of moorland cover. Secondly, for each period, a map showing the distribution of scores for Fenton-Thomas' (1992) agricultural: arable index would be presented, for the reasons explained above. Thirdly, a series of maps of selected individual indicator species, discussed in Appendix B, would be presented.

The choice of method of pollen mapping to use to create these maps depends upon several factors. For the purposes of this study, firstly each map should be able to clearly show variations in pollen percentages for a given pollen type across the region, whilst also highlighting smaller scale variations due to differences between individual sites.

Secondly, ideally it should be possible to create a map which interpolates pollen values for a given pollen type from the pollen sites to create a continuous surface across the whole region, so that for any given point in the region it is possible to extract a pollen value. Thirdly, all the maps should be easily comparable, between different periods and between different pollen types. Fourthly, the given method of pollen mapping should be able to display clearly pollen data from a large number of pollen sites.

There are a number of different methods that have been used in the pollen literature to display pollen data from large numbers of pollen sites. Whilst a pollen diagram is the most popular method for displaying pollen data from an entire sequence of a single pollen core, when a study is using data from large numbers of pollen sites, this method no longer becomes practical, and it is difficult to compare what is happening at large numbers of pollen core sites at any one point in time. By using maps, it is possible to display data from large numbers of pollen cores and show how that data varies spatially across the region. There are various methods for displaying spatially varying data in map form (reviewed in Huntley and Birks 1983). Some of the simplest methods include the use of symbols positioned at the locations of each pollen core site which indicate the amount of a particular pollen type at each core site from the size or type of the symbols (for example Von Post 1929), or the use of pie-charts indicating the percentage of different pollen types at each pollen core site (Godwin 1940; Jessen 1949; Neustadt 1959; Ritchie 1976; Fenton-Thomas 1992). Fenton-Thomas (1992) used pie charts to display the percentage of arable pollen types at each site of total agricultural pollen types and also tree pollen as a percentage of total pollen to give a picture of tree cover at each site. This method is a particularly good way of displaying information about more than one pollen type on the same map, but is however best used when there are only a relatively small number of pollen core sites on the map, for reasons of clarity.

When using large numbers of pollen core sites, a clearer method is to use contour maps. Contours (or "isopoll" lines) are drawn between geographical localities with the same pollen percentage for a given pollen type at a particular point in time (Szafer 1935; Firbas 1949). Isopoll mapping has been used by various pollen workers to summarize information from large numbers of pollen diagrams in eastern North America (Bernabo and Webb 1977; Webb *et al.* 1983; Jacobson *et al.* 1987), for Europe (Huntley and Birks

1983), for the British Isles (Birks, Deacon and Peglar 1975), for Finland (Sauramo 1940; Birks and Saarnisto 1975) and for central Europe (Bertsch 1953) and Poland (Ralska-Jasiewiczowa 1983). The use of isopoll maps means that information about only one pollen type can be displayed on a single map, unlike pie-chart maps, although contour maps can be used to summarize several pollen taxa by displaying totals for groups of pollen taxa (such as summary maps of total trees, shrubs, herbs and dwarf shrubs) or by displaying summarized information from many pollen taxa produced by multivariate analyses (for example the use of contour maps by Huntley and Birks (1983) to display principal components analysis (PCA) scores summarizing the trends in a group of pollen taxa). Palaeovegetation maps have been produced by considering the pollen of several different taxa together to map the distribution of different vegetation units in the past. An example of this is Huntley's (1990 b) collection of palaeovegetation maps for Europe from 13000 to the present day, using multivariate classification methods to cluster together similarly behaving pollen taxa into broad vegetation units, which can be demonstrated to change in composition, distribution and extent over time. Prior to this, palaeovegetation units had been only subjectively inferred from pollen maps (Huntley and Birks 1983; Jacobson *et al.* 1987; Bennett 1989, mapping the distribution of woodland types across the British Isles at 5000 years BP). Huntley (1990 c) has also used a multivariate dissimilarity measure (described in Overpeck *et al.* 1985) to identify and map the changing distribution and extent of vegetation units which existed in the past which have no present day analogues. The validity of reconstructing palaeovegetation units from pollen data has been supported by research using isopoll maps to compare recent pollen data with the known modern distributions of different vegetation units (for example by Peterson 1983 for the Western U.S.S.R.).

The use of contours in isopoll maps (especially when the areas between contours are shaded) provides a very clear method of presenting pollen data which highlights spatial trends well, and which also creates a continuous pollen map rather than a map with isolated pollen values at each pollen core site. A feature of the use of isopoll maps is that to show change over time in pollen taxa, it is necessary to produce a series of maps for different points in time (for example, Huntley and Birks' (1983) use of maps at 1000 year time intervals from 13000 years BP to the present and the production of maps at 200 year intervals by Jacobson *et al.* (1987) for eastern North America) This can either be done, where radiocarbon dating is not available, by averaging pollen values for each site for each biostratigraphical pollen zone (for example Turner and Hodgson (1979), who presented maps for various tree pollen taxa by averaging pollen values for the Boreal period), or if radiocarbon dating is available, by selecting fixed points in time and choosing the pollen level at each site corresponding to (or nearest to) that date. Alternatively, pollen values can be averaged over fixed time intervals, such as every 1000 or 500 years. Averaging can be a useful way of showing up rare pollen types which might not show up if data from only one pollen level is displayed.

In certain cases where the variation in timing of a particular "event" across a region is being investigated, such as the first appearance of a taxon or first rise in pollen percentages at every pollen site (such as the *Alnus* rise), or timing of the decline in pollen percentages of a pollen taxon (such as the *Ulmus* decline), it is possible to use contour maps to display both spatial and temporal information on the same pollen map. With this form of mapping, "isochrone" mapping, the contours (or "isochrones") join geographical locations where the event being investigated occurred at approximately the same time. Isochrone maps have been used in eastern North America, for example by Moran (1973) to document variations in timing of the *Picea* decline in the late-glacial (also by Davies 1976, 1981, 1983, 1987; Jacobson 1979; Webb *et al.* 1983; Webb *et al.* 1984; Davies and Jacobson 1985; Gaudreau and Webb 1985; Davies *et al.* 1986) and in Fennoscandia, for example by Donner (1963) to map the variations in timing of the major changes in forest composition in the post glacial, by Moe (1970) to investigate the timing of arrival of *Picea abies* into the region in the post-glacial, and for the British Isles by Birks (1989), to map variations in timing of the first expansion in pollen diagrams of different tree taxa. However, such isochrone maps do not give any information about an event except the variation in its timing across a region and therefore it is very important that exactly the same definition of the event to be mapped is used when extracting data from each pollen sequence.

As explained in Chapter 3, for the purposes of this study, it was decided to produce maps by averaging pollen values over 500 year periods at selected time intervals since 8000 cal. BC, so that each archaeological period was represented by at least one 500 year pollen mapping period. As for the method of mapping used, it was decided to produce for each pollen taxon or group of taxa, for each 500 year period, a continuous pollen map across the whole region, rather than a map showing isolated pollen values at each pollen site. A continuous map was required since, firstly, for the purposes of subsequent analysis in this study it would be necessary to use these maps to extract pollen values for each archaeological site location and secondly, because it creates an attractive map which clearly shows spatial trends in pollen data. Isopoll maps could have been used, but firstly with most contour maps the choice of place to draw the contours is largely subjective (especially if the contours are drawn in by hand, although programs do exist to calculate where contours should be drawn on the basis of the pollen values at each core site), and secondly contour maps produce bands for each range of pollen values, and there is no way of telling the exact pollen value for any given point. Since a method was needed which could produce a pollen value (rather than a range of values) for any given point across the region (for the purposes of subsequent analysis) it was decided to use an interpolation method to interpolate pollen values from individual pollen core locations to every point across the region.

Interpolation programs have been used in the ecological and palynological literature mainly to interpolate climatic data from meteorological stations to a whole series of localities in a given area (Hutchinson 1989; Nix and Switzer 1991; Huntley *et al.* 1995). Until recently, available programs for interpolation have not been able to take into account the effects of variation in elevation across a region, which is important since it is an important factor affecting climatic conditions across a region and also, for the purposes of this study, because elevation is an important factor affecting vegetation distributions and therefore pollen distribution patterns, as discussed in Chapter 2. However, the technique recently developed by Hutchinson (1989), which carries out interpolations by means of Laplacian thin-plate spline surfaces fitted to the data, enables interpolations to be made which are sensitive to elevation as well as location. Nix and Switsur (1991) have used this elevation-sensitive interpolation technique for the wet tropical regions of Australia to interpolate climatic conditions from meteorological stations to locations where vertebrates endemic to Australia's tropics have been recorded, and have used the data to predict the areas (the "bioclimatic envelopes") where these vertebrates are also likely to occur. Huntley *et al.* (1995) have used Hutchinson's technique to interpolate climatic data from meteorological stations across Europe to each

10 degree longitude-latitude grid cell across the region, and subsequently to investigate the relationship between the present day distribution of a range of species and climatic data, using climate response surfaces. This data is used to predict potential future ranges of these plant taxa, considering possible changes in climate. To the author's knowledge, so far this interpolation technique has only been applied to interpolate climatic data and not to interpolate actual pollen values themselves.

Using the interpolation technique devised by Hutchinson (1989), pollen values were interpolated for each pollen type to be mapped, for each 500 year period, for every 500 metre square across the region. A resolution of 500 metre cells across the region was chosen since this was felt to be fine enough to firstly produce attractive maps without too-discernable pixels and secondly for the purposes of analysis, to be able to extract pollen values corresponding to any archaeological site location from the region. Interpolation creates a surface of pollen values by interpolating the pollen values from each pollen core site to every 500 metre cell across the region taking into account easting, northing and elevation. For example, if all the highest values for total tree pollen in a given period occur at the pollen sites with the lowest elevations and the lowest tree values at those sites at the highest elevations, the program would interpolate a clear trend reflecting this. Similarly if all the sites with the highest values occurred in the north of the region at all elevation ranges, and the lowest in the south at the same range of elevations, interpolation would produce a clear trend from north to south. However, when two sites in the same geographical area and at similar elevations have widely differing pollen values, the interpolation program averages those values. This can occur, for example, when two pollen sites close by are very different in nature and catchment area, for example a small bog and a lake. To minimise this problem, where there were several sites close together, only one site would be chosen for use in the interpolation which had a pollen value in keeping with the others in the area. In order to do this, a digital terrain model first had to be created of the region so that information on location in terms of easting, northing and elevation could be extracted for each 500 metre cell. This was created in Arc/Info by converting a contour map of the region obtained from the Bartholomews digital map data set into a TIN (triangulation network) and then into a 500 metre cell grid giving an elevation for the centre of each 500 metre cell. This grid was then exported and converted into ascii format suitable for importing into the interpolation program. Following interpolation, the data files containing interpolated pollen data for every 500 metre cell across the region were imported into Arc/Info and converted into grids. These grids were displayed as maps by shading grid cells falling into the same range of pollen values with the same shade. The resultant maps resemble isopoll maps in that they are made up of areas sharing the same range of pollen values, but unlike isopoll maps there is for each interpolated map a model in Arc/Info GIS which describes the interpolated pollen value for each individual 500 metre grid cell across the region. The resultant maps are therefore not only a way of displaying pollen data but also a valuable investigative tool, whereby the pollen values for any grid cell or combination/ area of grid cells can be extracted for the purpose of analysis.

When interpreting interpolation maps a number of points must be borne in mind. Firstly, if high values for, say, *Plantago*, occur at a given pollen site, but there are a number of pollen sites close by at similar elevations with consistently lower *Plantago* values, the resultant interpolation will smooth over the peak at the one site by averaging the values. Conversely, if there is one pollen site with a high *Plantago* value in an area with very few or no other pollen sites, and there are few or no other pollen sites at that elevation, that site will result in a peak in the interpolation surface and produce a "bullseye" on the resultant pollen map. The fewer the sites there are in an area, and the more different the pollen value is at that isolated site than in the rest of the region, the more pronounced the bullseye. For example, the distribution of pollen sites in Northumberland is far sparser than in upper Teesdale, so that if one site in upper Teesdale had an unusually large *Plantago* value, the large number of surrounding pollen sites with lower values would result in this aberrant site being averaged out, whilst if one site in Northumberland had a very large *Plantago* value, since there are fewer surrounding sites, this site is more likely to be surrounded by a bullseye. Since interpolation results in an averaging and smoothing of pollen values to create a continuous surface, very local differences in pollen values between sites can sometimes be played down. As a result, ideally each interpolated map should be accompanied by a map showing the pollen values at each site used in the interpolation, to aid interpretation.

In Part III, chapter 7 presents interpolated maps produced using interpolation for each 500 year period selected from 8000 cal. BC to cal. AD 500. For each period, the following maps are displayed: firstly, four summary maps of total tree pollen, total shrub pollen, total herb pollen and total dwarf shrub pollen to reconstruct the relative importance of woodland cover, open ground and moorland taxa in each period, secondly an interpolated map of agricultural: arable index scores is presented, to look at changing proportions of arable type taxa and general agricultural type taxa. These maps were presented for all periods, even the earliest, Mesolithic, periods which are generally held to be pre-agricultural, since many of the arable types are useful disturbance indicators and can be used to indicate areas of disturbance rather than arable activity *per se*. Thirdly, maps are presented of a range of different pollen types used as indicators, including general anthropogenic/ disturbance indicators, arable indicators and grassland indicators, (Gramineae, *Cerealia*-type, *Artemisia*, Caryophyllaceae, *Centaurea*, Chenopodiaceae, Compositae, Cruciferae, Leguminosae, *Plantago*, *Polygonum*, Ranunculaceae and *Rumex*). These were chosen since they are commonly used indicator types which tend to be consistently recorded, if present, by most pollen workers. Rarer and less commonly recorded indicator types such as *Cannabis*, *Knautia*, *Centaurium* and *Fagopyrum* noted in Appendix B were not chosen for mapping since they are only recorded at a small number of pollen sites, and only recorded by certain pollen workers.

6 Methods II:

Combined pollen and archaeological approaches for reconstructing settlement and land-use: the "catchment" and "interpolation" approaches.

6.1 Introduction

This chapter will describe two methods for using both pollen and archaeological data to shed light upon settlement and land-use. Maguire (1983) has proposed that "..combined multidisciplinary approaches provide one of the most promising avenues of research for those trying to reconstruct land-use." (p.14) However, little is said about what form such "combined multidisciplinary approaches" should take. Here two methods will be proposed which draw upon both pollen and archaeological datasets. The first method, the "catchment approach", aims to fill in gaps in the often patchy archaeological record by identifying areas where the pollen evidence indicates human activity, but archaeological evidence is sparse or absent. The second method, the "interpolation approach" aims to understand more about the types of vegetation associated with different archaeological site types, by interpolating pollen values for each archaeological site location.

In the pollen literature few attempts to reconstruct past land-use have expanded beyond using pollen data alone, to using other types of evidence for land-use, whether this is archaeological, palaeoenvironmental, historical, documentary or cartographic in nature. However, historical and archaeological evidence has been used to support statements made from the pollen evidence by Donaldson and Turner (1979) at Hallowell Moss, Roberts *et al.* (1973) in mid-Weardale, Davies and Turner (1979) in Northumberland, and for Mesolithic period studies in the North York Moors (Turner *et al.* 1990). However, this use of supporting evidence rarely moves beyond the search for local archaeological sites "responsible" for clearance events or agricultural activity identified from the pollen evidence. In some pollen studies other types of palaeoenvironmental evidence are drawn upon to support statements made about land-use from the pollen evidence, such as sedimentological evidence for erosion and inwashing of material attributed to local soil disturbance (including particle size analysis, magnetic susceptibility, loss on ignition, X-ray photography of cores, or geochemical analyses of sediments) (Bennett *et al.* 1990; Butler 1992 b; Dugmore and Newton 1992; Edwards and Rowntree 1980), or analyses of fungal palynomorphs as indicators of anthropogenic activity (Clarke 1995), or of algal remains such as diatoms and chrysophytes (Haworth 1992). Few attempts have been made to incorporate pollen and archaeological evidence on a scale larger than a single pollen core, or small group of closely spaced cores. Those that do merely provide a qualitative rather than quantitative study, providing only a description of available archaeological evidence in each area alongside a description of the clearance events in the pollen cores in each area (for example, Wilson 1983).

6.2 The "catchment approach"

An attempt to combine pollen and archaeological data to highlight gaps in the first millennium BC - AD settlement evidence for north-east England has been undertaken by Ferrell (1992). She estimated the catchment area size for each radiocarbon dated pollen core in the study area, and noted the numbers of settlement sites within each pollen catchment. For each pollen core, the number of archaeological sites in its catchment area (the source area for the pollen in a pollen core) was compared with any evidence for clearance in the pollen diagram dating to that period. Where pollen evidence suggested clearance, but there were no, or few, archaeological sites in the catchment, it was suggested that there was a gap in the archaeological record. In this way, pollen could be used to fill in gaps in the often patchy archaeological record for the region. This basic "catchment" approach is used as the starting point for the approach adopted here.

This approach seeks to be able to identify gaps in the archaeological record by comparing, for each archaeological period, the number of archaeological sites within the catchment area of each pollen site with averaged pollen values for that period. The pollen catchment area is used, rather than a fixed radius around all pollen sites, to account for the fact that different pollen cores have different sized pollen source areas, depending upon factors such as topography, drainage and height of local vegetation. It is assumed that anthropogenic activity within the catchment area of a pollen site will be reflected in the pollen record by evidence for clearance or disturbance, in the form of lower values for arboreal taxa, and higher values for herb taxa, and in particular higher values for disturbance and open ground indicators, and/or agricultural indicators. The basic assumption is that the larger the number of archaeological sites within a pollen site's catchment area, the greater the evidence for disturbance in the pollen record. Therefore, if the pollen record indicates disturbance, and there is no archaeological evidence for activity, it follows from this assumption that either there is a gap in the archaeological record, or that activity was present but did not leave any surviving or visible archaeological traces. Obviously, this assumption is simplistic, and there are several complicating factors which need to be taken into consideration. For example, archaeological evidence for activity may be present within a catchment but there may be no obvious pollen evidence for that activity, i.e. no peaks in traditional "indicator" types. This might be because the indicators of activity commonly used in the pollen literature, based upon modern-day observations and used with uniformitarian assumptions, may not be relevant to that period, or type of environment.

Instead, other taxa might show a relationship with large numbers of archaeological sites in the catchment area. The catchment approach therefore in these cases might be a useful method for suggesting more relevant indicator types to be used for that period or type of environment. The choice of indicator types would therefore be not based on uniformitarian assumptions, but instead rely on archaeological evidence to identify which taxa are useful in each case. Secondly, archaeological evidence but no pollen evidence for activity might be due to the catchment area being smaller than estimated due to a very local dominance of vegetation that "screens out" any evidence for activity, or totally dominates the pollen rain. Thirdly, the relationship between number of archaeological sites in a catchment and pollen evidence for activity can be confused by the position of archaeological sites within the catchment area. It is difficult in the pollen record to distinguish between one single site of activity very close to the site of the core, and many sites of activity further away from the core site. Therefore, if a pollen catchment has only one recorded archaeological site but considerable pollen evidence for activity, it does not necessarily follow that there are "missing" sites or evidence yet to be accounted for. The site of activity might just have been very close to the pollen core, and therefore give a misleading impression of the scale of activity in the catchment. In addition, large amounts of archaeological evidence just within the catchment area but around the fringes might not be picked up in the pollen record, especially if only a rough estimation of catchment size was made. It is therefore obvious that local conditions around each pollen site and pollen taphonomy need to be taken into consideration when interpreting the significance of presence or absence of archaeological evidence in the catchment area.

The estimation of pollen catchment area size is based upon several factors, including local topography, type of deposit and surrounding vegetation. A considerable amount of work has been carried out into catchment size, and how this is affected by different factors. Jacobson and Bradshaw (1981) have divided pollen site catchments into three size categories and related them to different types of topography, size of deposit, and position with respect to the edge of the bog; very local, local and regional catchment sizes. Pollen cores with local catchments are dominated by pollen from plants growing in the near vicinity of the core, usually within 100 metres of the core site, with only a small proportion coming in from outside. Examples include small peat deposits in stream channels surrounded by steep valley sides, or a small woodland clearing. Extra-local catchments include pollen from a wider area, usually from within a few hundred metres of the core site. Regional catchments have the majority of their pollen coming from outside the local area, and include pollen cores taken on plateaus, large scale blanket bogs and lake cores where pollen is brought in from the watershed by streams and rivers.

A further point to note in estimating catchment size of a pollen core is that the catchment area may have changed over time, affecting the area from which pollen is derived. An important factor is changing tree cover in the vicinity of the core. As tree cover decreases, removing the "screening" effect of tall vegetation, the catchment area of sites will tend to increase. Prentice (1985) has modelled pollen recruitment by basins representing different sized openings in the forest canopy, and shows that pollen catchment areas increase as the tree canopy opens out. The relationship between pollen catchment area and basin size predicted by this model has been supported by field data provided by Bradshaw and Webb (1985). A second factor which changes over time is size of the peat deposit where the core is taken. This can be affected by growth of blanket bog. With the spread of blanket bog, previously small deposits of peat in hollows with local or very local catchment sizes will now widen their catchments to more regional sizes. Lastly, the infilling of lakes (which tend to have regional catchment areas due to their lack of surface vegetation and pollen being brought in from the whole watershed) and subsequent development of woodland on a site will decrease a site's catchment area. It is therefore necessary to estimate the catchment size for each core for each period, by taking into account changes in tree cover, Ericaceae values and the sediment record.

In this study, the catchment area of each pollen core was estimated as follows: a basic score was given for each site based on its site type (lake, plateau, shelf, col, stream channel, basin, or glacial hollow, kettle hole or glacial channel), modified for each archaeological period depending upon whether there was blanket bog growth or infilling of lakes. Turner and Hodgson (1983) state that all types of pollen site except plateaux or lake-deposits (which would always tend to have very large catchment areas) would have a basic extra-local site catchment area in the earlier periods (ignoring at the moment the additional effect of tree cover on catchment size). Channel and basin mires are likely to have changed little in their catchment area size over time. However, the catchment size of mires on hillsides, in cols and on shelves, which were originally likely to have been small topogenous (i.e. formed by the local topography) mires in shallow depressions, will have grown over time with the spread of blanket bog. This would have extended the size of the peat deposit so that over time peat grows out from the original hollow, often merging with other areas of peat to form a continuous blanket. Since large scale blanket bog formation occurs in the Bronze Age period at many sites (Turner *et al.* 1973) these sites are modified from extra-local to regional catchment types. Finally, the effect of changing local tree cover is taken into consideration, and the catchment areas of sites modified accordingly.

Table 6.1 gives the estimated pollen catchment area for each pollen core inside the boundaries of the study region, for each period. Pollen sites near to the edges of the boundary of the study area were not used, since the catchment areas would include areas outside the study.

The number of archaeological sites within the catchment of each pollen site in each period was calculated by using the method of "buffering" in the Arc/Info GIS (Environmental Systems Research Institute 1993). For each period, a points coverage was created of all the archaeological sites in the region used in this study. A second points coverage had the locations of all the pollen cores to be used. Around each pollen site a "buffer" was created, the same size as the estimated catchment area for that period. Sites with estimated "local" catchments were given a buffer of 100 metres radius, sites with "extra-local" catchments a buffer of 500 metres radius, and sites with "regional" catchments a buffer of 5 kilometres radius. Obviously this is only a very rough estimate of the actual catchment size of a site at any one time. These buffers were then used to extract a list of all the archaeological sites within the catchment areas of each pollen site. This has been summarized in Tables 6.2 to 6.6.

To investigate the relationship between number of archaeological sites within the catchment area of each site, and the pollen record for each site, triangular ordination plots were produced for each period. A mock example of a triangular plot, produced with made-up data purely for the purpose of illustrating the method used to present the results of the catchment approach is presented in Figure 6.1. The results of triangular plots produced for each archaeological period will be discussed in detail in the results section in Chapter 8. Such triangular diagrams plot pollen sites with respect to their averaged arboreal pollen (trees plus shrubs), herb and Ericaceae values for each period. The size of the circle representing each pollen site indicates the number of archaeological sites within its catchment in that period. In this way it can clearly be seen which pollen sites have low arboreal pollen but no archaeological sites, and therefore which might suggest a gap in the archaeological record.

As has already been mentioned, care must be taken in the interpretation of such diagrams. Merely using total arboreal, herb and Ericaceae pollen as basic indicators of clearance activity overlooks a lot of information that could be provided by individual herb taxa. Also, low arboreal pollen may not necessarily be due to human activity: a lack of archaeological sites in the catchment of an upland site dominated by blanket bog, with few trees and shrubs and a dominance of Ericaceae, may be due to a gap in the archaeological record, but then again it may be due to a lack of human activity in the catchment. Low arboreal cover in such areas might just as easily be the result of the spread of blanket bog preventing regeneration of trees. Interpretation of pollen in terms of human activity in upland areas is difficult on account of this. However, each site should be interpreted in the light of knowledge of trends in other pollen taxa, and in the light of how much archaeological survey has gone on in the area.

6.3 The "interpolation approach"

This approach aims to identify which archaeological site types are associated with different types of land-use, specifically which types are associated with woodland, clearances, moorland, and arable as opposed to more pastoral activity. This is done by interpolating pollen values for total trees, shrubs, herbs and Ericaceae, and agricultural:arable index scores for the relevant time period for each archaeological site location. Each archaeological site is assigned pollen values by extracting them from interpolated pollen maps for each taxon.

In order to be able to extract pollen values for each archaeological site location, continuous maps were produced for each taxon (total trees, shrubs, herbs, Ericaceae, and for the agricultural:arable index scores) for each archaeological period. This was carried out using pollen interpolation. The study region was divided into a series of points at 500 metre intervals, and pollen values interpolated from all the available pollen core sites to each point across the region. The interpolation program already described in Chapter 5 was used to carry out pollen interpolation. The input file for each period contains averaged values for that period for trees, shrubs, herbs and Ericaceae for each pollen site with information available for that period.The resulting data for each point were converted into a format suitable for importing into Arc/Info, where they were converted into grid coverages. One grid was created for each taxon for each period. By converting to a grid coverage, each point was converted to a 500 metre grid square, each of which had an associated pollen value.

Values for each taxon were then extracted for the 500 metre square corresponding to each archaeological site location. Locations of each archaeological site were entered into Arc/Info, noting information such as the site type, and period, as a points coverage. Pollen values were then extracted for each archaeological site location from the relevant grids, depending upon the period of each archaeological site. If an archaeological site type spanned more than one archaeological period, pollen values for all the relevant periods were extracted for those sites.

Owing to the large numbers of archaeological sites, it is not possible to present the interpolated pollen values for each site. Instead, archaeological sites were divided into site types, and an idea of the range of pollen values associated with each site type was gained by calculating the mean pollen values for trees, shrubs, herbs and Ericaceae, and agricultural:arable index scores, together with a measure of variability around the mean. It was decided to present the results in the form of a "summary pollen diagram" of total trees, shrubs, herbs and Ericaceae, and agricultural:arable index scores for each type of archaeological site, using error bars to indicate the variation around the mean values. Instead of using standard deviation, it was decided to double the standard deviation in each case to give an approximation of the 95% confidence limits. 95% confidence limits were used as explained in Chapter 3, according to standard statistical practice (Shennan 1988). An example of one such "summary pollen diagram" showing the mean values and variation in the interpolated pollen values for different archaeological site types is provided in Figure 6.2. The diagram presented here is merely for the purpose of illustrating the methods used in presenting the results of this approach. The actual results in this diagram will not be discussed here (as the data used to make this example diagram are not 'real' data, instead being made up to illustrate a point), and the results of the interpolation approach will be discussed in full for each period in Chapter 8. Using these diagrams it is possible to visually compare the mean interpolated values for each type of archaeological site type. By comparing these summary statistics between different types of archaeological site it is then possible to discern whether different types of archaeological site are associated with particular types of vegetation and land-use, or conversely, whether certain types of site tend to be associated with a wide range of different types of vegetation and land-use.

For the purpose of illustration, in Figure 6.2 it can be seen that there is comparatively little variation between different archaeological site types in the mean and range of interpolated pollen values for trees or shrubs, but a far greater degree of variation between site types in interpolated herb and Ericaceae pollen values. Quern findspots and burial sites have the smallest variation in herb and Ericaceae values whilst monuments, cairnfields and settlement sites have some of the widest variation in pollen values, which suggests they occurred across a wider range of environments than recorded quern or burial findspots. This is only a very simple example of the sort of information that can be gained from such diagrams, and a more in depth disussion of each diagram and their implications for a discussion of settlement and land-use in each period will be provided in Chapter 8. Using such diagrams it is possible to reconstruct the range of types of environment in which different types of archaeological site or findspot type occurred in a given period, bearing in mind the variations and biases in preservation and recovery of archaeological material which affect distribution patterns.

The catchment approach and interpolation approach are applied to data from north-east England in chapter 8.

Development of Methods for Investigating Settlement and Land-use using Pollen Data:

A Case-study from North-east England, *circa* 8000 cal. BC - cal. AD 500

Volume one
Text of Chapters 1-10, Appendices and References

Part two
Text of Chapters 7-10, Appendices and References

Submitted for the higher degree of PhD
by Kathryn Elizabeth Pratt MA (Cantab.), MSc

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1996

Part III

Results

Investigating settlement and land-use for north-east England from the Mesolithic to the end of the Roman period,

circa 8000 cal. BC - cal. AD 500

7 Results I:

Pollen-only approaches for reconstructing settlement and land-use, *circa* 8000 cal. BC - cal. AD 500.

This chapter will present the results produced using the purely pollen based approaches described in Chapter 5 for reconstructing settlement and land-use. These approaches use pollen maps to describe woodland cover, evidence for clearance, and the proportion of arable pollen as a percentage of total agricultural pollen in each period. Results will be described period by period. Results of the combined pollen and archaeological methods described in Chapter 6 will be presented in the following chapter, Chapter 8. Interesting questions that are raised by these results concerning settlement and land-use in each period will be discussed in Chapter 9.

Pollen maps are presented together for a range of different pollen taxa for each 500 year period. At the start of each section of maps for a period there is a list of all the figure numbers for each of the maps for that period. There then follows a table summarising the trends observed in that period for four main areas of the region: the Durham and Cleveland lowlands in the south east of the region, the foothills and lower valleys of the Derwent and Weardale area, Northumberland and the uplands of the Northern Pennines. This table is followed by a map showing the location of all the pollen cores used to create the interpolated pollen maps for that period. This is then followed by the interpolated maps for that period. The maps used in this chapter to present the results divide into three types for each period. Firstly, summary maps of total tree, shrub, herb and Ericaceae pollen as a percentage of total dry land pollen are presented. These are followed by a map of agricultural:arable index results. There then follows a series of maps of selected individual herb taxa used as indicators of disturbance, arable activity, meadow and pasture, as described in Appendix B. Trends in the maps are described in detail, area by area, in tables for each 500 year period. These results for each 500 year period are discussed with reference to trends in individual pollen diagrams within the study region and with pollen sites outside north-east England.

At the end of the chapter a summary of trends occurring in different areas of the region throughout the whole period is given.

7.1 The Mesolithic, *circa* 8000 - 4000 cal. BC

Three pollen mapping periods are used here for Mesolithic period. The first extends from 7800 - 7300 cal. BC, the second from 6800 - 6300 cal. BC and the third from 5500 - 5000 cal. BC.

Although studies by Turner and Hodgson (1979, 1981) have analysed large numbers of pollen diagrams in order to investigate tree cover during pollen zones corresponding to the Mesolithic period (the Boreal and Atlantic zones), these studies were mostly confined to the Northern Pennines and involved multivariate analysis rather than mapping. There has been no attempt to map changing levels of different pollen taxa in this period across the whole of the north-east of England.

7.1.1 Tree and shrub cover: changes through the Mesolithic period and variations in tree and shrub cover across the region

The summary maps of trees, shrubs, herbs and Ericaceae for the Mesolithic can be used to gain a picture of the changing nature of tree and shrub cover through time, and how this varied across the region.

Throughout the whole of the Mesolithic period tree and shrub pollen, taken together, dominates the pollen at most sites across the region. The main variations between sites and over time are in the relative amounts of trees and shrubs. The main factor responsible for this patterning is the rise of *Corylus* during this period to very high levels at many pollen sites from across the region, so that it dominates the shrub pollen. In this Mesolithic section shrub pollen will be referred to as *Corylus*, since it almost entirely dominates the shrub pollen at pollen sites in this period. If the shrub pollen at a given site is largely another shrub taxon than *Corylus* (for example *Salix* or *Juniperus*) this will be explicitly stated in the text. During the three 500-year periods studied here between 8000-4000 cal. BC, the proportion of *Corylus* pollen of total pollen increases markedly at many sites up to the period 6800-6300 cal. BC (Fig. 7.1.21), and then declines, to be replaced by trees by 5500-5000 cal. BC (Fig. 7.1.38).

In all three periods of the Mesolithic, some of the highest tree pollen values occur in the centre of the region, between the lowlands and uplands, at elevations of 200-300m a.s.l., and include sites in the Tyne Corridor, the upper Derwent and mid Weardale (Figs. 7.1.2, 7.1.20 and 7.1.37). *Corylus* pollen is far more important in the south east of the region, although together the pollen of trees and *Corylus* make up virtually all the pollen at these sites. Herb and Ericaceae pollen is very low. The exception to this is unusually high herb pollen values at Bishop Middleham. The high *Corylus* levels in the south east of the region continue to dominate through the first and second periods of the Mesolithic (Figs. 7.1.3, 7.1.21), but by 5500-5000 cal. BC (Fig. 7.1.38) *Corylus* pollen declines markedly as tree pollen increases to replace it (Fig. 7.1.37). By this last period, most of the sites in the lowlands resemble the Weardale and Derwent sites in their dominance of trees.

Most sites in the north of the region, in northern Northumberland, behave similarly to sites in the south east of the region, with tree and *Corylus* pollen together making up almost all the pollen at these sites, but being made up mostly of *Corylus* pollen. Tree pollen is higher at a couple of sites in the area (Lilburn Steads and Trickley Wood, in the lowlands of northern Northumberland) and here *Corylus* pollen is lower. At virtually all sites, as in the south east of the region, herb pollen levels are low, with the exception of Akeld Steads, which has unusually high herb levels (80% tdlp, Fig. 7.1.3). Ericaceae levels are higher at most sites in northern Northumberland compared to the south east of the region, rising to 14% tdlp. Through the Mesolithic, *Corylus* values increase at these northern sites to maximum levels in the period 6800-6300 cal. BC, accompanied by a drop in tree percentages, but by the final period, 5500-5000 cal. BC, as in the Durham lowlands, trees recover again. Here trees and *Corylus* have almost equal levels at most Northumberland sites.

In the uplands of the region total tree and *Corylus* pollen values are lower than found elsewhere, and shrub pollen is most important, with tree pollen rarely exceeding 30% tdlp (Fig. 7.1.1). Ericaceous pollen levels are greatest on the upland tops, at the highest elevations in the region (Fig. 7.1.4). On the upland tops herb pollen is low, compared with sites in more sheltered locations and at lower elevations in the uplands, where herb pollen values are considerably higher. In upper Teesdale herb pollen values reach some of the highest values found across the region, rising to 40% tdlp (Fig. 7.1.3). Through the Mesolithic, as in other areas of the region, *Corylus* percentages increase at most sites in the uplands, and high herb pollen levels in Upper Teesdale decline, and by 5500-5000 cal. BC tree pollen percentages recover to replace shrubs. Throughout the period levels of Ericaceae increase steadily, particularly at higher elevations (Figs. 7.1.4, 7.1.23 and 7.1.38).

7.1.2 Discussion: factors responsible for changes in tree and shrub pollen values in the Mesolithic.

a) Major changes in tree and shrub taxa during the Boreal and Atlantic periods (pollen zones V/VI and VIIa).

In order to account for the changes in tree and shrub pollen values in the Mesolithic and for differences between different areas, it is necessary to investigate a range of factors which may have been responsible for these changes and differences, such as climatic changes during this period, or the spread of tree and shrub taxa into the region following deglaciation, before considering the role of human activity on tree and shrub cover during this period. It is important to briefly note the wider context of major changes in the tree and shrub pollen spectra which occur at many pollen sites across Britain during the Mesolithic period. These changes concern the timing of spread of different tree and shrub taxa across Britain in the Holocene following the deglaciation, and form an important backdrop to smaller scale events due to human activity. This variation in timing of spread of different taxa strongly influences the changing proportions of trees and shrubs in this period.

The Mesolithic period dealt with here covers two of Godwin's zones, the Boreal (zones V/VI), covered here by the periods 7800-7300 cal. BC and 6800-6300 cal. BC, and the Atlantic (zone VIIa), here covered by the final period 5500-5000 cal. BC. The start and end of these zones are defined by major, widespread events in the tree and shrub pollen curves. Since these events vary in timing from site to site, they are not strictly synchronous. At the start of the Boreal, high levels of *Corylus* are already present at most sites, having appeared and risen rapidly in the preceding Pre-Boreal zone (Zone V), which dates from 8810 cal. BC at Scaleby Moss and 9040 cal. BC at Din Moss in Northumberland. The start of the Boreal is marked by the appearance and rise of *Ulmus* (elm) and *Quercus* (oak) pollen, with the continuation of high *Corylus* values from the preceding period. This is dated at Din Moss to 8000 cal. BC and at Scaleby Moss to 8030 cal. BC. Levels of *Pinus* (pine) and *Betula* (birch) are also high in this period, continuing from their dominance in preceding periods. During the Boreal period, small amounts of *Alnus* (alder) pollen start to appear (the "empirical" rise of *Alnus*), dated to 7270 cal BC at Tinkler's Sike and 7030 cal. BC at Weelhead Moss in Upper Teesdale, and 6180 cal. BC at Din Moss. During the Boreal period *Corylus* values increase further at many sites, clearly seen in the pollen map for shrubs for 6800 - 6300 cal. BC, with a corresponding decline in tree pollen percentages at many sites. However, *Corylus* values at most sites decline by the third Mesolithic period studied here, 5500-5000 cal. BC, when shrub pollen levels decline considerably at most sites.

The end of the Boreal and start of the Atlantic is distinguished by a marked drop in *Pinus* pollen and significant rise (the "rational" rise) in *Alnus* pollen. This varies in date from site to site, but is dated at Mordon Carr in the Durham lowlands to 6540 cal. BC, and in the uplands at Weelhead Moss to 5376 cal. BC and at Valley Bog to 5620 cal. BC. The decline in shrubs and rise in trees characteristic of the Atlantic period is clearly seen at most sites in the region in the period 5500-5000 cal. BC. The end of the Atlantic is marked by the widespread *Ulmus* decline (discussed in the next section). These major changes related to climate and tree-spreading are responsible for the large-scale changes over time in tree and shrub proportions at sites in the region.

These changes characterising the different pollen zones in the Mesolithic period are well known in the pollen literature. However, the pollen maps show how different areas of the region respond to these changes. The different proportions of trees and shrubs in different areas of the region, and variations in openness of woodland cover, however, are related to factors such as soil (nutrient status and moisture content), underlying bedrock geology, rainfall, temperature, slope, aspect and also disturbance, whether natural or due to human activity.

b) Nature of woodland cover in the Mesolithic

Whilst the pollen maps only look at changes in total tree and shrub pollen, it is interesting to consider these changes in the light of changes occurring in individual tree and shrub taxa in the region. As already stated, for most of the earlier part of the Mesolithic *Corylus* dominates the pollen sum. *Corylus* plays an important role in woodland development in invading open ground, forming scrub and light woodland. However, its importance in woodland can be exaggerated as it tends to overproduce in open situations such as light woodland, and to be a very high pollen producer except in shaded conditions. Even so, such large percentages are likely to indicate that it was a dominant component of the woodland at many sites, particularly in the uplands, and that this woodland is likely to have been open. According to Tinsley and Smith (1974), figures over 20% total pollen can safely be taken to indicate local presence.

In the uplands, where *Corylus* is dominant, tree pollen does not exceed 30%, and is made up primarily of *Betula* and *Pinus*, with small amounts of *Ulmus* and *Quercus*. The amounts of each type vary from site to site, depending upon local conditions, with *Pinus* and *Corylus* on the better drained soils and *Betula* in the wetter hollows and on exposed situations. Where *Ulmus* and *Quercus* do occur, they are most likely to have been on more steep ground (Chambers 1978), although Turner *et al.* (1973) argue that the small amounts of *Ulmus* and *Quercus* pollen in Upper Teesdale are most likely to have been blown in from lower down the valley. The picture of open woodland is supported by herbaceous pollen, which is highest in this part of the region and more varied compared to the lowlands, with values up to 68% tdlp at selected sites in Upper Teesdale, although at other sites it is as low as 10%. Peat deposits are present in hollows at some sites at the highest elevations.

Over time, tree pollen levels increase, as levels of *Ulmus*, *Quercus* and *Alnus* increase, and *Corylus* decreases, so that by 6800-6300 cal. BC tree and shrub levels are equal at many upland sites, with trees around 30-40%, and by 5500-5000 cal. BC tree values of 40-50% are common, except on the more exposed uplands where shrub pollen continues to dominate. During this last period and up to the *Ulmus*-decline trees reach their maximum values at most sites. Turner *et. al.* (1973) describe how the timing of the spread of *Alnus* and *Quercus* and decline of *Pinus* is related to elevation, exposure, and how well drained the soil is; in the more sheltered Cow Green reservoir basin the spread of *Alnus* occurs early, most probably having spread up the floor of the valley, whereas on the more exposed and better drained limestone fells *Pinus* hangs on longer, before finally declining just before the *Ulmus*-decline. During the Atlantic period conditions become wetter at most sites, favouring the spread of *Alnus* over *Pinus*. Values for *Calluna* (heather), which dominates the Ericaceae percentage, also increase throughout the Mesolithic at upland sites, from up to 8% in the period 7800-7300 cal. BC to up to 37% at some sites in 5500-5000 cal. BC. In this period peat was beginning to form in areas which were previously peat free, although at some sites peat had been present in hollows from the start of the period.

In the lowlands in the first two periods of the Mesolithic studied here, shrubs are as important, if not more important, in south east Durham and northern Northumberland, as in the uplands; herb levels are lower and there is virtually no Ericaceae in the Durham lowlands and at some Northumberland sites. The lack of *Calluna* at these sites is probably due to the nature of the sites: infilled glacial hollows and channels as opposed to peat deposits in the uplands. Total tree and shrub cover is higher, implying less open woodland than in the uplands. At some sites between 200-300m a.s.l. trees are more important, reaching 71% tdlp. In these woodlands *Pinus* and *Betula* dominate locally around the sites. Later in the period, the area covered by more tree-dominated as opposed to *Corylus* dominated woodland spreads, so that by 5500-5000 cal. BC it includes sites in the south-east Durham lowlands, and the proportion of trees continues to increase at these sites, as *Quercus*, *Ulmus* and *Alnus* increase in importance in the lowlands. The earlier *Alnus* rise in the lowlands supports the view that conditions were more favourable for its early spread in the lowlands. The decline of *Corylus* values during the Atlantic suggests that now it acted as an understorey shrub in denser woodland. However, its actual importance might be greater than suggested, since its values are underrepresented as an understorey shrub. Herb values remain lower than in the uplands throughout the period, seldom increasing beyond 5%.

c) Clearance in the Mesolithic

i) Distinguishing the role of human activity in creating clearances from other factors in the pollen record - some problems

Research interests

Pollen evidence forms one of the main sources of evidence for hypotheses about Mesolithic land-use. The reconstruction of human activity in the landscape in the Mesolithic has relied almost entirely upon the identification of woodland "disturbances" or "clearance events" in the pollen spectra, by the occurrence of certain "indicators" of openings in woodland. However, compared to the Neolithic period, surprisingly little attention in the pollen literature from the north-east has been paid to the identification of human activity in the Mesolithic from pollen evidence. Few pollen cores from the region have been studied with the specific aim of reconstructing Mesolithic land-use: most work on this period has concentrated upon the appearance and spread of tree taxa up to their maximum levels that occurs in this period. In many ways the nature of the available pollen evidence for north-east England is insufficient to identify disturbances, and this therefore restricts the amount of information that can be gained about land-use in this period.

Resolution of sampling

Most pollen studies that have focused upon the identification of Mesolithic activity have used fine-resolution pollen sampling, as close as 1mm resolution at North Gill in North Yorkshire (Turner *et al.* 1993). At these pollen sites it is possible to identify not only individual disturbance phases, but stages within each disturbance, and the use of close radiocarbon dating enables a rough estimate of duration of clearance and differences in the timing of disturbance between sites. However, for the majority of pollen cores from north-east England with levels dating to the Mesolithic, the sampling interval is too coarse to identify individual disturbance events. This is mainly because so few pollen cores were taken to specifically address Mesolithic land-use. Disturbances might be missed entirely as they fall between sampling points, or be hard to identify if they were only represented by one sample level, or a single sample might mix pollen from clearance and woodland regeneration phases and so fail to show a clear and identifiable disturbance episode. In addition, the lack of radiocarbon dating at most sites, plus the wide interval of dates at dated sites, means that it is inadvisable to compare the timing and duration of disturbances at different sites, where they can be identified, within at least 500 years. The use of averaged values from 500 year intervals to map pollen types in this study also obscures any clearance events if they only lasted for short periods.

500-year averaged maps can be used to identify sites where clearance lasted longer than a 500 year period, or where clearance was more extensive, identified by lower average values for closed woodland types and the occurrence of taxa preferring open conditions, compared with other sites in an area. The advantage of mapping results from large numbers of pollen sites is that abnormally behaving sites for a particular area/elevation/bedrock geology type can be identified. Also by averaging pollen values over a 500-year period, the occasional or single occurrence of certain pollen types which may help identify clearance will be identified. In addition to identifying sites where clearance occurred, averaged maps can be used to reconstruct the general patterns of vegetation across the region in this period, and this can be used to form hypotheses about land-use.

A further problem lies with distinguishing anthropogenic (man-made) clearances from natural events such as climatic changes, changes in nutrient status or moisture content of the soil, and natural fires. At the closely-spaced, finely-sampled, well dated sites at North Gill, it was possible to identify certain clearances as anthropogenic, since regeneration did not occur after the same time at each site: regeneration following natural events would be expected to be the same at each site. However, it is possible that clearance due to natural causes could be exploited by people, and clearances maintained. In the absence of such fine dating elsewhere, it is impossible to tell anthropogenic from non-anthropogenic clearances on these grounds. However, by mapping pollen from large numbers of sites, changes at any site which are not found at other sites in its area are more likely to be anthropogenic in origin or caused by small scale natural disturbances than changes which occur widely across a region, and which coincide with climatic changes.

ii) Evidence for clearance

The *Corylus* maximum and human activity

The very high values of shrubs, particularly *Corylus*, in the Mesolithic in both upland and lowland situations, especially in the earlier part of the Mesolithic, and then mostly in the uplands in the later Mesolithic, have been commonly interpreted in the pollen literature as the result of woodland disturbance, owing to the ability of *Corylus* to quickly invade after clearance. The high *Corylus* values have been seen as being encouraged and maintained by human activity in the landscape (Perring, 1965, Jacobi, 1978). However, the initially high values of *Corylus* in the Pre-Boreal and Boreal could instead be merely the result of its role as an early coloniser of open ground, forming scrub and open woodland, and spreading rapidly from refugia close to, or in Britain, in the late glacial. Its continued importance in the Boreal could be explained by the slower spread of tree taxa such as *Alnus*, *Quercus* and *Ulmus*, and the persistence of open woodland in the uplands. In addition, the assumption that increased *Corylus* values are always a good indicator of clearance should be questioned. In situations such as heavy grazing, invasion of *Corylus* into clearings would most likely be prevented as seedlings were grazed, resulting in a drop in its values. If grazing were light, however, or woodland were cleared specifically for the use of *Corylus* (for example, for nuts or timber) values would increase. It is therefore possible that human activity might have played some role in prolonging the dominance of *Corylus* in woodlands, although if this were the case, it would mean that such activity was widespread across the region, since it occurs at most pollen sites. If human activity is to be seen as responsible for the widespread *Corylus* maxima, more evidence for large-scale clearance activity would be needed to support this.

The appearance of other tree and shrub taxa preferring light, open conditions has also been seen as evidence for clearance. At Valley Bog, a clearance event with an increase in *Corylus* and light-demanding herbs dated to the later Mesolithic is accompanied by a notable increase in the occurrence of *Fraxinus* (ash) pollen. *Fraxinus* is commonly seen as first appearing, or increasing, with clearance activity (Godwin 1975a). Its often erratic curve is seen as reflecting its response to successional stage changes in woodland clearings, whether natural or anthropogenic. The under-representation of the pollen of this tree means that it is likely to have played a more important role in woodland composition, taking advantage of openings in woodland to quickly spread, but being quickly shaded out again by other trees. The appearance of *Fraxinus*, and shrubs such as *Ulex*, *Prunus* and *Sambucus*, which all do not occur in large amounts until after the *Ulmus*-decline, could however be explained by the existence of upland refugia, as with disturbed ground indicators. However, even if this were the case, any disturbance activity would encourage growth of these species. In many clearance events noted at sites, there is a decline in *Ulmus* pollen. Since many of the reasons for this decline in *Ulmus* have been put forward to account for the major *Ulmus*-decline event in the early Neolithic, it will not be dealt with in any detail here. Instead, reasons for the *Ulmus* decline will be discussed in the section on the early Neolithic.

Herb pollen evidence for clearance

Prior to this study, most pollen studies from this period in the region have concentrated upon changes in tree and shrub taxa, with little attention paid to changes and variations between areas in herb taxa. The agricultural:arable maps in Figs. 7.1.6, 7.1.24 and 7.1.41 would seem to have little relevance to a discussion of Mesolithic clearance. However, many "arable" type taxa are also useful indicators of open and disturbed ground, and non-arable, 'pastoral' type taxa are likely to have occurred in open grassland situations, as discussed in Appendix B. The relative amounts of different types of herb taxa can therefore be used to investigate degree of disturbance. The maps of individual indicator taxa are also very useful for shedding light upon clearance activity. The distributions of pollen of different herb taxa can be interpreted in the light of knowledge about the ecological tolerances and types of situations they are found in today, discussed in Appendix B.

Throughout the period, the highest values for Gramineae, as for herb pollen values in general, occur in the uplands (Figs. 7.1.7, 7.1.25 and 7.1.42). Grass pollen values increase over time so that in the period 6800 - 6300 cal. BC (Fig. 7.1.25) more sites across the region have grass pollen values over 5% tdlp. However, by the final period grass pollen values decline at all sites except in the uplands (Fig. 7.1.42).

The other herb taxa divide into two groups based on their distribution patterns across the region in the Mesolithic, and upon how their distributions change through time. The first group of herb taxa occur in the first Mesolithic period only at sites at the highest elevations in the west of the region, but by the third period of the Mesolithic, 5500 - 5000 cal. BC, have spread out from the upland tops to other parts of the uplands, at lower elevations. The second group of herb taxa occur in the first Mesolithic period only at lower elevations in the uplands, such as in upper Teesdale, rather than the upland tops, and sometimes at sites in northern Northumberland. By the third Mesolithic period, many of these taxa have, like the first group, spread to other areas in the uplands, including the upland tops, and also spread to other areas of the region, such as the south east of the region. The first group, including *Artemisia* (Fig. 7.1.8, 7.1.26, 7.1.43), Caryophyllaceae (Fig. 7.1.9, 7.1.27, 7.1.44) and Leguminosae (Fig. 7.1.13, 7.1.31, 7.1.48), like that of Ericaceae, is found almost only on the upland tops at the highest elevations in the region throughout this period, although *Artemisia* also appears at some sites in northern Northumberland with high values. However, by the last Mesolithic period, 5500 - 5000 cal. BC, many of the herb pollen taxa formerly only occurring on the upland tops now spread to other sites in the uplands, such as into upper Teesdale. Ranunculaceae also occurs at sites at high elevations in the uplands in the first and second Mesolithic periods, but also occurs at most sites in northern Northumberland and some sites in the south east of the region (Figs. 7.1.16, 7.1.34), but by the third Mesolithic period values have increased in northern Northumberland and Ranunculaceae appears for the first time in other areas of the region (Fig. 7.1.51).

The second group of herb taxa includes Chenopodiaceae, Compositae, Cruciferae and *Plantago*. Chenopodiaceae pollen occurs through most of the Mesolithic only at sites in upper Teesdale (but is absent from the upland tops where taxa in the first group are present) and in the north of Northumberland (Figs. 7.1.10, 7.1.28). However, by the final Mesolithic period, Chenopodiaceae pollen spreads out from these areas to appear, not only at other sites in the uplands than upper Teesdale, but also at sites in the south east of the region (Fig. 7.1.45). Compositae start off occurring only in upper Teesdale (Fig. 7.1.11), but by 6800-6300 cal. BC it has appeared at sites in the south east of the region (Fig. 7.1.29) and by 5500 - 5000 cal. BC values increase further in the south east (Fig. 7.1.46). In this final period it also spreads across the uplands in this region out from its former location in upper Teesdale onto the upland tops. Cruciferae also occurs only in upper Teesdale and in small amounts in northern Northumberland in the first Mesolithic period (Fig. 7.1.13), but by 5500 - 5000 cal. BC it has spread to other areas of the uplands (Fig. 7.1.47). *Plantago* occurs at a small number of sites in upper Teesdale in the first two Mesolithic periods (Figs. 7.1.14, 7.1.32), but by the final period (7.1.49) has increased in northern Northumberland and appeared at sites in the south east of the region. *Polygonum* occurs in small amounts in upper Teesdale and northern Northumberland throughout the period and is absent from the rest of the region (Figs. 7.1.15, 7.1.33, 7.1.50).

The occurrence of the first group of taxa, including Artemisia, Caryophyllaceae, Leguminosae and Ranunculaceae, on the upland tops in the west of the region in the Mesolithic, particularly in the early periods when pollen of these types did not occur at many sites outside these areas, suggests that these types are in some way suited to conditions at high elevations. The occurrence of *Artemisia* in the earlier Mesolithic periods solely at sites at the highest elevations is consistent with its present day occurrence in conditions which are relatively disturbed, such as rubble or ballast heaps, where taller species are prevented from growing (Grime *et al.* 1992). One could envisage such situations occurring in rocky and exposed situations on the upland tops. Similarly, many members of the Caryophyllaceae family (Type A Caryophyllaceae discussed in Appendix B) and also of the Leguminosae family (Type A Leguminosae) today occur in short turf on thin, well drained soils, often on igneous rock or rocky outcrops, including the Whin Sill, and on limestone or sandy soils (all of which occur in the Northern Pennine uplands and in the Cheviots). The present day occurrence of other members of the Caryophyllaceae (Type C) family on waste ground is consistent with the occurrence of other members of the same families in natural disturbed habitats, and it is quite possible that these species had their origins in this type of habitat. The occurrence of Ranunculaceae pollen on the upland tops in the Mesolithic is not inconsistent with the picture above; although this family includes types occurring in a wide range of environments, a couple of species today are found on disturbed waste ground (Type D Ranunculaceae) and it is possible that in the past they were found in such situations. High Gramineae values and Ericaceae values for the upland tops also are consistent with the picture of open grassland with short turf and some areas of dwarf shrubs (note that pollen of all dwarf shrubs have been included in the term "Ericaceae" although technically they are not all members of this family), probably those suited to high levels of exposure and rocky conditions such as *Vaccinium* and *Empetrum*, rather than *Calluna*.

It is particularly interesting in the light of the above discussion that during the third

Mesolithic period, 5500 - 5000 cal. BC, pollen of the above taxa suited to disturbed conditions spread to areas outside the naturally occurring disturbed conditions at the highest elevations. This evidence suggests that by this period disturbed conditions were occurring at lower elevations in the uplands, such as in upper Teesdale.

In upper Teesdale in the earlier periods of the Mesolithic the second group of taxa including Chenopodiaceae, Compositae, Cruciferae, *Plantago* and *Polygonum* were most common. Those members of the Chenopodiaceae family not occurring today on the coast tend to occur in disturbed (like the first group) but, unlike the first group, in relatively fertile, nutrient rich (often nitrogen rich), disturbed habitats which are not too dry. Typical examples of such habitats today are found on cultivated land, waste dumps, road verges and manure heaps, or near habitation. Many members of the Compositae family also occur on waste ground, cultivated ground and road verges (Type B Compositae), or in damp disturbed situations such as pasture or riverbanks (Type A Compositae). Members of the genus *Polygonum* today occur in a range of disturbed, often trampled, habitats, on waste and cultivated land, but several members also occur by streams and rivers. The occurrence of *Plantago* in this area could be *Plantago lanceolata*, a successful coloniser of disturbed ground found in grassland or waste ground, or *P. major*, common on disturbed ground, waste and cultivated ground and farmyards, or *P. media*, common on limestone grassland. The occurrence of Cruciferae is also not very straightforward to interpret, since members of this family today occur not only commonly in damp grassland in the uplands (Type B Cruciferae), but also on disturbed ground on dry, calcarous or sandy soils, sometimes on rocky outcrops (Type A Cruciferae). Both types of conditions could occur in upper Teesdale. The picture for upper Teesdale and the lower elevations in the uplands in the earlier Mesolithic is less easy to interpret, but it is apparent that many of these types are associated with disturbed, but generally less dry and exposed situations than on the upland tops, and associated with often more nutrient rich, damp conditions or with grassland.

It is therefore likely that the appearance of these types associated with various types of disturbed habitats in other parts of the region than the uplands in the period 5500 - 5000 cal. BC, whereas before these types were almost entirely found in upland areas alone, is associated with an increase in this period of disturbed conditions across the region. Since these types are throughout the period most abundant in the uplands of the region, in the uplands of the Northern Pennines and of northern Northumberland, it seems likely that disturbed conditions were most common in upland areas, although by the end of the period they appear to be increasing in parts of the lowlands. This apparent greater amount of disturbance in the uplands must however be interpreted with caution, since there are fewer sites in the lowlands, and it may be that pollen core locations in the lowlands are not favourably located to pick up evidence for disturbance that may have occurred in the lowlands.

Maps of pollen data averaged over 500 year periods can be useful for looking at broad trends across this time period, and it is possible to identify the occurrence of small amounts of herb taxa by using averaged pollen values. However, these pollen maps are not so useful for investigating individual clearance episodes. Therefore the above discussion is here complemented with more detailed evidence for clearance episodes identified in the sequences of individual pollen cores from the region. Few of these clearance episodes have been discussed in the published literature concerning sites from north-east England, since most discussion has concerned changing levels of tree and shrub pollen rather than investigating clearance episodes.

At Valley Bog in Upper Teesdale, a late Mesolithic decline in tree pollen values plus a rise in *Corylus* and several herb pollen taxa associated with disturbance The taxa that increase include open ground indicators such as *Umbelliferae*, and disturbed ground indicators such as *Plantago*, Chenopodiaceae and *Artemisia* and also *Potentilla*, Umbelliferae and *Urtica* make a rare appearance. Although evidence for clearance is less clear at other upland sites, due to the sampling interval used, a very similar suite of taxa appear at sites in this area. Disturbance events occurring throughout the Boreal and Atlantic periods can be identified at several upland sites with good sample resolution: at Tinkler's Sike at 80cm an increase in *Corylus* is accompanied by peaks in Gramineae and *Pteridium*, and at 60cm *Melampyrum* (which has been used as an indicator of burning, and which occurs early in the sequence of clearance at North York Moors sites) is accompanied by Umbelliferae, Leguminosae and *Potentilla.* At Foolmire Sike in the Boreal at 240cm an increase in *Corylus* is accompanied by a decline in *Quercus* and *Ulmus* , a marked peak in Umbelliferae, plus *Plantago lanceolata*, *Plantago major/media*, *Urtica*, *Potentilla* and *Pteridium.* At Weelfoot Moss, between 270-250 cm there is a large peak of *Melampyrum*, with high but wildly oscillating values of *Corylus*, accompanied by Umbelliferae, *Potentilla*, and some *Urtica*, *Succisa* and *Pteridium*. At Weelhead Moss I at the start of the Boreal and through the Atlantic there are peaks in Chenopodiaceae, *Succisa*, Umbelliferae and *Pteridium*, and in the Atlantic period at Weelhead Moss II at 270cm there is an occurrence of *Fraxinus*, a rise in *Corylus* and Gramineae, Umbelliferae, *Potentilla* and *Rumex*. At many sites in the levels immediately preceding the *Ulmus*-decline there is a massive increase in the occurrence of such taxa, with especially a marked rise in Umbelliferae, Gramineae, *Corylus* and disturbance indicators. The significance of this pre-*Ulmus*-decline phenomenon will be discussed below.

The clearest evidence for clearance activity therefore comes from the uplands of the region. This phenomenon has also been noted by Turner and Hodgson (1983) - clearances with losses of tree and shrub pollen only occur above 480m, whilst in the North York Moors clearance has only been noted on the highest moors rather than the hill slopes (Simmons and Cundill 1974b). This phenomenon has also been noted on the central Pennines (Jacobi *et al.* 1976). Much of the noted clearance activity occurs in the uplands and on sandy bedrock types, but this may be only a sampling phenomenon: for example at Kildale Hall in the North York Moors, at 168m a.s.l. clearance occurs on lower ground, and Turner and Hodgson (1983) note that clearance also occurs on limestone substrata in the Northern Pennines.

Evidence for forest disturbance is much less clear at most lowland sites. Herb pollen levels overall are much lower than in the uplands, Ericaceae is almost absent and tree and shrub pollen makes up almost all pollen. At those sites between 200-300m where tree pollen has very high values, there is a picture of dense unbroken woodland around these sites throughout the Mesolithic, which spreads across the lowlands in the Atlantic period, as the predominance of *Corylus* disappears. However, with clearance, the values of *Corylus* would be expected to rise suddenly and rapidly as it takes advantage of open conditions, and this would be supported by the appearance of herb pollen types in greater amounts. The dominance of tree and shrub pollen at lowland sites has led many pollen workers to postulate only limited Mesolithic activity in the lowlands. For the south-east Durham lowlands Bartley *et al.* (1976) state "There is no evidence of Mesolithic man here as there is in the uplands of Teesdale. This probably reflects the difference between the more open conditions of the uplands and the dense woods and swamps of the lowlands.. " (p. 462). However, some evidence for erosion in the form of minerogenic material plus the appearance of disturbance indicators in the Craven lowlands of north-west Yorkshire has led Bartley *et al.* (1990) to revise this view, although overall they maintain that "...human interference, although probably present, was not a major influence on the vegetation in this lowland area."

At lowland sites there are only a few indications of instability in the forest cover. It has already been shown from the pollen maps for the period 5500 - 5000 cal. BC that disturbance indicators such as Artemisia, Chenopodiaceae, *Plantago* and other herbs increase in areas outside the uplands in this period. At Mordon Carr, there are occasional occurrences of light demanding herbs and disturbance indicators such as Umbelliferae, *Artemisia* and *Succisa* and at 260cm there is a peak in the *Corylus* curve. At Bishop Middleham, throughout the Boreal and Atlantic there are occasional peaks in Umbelliferae, Chenopodiaceae, *Pteridium* and *Senecio*-type. The high herb values at this site are, however, accounted for by the dominance of Cyperaceae (sedge) pollen in this period, together with the occurrence of tall herb taxa characteristic of nutrient rich wetlands (such as *Filipendula*). Neasham Fen is even more tree dominated than the other sites. On the whole, evidence for woodland disturbance at these sites is scanty throughout the Mesolithic, with little change occurring in overall tree values until levels immediately before the *Ulmus*-decline. In these levels at most lowland sites, as in the uplands, there is an increase in many taxa indicating woodland disturbance, such as *Fraxinus* and *Corylus*, accompanied by a rise in disturbance indicators and light-demanding types. Unlike in the uplands, at most lowland sites this is the first major evidence for woodland disturbance. Similarly in the lowlands of northern Northumberland tree and shrub pollen makes up virtually all pollen at the sites in this area, with very low herb pollen values. However, the appearance in the period 5500 - 5000 cal. BC of disturbance indicators such as *Artemisia*, Compositae, Leguminosae and *Plantago* at sites which formerly had only a small range of herb types suggests that disturbance occurred in this area also. Unfortunately the sampling resolution at most of the northern Northumberland sites within the region is not very high to investigate these episodes in any great depth.

The implications of this pollen evidence for clearance, for Mesolithic settlement and for land-use in north-east England will be discussed in the following chapter.

7.2 The Neolithic period *circa* 4000-2000 cal. BC

Two pollen mapping periods are used for the Neolithic, the first, from 3800 - 3300 cal. BC corresponding to the earlier Neolithic and the second, from 2800 - 2300 cal. BC corresponding to the later Neolithic.

7.2.1 The earlier Neolithic

a) Tree and shrub cover

Compared to the later Mesolithic period, by the early Neolithic period, 3800 -3300 cal. BC, the most marked change at most pollen sites is a marked decline in shrub pollen values (Fig. 7.2.3), which is essentially a marked decline in the formerly dominant *Corylus*. Tree pollen values remain little changed from the previous period, remaining high in the south east of the region but not as high as in the upper Derwent and mid Weardale area where tree values actually increase further in this period to over 80% tdlp at a couple of sites (Fig. 7.2.2). In northern Northumberland tree pollen levels remain similar to the previous period, but vary greatly from site to site, from 13% to 78%. In the uplands tree pollen lies between 30-50% at most sites, as in the previous period. Shrub levels decline to 20-30% at sites in the south east of the region (Fig. 7.2.3) and there is a marked decrease at most sites in northern Northumberland, so that shrub values lie below 10% at all sites. Shrub values drop particularly markedly in the uplands of the region, falling from 60% to 30% at some sites, so that now shrub levels are equal to that of trees. Despite this decline, shrub levels in the uplands are higher than in any other area of the region.

In the lowlands of the south east of the region, in northern Northumberland and at some sites in Upper Teesdale, this shrub decline is accompanied by an increase in herb values (Fig. 7.2.4). Herb pollen values increase up to 30-40% at a couple of sites in the south east of the region, and at most sites in northern Northumberland there is a marked rise in herb pollen values, from 13-62% at Akeld Steads and 7-42% at Trickley Wood. At Cronkley Pastures in upper Teesdale unusually high herb levels of 80% occur in this period. At most other upland sites, however, there is an increase in ericaceous pollen values (Fig. 7.2.5), continuing the trend observed in previous periods.

b) Herb pollen evidence for disturbance

This period sees a further expansion in the area covered by various herb pollen taxa, with herb pollen taxa that had previously only occurred in the uplands now occurring at locations in the rest of the region, and many taxa that had in the previous period spread to the rest of the region now increasing in value in these areas.

Grass pollen values increase further at many sites in the region in this period, particularly in the uplands (Fig. 7.2.7), up to values of 30% tdlp, although in the lowlands much lower values under 10% occur. It occurs at slightly higher values in the lowlands of northern Northumberland. Several of the pollen taxa which for most of the Mesolithic had only occurred at the highest elevations, but later in the Mesolithic had appeared at other sites in the uplands, now increase their values at many sites in the uplands, or appear at a larger number of sites, or even spread outside the uplands for the first time. For example, *Artemisia*, which unlike other herb taxa in its group, had not spread from the highest elevations in the later Mesolithic, now spreads from sites at higher elevations to more sites in the uplands, including upper Teesdale. In addition *Artemisia* values now increase at many sites where it had previously occurred, including at sites in northern Northumberland (Fig. 7.2.9). Caryophyllaceae pollen appears for the first time outside the uplands (Fig. 7.2.10), continuing its spread into new areas from the previous period, when it spread from the highest elevations to locations at lower elevations in the uplands. It now appears at several sites in East Durham and on the coast, and also at a site in northern Northumberland for the first time, although the highest values for Caryophyllaceae continue to occur in the uplands. Cruciferae continue to occur in the Northern Pennine uplands and northern Northumberland, but also appear in the Tyne Corridor in this period with high values (Fig. 7.2.14). Leguminosae values increase from the previous period in the uplands and also appear in northern Northumberland and in the south east of the region (Fig. 7.2.15) for the first time.

Of the pollen types occurring in the second group (those which had occurred in upper Teesdale and parts of northern Northumberland and several of which had spread to sites in the lowlands in the later Mesolithic), many now appear at more new sites, or increase at sites where they had already occurred. Chenopodiaceae pollen, which had in the previous period appeared for the first time in the south east of the region, continues to occur in this area, but in this period increases further in northern Northumberland (Fig. 7.2.12). Compositae, which like Chenopodiaceae had spread in to the south east of the region in the previous period, has high values in this area in this period and also appears for the first time at one site in northern Northumberland (Fig. 7.2.13). *Plantago* pollen appears at a large number of sites in this period (Fig. 7.2.16); whereas before it had only really occurred in upper Teesdale, it now appears at a larger number of sites across the uplands and also appears in small amounts at several sites in the south east of the region. Ranunculaceae pollen values increase at several sites in northern Northumberland and in the upper Derwent area, where it appeared for the first time in the previous period. It continues to occur in the uplands and in the south east of the region (Fig. 7.2.18). *Rumex* values remain little changed, but increase at several sites in upper Teesdale and northern Northumberland (Fig. 7.2.19). However, *Polygonum* does not appear at any new sites; it continues to occur only in upper Teesdale and northern Northumberland (Fig. 7.2.17).

There is therefore considerable evidence for an increase in both the amounts of herb types characteristically found in disturbed areas, and also the numbers of sites at which they occur in the earlier Neolithic, compared to the previous period. There is however no great reduction in tree pollen values and no increase in shrubs which would be associated with high levels of clearance (in fact shrub levels decline at most sites), and so the increase in herb types indicates low-level disturbance.

If we examine the sequences for the earlier Neolithic at individual pollen sites in detail, there are a number of trends that occur at several sites in this period. The *Ulmus*-decline is a much discussed phenomenon, occurring around the time of the early fourth millennium cal. BC in many British pollen diagrams, and dominates most accounts of the Neolithic in the pollen literature. However, it is important not to overlook major changes in other taxa that occur immediately before or around the time of the *Ulmus*-decline at many sites, that might be linked with the *Ulmus*-decline. In many pollen diagrams immediately prior to or after the *Ulmus*-decline there is the increase or first appearance of a number of herb taxa associated with disturbance, as has been demonstrated from the pollen maps. *Plantago lanceolata* and

Rumex acetosa make their first appearances in the period imediately following the *Ulmus*-decline at many sites, including those in the south east of the region, such as Mordon Carr, Bishop Middleham, Neasham Fen and Hutton Henry. *Plantago lanceolata* also appears for the first time just after the *Ulmus* decline at Valley Bog in upper Teesdale, and Black Lough in northern Northumberland. At most sites there is a marked rise in Gramineae, plus other light demanding herbs and disturbance indicators such as Umbelliferae, Cruciferae, *Artemisia* and Chenopodiaceae occurring immediately prior to and after the *Ulmus*-decline. *Cerealia*-type makes its first appearance at Mordon Carr, Neasham Fen, Weelhead Moss and Valley Bog at this time.

At the tree dominated sites in the Derwent/Wear area, there is little evidence, however, for any activity before the end of the Neolithic/early Bronze Age period. At Hallowell Moss, where the diagram starts in the early Neolithic, after the *Ulmus*-decline, forest cover is very dense with very low amounts of light-demanding shrubs and herbs. The area is characterised by *Quercus* dominated forest with some *Tilia* and very little *Ulmus*. The herbs present conform with woodland flora, and include *Anemone*, *Ranunculus*, *Filipendula* and *Succisa*.

ii) Evidence for agricultural activity

Cerealia-type pollen appears at five sites in this period for the first time (Fig. 7.2.8), occurring at high values of over 1% tdlp at Trickley Wood in northern Northumberland, but at much lower values on the coast at Hartlepool and at Mordon Carr in the south east of the region. In upper Teesdale *Cerealia*-type pollen is recorded at Weelhead Moss and Howden Moss. The agricultural:arable map for this period shows that the highest, most arable scores occur in the south east of the region, and this is because arable type taxa completely dominate at Hartlepool (this is made up of *Cerealia*-type, Compositae, Chenopodiaceae and Cruciferae). However, the high arable score at this site must be treated with caution; firstly it is the only site in the region with such high arable scores in this period and all other sites have non-arable scores (well below 50%) since in this period values for the pastoral indicators *Plantago* and *Rumex* increase markedly at many sites in the region. Secondly, the site of Hartlepool Bay 4 occurs on the coast, and several members of the Cruciferae family occur in coastal areas, as do many members of the Chenopodiaceae family and three genera of Compositae (Appendix B). The *Cerealia*-type pollen at this site may in fact not be cereal pollen but large grass pollen grains from grass species occurring naturally in coastal environments, such as *Elymus arenarius*. There is certainly no macrofossil evidence for cereals which would support the presence of cereal pollen. This high arable score can therefore be discounted as being the pollen of naturally occurring coastal taxa.

High arable scores for this period for the agricultural:arable index also occur at a small number of sites in upper Teesdale, where arable scores have been produced for Dubby Moss, Mire Holes, Long Crag and Cronkley Pastures. Interestingly, the two sites with recorded *Cerealia*-type pollen for this period do not have high index scores, as in this period values for Ranunculaceae, *Rumex* and *Plantago* are high at these sites, although "arable-types" such as *Artemisia*, Compositae and Cruciferae are also present. The high arable scores at these sites in upper Teesdale are accounted for by high Compositae over 1% tdlp plus Chenopodiaceae, Caryophyllaceae and Cruciferae at Dubby Moss and only small amounts of the pastoral type *Rumex*. These taxa also dominate at the other sites with high arable values. The occurrence of high values of these particular herb taxa together support the picture of disturbed, relatively fertile conditions such as are found on cultivated fields today, but also around recently disturbed areas on relatively nutrient rich soils or around areas of habitation: those members of the Chenopodiaceae today found inland tend to only occur in fertile, disturbed habitats, and rarely are found on grazed land, as many species are intolerant of grazing. Consistent with this, several members of the Compositae family are found on waste and disturbed land (Type B Compositae) and several members of the Caryophyllaceae family occur today on disturbed fertile land (Type D Caryophyllaceae). However, care must be taken when interpreting the occurrence of arable type taxa in terms of arable agriculture; many members of these families occur in different environments including grassland and meadow. However, when a group of pollen taxa occur at the same site which produce a consistent picture of disturbed land such as that found in cultivated areas, the interpretation is more secure than relying upon the presence of one arable indicator alone. Elsewhere in this period values for *Plantago*, Ranunculaceae and *Rumex* are much higher and dominate the arable type taxa at all other sites across the region.

In the north of Northumberland, despite increases in many arable type taxa, particularly the appearance of *Cerealia*-type in such large amounts, the appearance of *Centaurea* at Trickley

Wood and the occurrence of Compositae, Chenopodiaceae, *Artemisia* and Cruciferae at this site, the agricultural:arable index score is surprisingly low and non-arable. This is because even larger values for the non-arable types *Plantago* (3.3% tdlp) and *Rumex* (1.6% tdlp) appear in this period. The high values of grassland type taxa may suggest that many of the so-called arable types at this site are in fact indicating open, disturbed conditions, rather than arable activity in particular, or perhaps a combination of different types of vegetation in the site's catchment, including cereal cultivation, other disturbed habitats and open grassland.

This picture is found across the region in this period; increases occur at many sites in both arable and pastoral type taxa, and although new arable type taxa such as *Cerealia*-type and *Centaurea* appear, pastoral types increase markedly to higher values. Particularly high values appear for *Plantago*, which occurs for the first time at many sites. The high values for grassland type taxa across much of the region throw doubt on the arable interpretation of the occurrence of taxa such as Compositae, Cruciferae, *Centaurea* and other so-called arable indicators, since members of these taxa also occur in grassland habitats today and the arable interpretation of these taxa is by no means straightforward, as has been shown in Appendix B.

The presence of *Cerealia*-type pollen at sites across the region in this period does seem to suggest some arable agriculture in the earlier Neolithic of north-east England, although its actual importance in the economy of the region cannot be ascertained with such limited evidence, especially given that Appendix B has demonstrated that so many so-called arable indicators include taxa that occur in grassland habitats and a range of naturally occurring plant communities.

7.2.2 The later Neolithic

a) Tree and shrub cover and evidence for woodland disturbance

The later Neolithic, 2800-2300 cal. BC, sees a decline in herb pollen values from the earlier Neolithic at certain sites in northern Northumberland, particularly those at lower elevations, most markedly at Akeld Steads and Trickley Wood where herb values decline from 62-22%

tdlp and 42-20% tdlp respectively (Fig. 7.2.23). This is accompanied by a sharp rise in tree pollen values (Fig. 7.2.21), up to 69% at Akeld Steads and 83% at Camp Hill Moss. At other sites in this area at higher elevations tree values are lower, but these are accompanied by high levels of Ericaceae (Fig. 7.2.24), up to 80% at some sites. In south-east Durham, the decline in herbs is not as marked as northern Northumberland and here it is accompanied by an increase in shrubs (Fig. 7.2.22) and a slight drop in tree pollen values. An exception to this is Bishop Middleham, where herb values actually increase (Fig. 7.2.23). In the Durham uplands herb values also drop in this period to values below 20% tdlp, and like those sites in the uplands of northern Northumberland, this decline in herbs is accompanied by an increase in Ericaceae. Ericaceae values continue to increase from previous periods in the uplands so that during this period Ericaceae values of 30% are common and values of 40% occur at a small number of sites (Fig. 7.2.24). The dominance of tree pollen at sites in the upper Derwent/mid Weardale area in previous periods continues in this period, with tree values, unlike in the rest of the region, increasing further at several sites, for example to 91% at Hallowell Moss and at Pow Hill to 73% (Fig. 7.2.21).

With the increase in tree pollen values in northern Northumberland and in the upper Derwent/mid Weardale area, the increase in shrubs at sites in the south east of the region and the rise in Ericaceae across the uplands, the values for many herb taxa decline in this period. Grass pollen values fall to very low values at sites in the lowlands of northern Northumberland where tree pollen increases and also to a lesser extent in south east Durham (Fig.7.2.26) , including at Bishop Middleham, which is the only site in this area to have an increase in herb pollen. This is however due to an increase in sedge pollen. On the coast grass pollen levels remain higher. At most sites in the upper Derwent/mid Weardale area the further increase in tree values is accompanied by a drop in grass pollen levels and a decline and even disappearance of many other herb types, so that at several sites only grass pollen remains. In the uplands grass pollen values are very low with the exception of sites in upper Teesdale where it rises at several sites, accompanied by a rise in other herb pollen values. A rise in grass pollen values also occurs in the Tyne Corridor at Fellend Moss and Muckle Moss, and just to the north at Coom Rigg Moss (Fig. 7.2.26).

With this decline in grass pollen levels, the values for many other herb types also decline. This decline is least marked in the south east of the region, where most herb types already present continue to occur at values little changed or actually higher than the previous period. However in the uplands, particularly in upper Teesdale, and also in the upper Derwent/mid Weardale area there is a notable drop in or disappearance of several herb taxa and in northern Northumberland the values of several taxa decrease. Of the herb taxa that decline in this period, *Artemisia* pollen occurs at much lower levels in this period compared to previous periods, particularly in northern Northumberland. It does however appear for the first time in the south east of the region at Neasham Fen and Mordon Carr (Fig. 7.2.28). Chenopodiaceae values, like *Artemisia*, also drop at many sites in this period, and it also occurs at far fewer sites in this period (Fig. 7.2.31), only remaining at Hutton Henry in the south east of the region, at two sites in upper Teesdale and in northern Northumberland. Compositae also disappears from all areas of the region, notably from upper Teesdale, with the exception of the south east of the region, where values actually increase at several sites in this period, and in the north of Northumberland where it continues to occur at lower values (Fig. 7.2.32). Cruciferae occurs at large values in the west of the Tyne Corridor, and continues in smaller values in the south east of the region and in the uplands in upper Teesdale, but is largely absent from northern Northumberland (Fig. 7.2.33). Leguminosae continues to occur in upper Teesdale, the west of the Tyne Corridor and in northern Northumberland, but like other herb taxa, values decline in this period in all these areas, whilst in the south east of the region values actually increase (Fig. 7.2.34). *Plantago* continues to occur in northern Northumberland, but at slightly lower values, and also continues to occur in southern Northumberland, in upper Teesdale and in the south east of the region at the same levels as before (Fig. 7.2.35). Ranunculaceae values, although highest in northern Northumberland, also decrease slightly from the previous period, but increase in the Tyne Corridor (Fig. 7.2.37). *Rumex* values are also highest in the north of the region, but do not show a decline in values in this period (Fig. 7.2.38).

To sum up, in this period the values of many herb taxa associated with disturbance have dropped, compared to the preceding period, accompanied by a rise in tree pollen levels in parts of northern Northumberland and the Derwent/Weardale area and a rise in Ericaceae at more upland sites in northern Northumberland and in the Northern Pennines. At sites in the Tyne Corridor and also in south east Durham this decline in herbs is not so marked, and at several sites values increase in this period, such as increases in Compositae, *Centaurea* and *Plantago* at some sites in this area. At many sites in the uplands a much smaller range of herb types occurs compared to previous periods, with only Gramineae, *Plantago*, Ranunculaceae and *Rumex* remaining. This occurs even in upper Teesdale; for example at Weelhead Moss, at the start of this period, there is a decline in all herbs except for occasional occurrences of *Plantago*, *Rumex* and Ranunculaceae, accompanied by a decline in *Corylus* and increase in trees. This decline can also be seen at Dead Crook. At Valley Bog, *Plantago lanceolata*, Gramineae and other herb types decline or disappear before the start of this period and continue to be absent throughout this period. The range of herb types present in the Derwent/Weardale area also declines with the increase in trees; for example, at Pow Hill, all herb types decline except *Ranunculus*.

ii) Evidence for agriculture

Agricultural:arable index scores are highest in this period in the south east of the region (Fig. 7.2.25), rising to 99% at Neasham Fen, 80% on the coast at Hartlepool, and above 50% at Hutton Henry and Bishop Middleham and slightly lower at Mordon Carr. The unusually high score at Neasham Fen is due to the presence of *Artemisia* as the only herb pollen type apart from Gramineae at this site in this period. Here tree pollen levels are high. On the coast, particularly high values of Compositae and Chenopodiaceae occur, which, as discussed in the previous period, include taxa that can be found naturally in coastal environments. In this area both arable and pastoral type herb taxa increase in this period, with Plantago, Ranunculaceae and Rumex occurring at most sites and also Caryophyllaceae, Compositae and Cruciferae. *Artemisia* and *Cerealia*-type (Fig. 7.2.27) occur in addition to these types at Hutton Henry and Mordon Carr, at slightly higher values than before.

Apart from the south east of the region, agricultural:arable index scores are very low across the rest of the region, with arable type taxa being almost entirely absent from the tree-dominated sites in the Derwent/Weardale area. Pastoral types are also only present in very small amounts at these sites and herbs in this area are represented almost entirely by Gramineae and Ranunculaceae. In many upland sites, also, arable types are absent in this period, especially at the higher elevations where Ericaceae dominates. In addition in this period arable types disappear from several sites in upper Teesdale, where they occurred formerly in high values. There is a marked decline in the range of herb types found at these sites, and Gramineae and predominantly open grassland types such as *Plantago*, Ranunculaceae and *Rumex* dominate the herb pollen at these sites. Even at those sites in upper Teesdale where arable types are present, pastoral types are present in greater amounts, and as a result the index scores at these sites are low. In northern Northumberland, also, index scores are low, indicating a dominance of pastoral type herb taxa. The exception to this is Trickley Wood where, despite the high tree cover in this period, there is an increase in several arable type taxa including *Cerealia*-type, although here also *Plantago* and *Rumex* pollen values increase. Further south in Northumberland at Muckle Moss and Coom Rigg Moss, grassland types such as *Plantago*, Ranunculaceae and *Rumex* predominate, with the exception of Fellend Moss where Caryophyllaceae and Cruciferae appear, raising the index score at this site to 43%.

7.3 The Bronze Age and earliest Iron Age *circa* 2000 - 500 cal. BC

Three 500-year pollen mapping periods are used to cover the Bronze Age and earliest Iron Age period. The first, extending from 2000 - 1500 cal. BC corresponds to the early Bronze Age period, the second, from 1500 - 1000 cal. BC corresponds to the middle Bronze Age period whilst the third, from 1000 - 500 cal. BC corresponds to the late Bronze Age and earliest Iron Age periods.

7.3.1 The early Bronze Age *circa* 2000 - 1500 cal. BC

a) Woodland cover

In the previous period, there had been an increase in tree pollen values at sites in the north of Northumberland and in the Derwent/Weardale area but only a slight increase in shrubs in the south east of the region. In this area the decline in the values of many herb types that occurred across the rest of the region did not occur to such a great extent, and in fact the values of several herb taxa actually increased. During the period 2000 - 1500, the early Bronze Age, the difference between the south east of the region and the rest of the region begins to become more marked.

During the early Bronze Age period, there is a massive decline in trees (Fig. 7.3.2) and shrubs (Fig. 7.3.3) at certain lowland sites, accompanied by a very marked increase in herb pollen (Fig. 7.3.4). This decline in trees and shrubs is most marked in East Durham at the sites of Bishop Middleham and Hutton Henry. Here tree values fall from 53-11% tdlp and 59-10% tdlp respectively (Fig. 7.3.2), and shrub values fall from 10-2% tdlp and 26-9% tdlp respectively (Fig. 7.3.3). Herb pollen values correspondingly increase from 36-84% tdlp at Bishop Middleham and from 14-80% tdlp at Hutton Henry (Fig. 7.3.4). However, at other sites in the south east of the region this decline in trees and shrubs is not so marked. For example at Mordon Carr, tree and shrub pollen values only drop slightly to 25% and 39% tdlp respectively, whilst at Neasham Fen, to the south in the Tees lowlands, tree and shrub levels remain much higher, although even here there is a slight drop in tree values to 48% tdlp, accompanied by a slight rise in shrubs to 48% tdlp.

At the sites in the Derwent/Weardale area which have always been dominated by tree pollen, tree levels remain very high in this period (Fig. 7.3.2), actually increasing further at Pow Hill to 80% tdlp and remaining above 60% at most sites in this area. However, at Hallowell Moss tree pollen values do drop slightly from the previous period, down to the still high value of 71%, accompanied by a slight increase in shrub pollen values, as has been observed in this period at Neasham Fen. Herb pollen values at these sites are extremely low, rarely rising above 3% tdlp (Fig. 7.3.4).

Herb pollen levels also increase markedly in this period at certain Northumberland sites, such as Fellend Moss and Steng Moss (Fig. 7.3.4), although further north in northern Northumberland tree pollen values remains high from the previous period, such as at Camp Hill Moss and Akeld Steads, where tree values remain between 60-70% tdlp (Fig. 7.3.2). There is a slight drop in tree pollen values at these sites compared to the previous period, however. At those sites in the uplands of northern Northumberland where Ericaceae pollen values had increased markedly in the previous period, Ericaceae values continue to rise in this period, up to 58% at Trickley Wood. (Fig. 7.3.5). These sites now resemble upland sites in the Northern Pennines closely.

At most upland sites in the Northern Pennines in this period, as observed further north in the uplands of Northumberland there is a further increase in Ericaceae (Fig. 7.3.5), accompanied by a further decline in trees (to between 15-40% tdlp) and shrubs (to between 20-30% tdlp), but nothing like on the scale found in the lowlands. Herb pollen values decrease at most upland sites to below 10% in this period, although at some sites in upper Teesdale higher herb pollen values occur, up to 30% tdlp at sites such as Weelhead Moss, Dead Crook and Tinkler's Sike (Fig. 7.3.4). Unusually high values for herbs continue to occur at Cronkley Pastures (72% tdlp) in upper Teesdale. High tree and shrub values continue to occur at a couple of upland sites, at Dufton Moss and Quick Moss, where together tree and shrub values make up 90% tdlp, although shrub pollen values are higher here in the uplands than in the tree dominated lowland sites in the Derwent/Weardale area and at Neasham Fen.

b) Herb pollen evidence for woodland clearance and disturbance

The marked increase in herb pollen at sites in south-east Durham in this period, accompanying the marked drop in tree and shrub pollen, is seen in the shift in emphasis of the maps of many herb types in this period, so that the highest values for most indicators of disturbance are now located in the south east of the region. A particularly notable example is the map for Gramineae (Fig. 7.3.7) which when compared to the map for the previous period (Fig. 7.2.26) shows a clear shift in emphasis away from the highest grass values occurring in the uplands to the highest values occurring in the south east of the region. Grass pollen values now reach 20% tdlp at Hutton Henry and 17% at Bishop Middleham and 30% on the coast at Hartlepool, although values are considerably lower at Mordon Carr and very low at the tree- and shrub-dominated Neasham Fen.

Several other herb types now shift emphasis to the south-east of the region, appearing in large amounts at several sites in this area in this period, including Chenopodiaceae, *Polygonum*, *Plantago* and *Rumex*. The highest values for Chenopodiaceae in this period (Fig. 7.3.11) are in the south east of the region as opposed to in the north of the region in the previous periods (Fig. 7.2.12, 7.2.31), occurring at particularly high values on the coast (most probably high amounts of the coastally occurring Chenopodiaceae types) but also at other sites in the south east. *Plantago*, unlike in previous periods, also now occurs at its highest values in the lowlands of the region, with particularly high values at Bishop Middleham (Fig. 7.3.15). *Polygonum* appears for the first time at two sites in the south east of the region (Fig. 7.3.16). The emphasis for *Rumex* (Fig.7.3.18) also shifts to the south east of the region from northern Northumberland with high values occurring at sites in East

Durham. Compositae also continues to occur at its highest values in the south east, and increases further in this area in this period (Fig. 7.3.12).

The marked rise in Compositae, *Plantago*, *Rumex* and the appearance of *Polygonum*, together with a large rise in Gramineae at sites on or near the East Durham Magnesian limestone plateau in this period are consistent with a rise in open, disturbed land in this area. However, the nature of this open, disturbed land is not easy to reconstruct. Although the majority of these herb types are used as pastoral indicators and occur in open grassland, they include a number of species that also occur on cultivated and waste ground. Similarly, although Compositae and *Polygonum* have been used as arable indicators, they also include types found on limestone grassland. For example, the genera *Polygonum* and *Plantago* include taxa that occur on calcareous grassland (*Plantago media, Plantago lanceolata* and Type D *Polygonum*) as well as types that occur on cultivated land (*Plantago major* and Type B *Polygonum*). Similarly, on the non-acidic soils in this area the *Rumex* pollen is most likely to be that of *R. obtusifolius* or *R. crispus*, as explained in Appendix B, although *R. acetosa* occasionally occurs on calcareous soils. These species occur in disturbed conditions not only on limestone grassland that is well grazed and/or trampled but today also occur on cultivated land.

Although at most of the sites in the Derwent/Weardale area herb pollen levels are very low, the slight opening of the tree cover at Hallowell Moss indicated by the slight decline in tree pollen levels and increase in shrub pollen values is acccompanied by the appearance of new herb taxa at this site and a rise in Gramineae values. Pollen of Chenopodiaceae, Compositae, Cruciferae and *Plantago* appear here for the first time in small amounts. Although some members of the families Compositae (some Type A Compositae) and Cruciferae (Type B Cruciferae) occur naturally in woodland environments, the occurrence of Chenopodiaceae and Plantago, both of which are not found in wooded situations today and which instead are associated with open, disturbed conditions, indicates a considerable degree of disturbance near this site in this period. The slight decline in trees at the heavily wooded site of Neasham Fen in the Tees lowlands is associated with less conclusive evidence for disturbance than Hallowell Moss. Here the tree decline is accompanied by a rise in shrubs, a very small rise in grass pollen and the appearance of Ranunculaceae and Cruciferae. Members of both the Ranunculaceae and the Cruciferae families include taxa that occur in woodland (Type C Ranunculaceae and Type B Cruciferae) and so are not inconsistent with a picture of a slight opening in woodland cover, with shrubs dominating, rather than a picture of a large, herb dominated clearance. Alternatively, the clearance could be occurring further away from the pollen core site and the herbs represented in the core are the herbs naturally occurring on the ground surface under woodland.

In northern Northumberland the slight drop in tree pollen values at these sites (although tree pollen always remains higher than at sites in the south east) is accompanied by an increase in the range of herbs found at these sites. This includes the appearance of, or increase in, *Plantago* at several sites. Further south in Northumberland the greater rise in herbs and decline in trees and shrubs at Steng Moss and in the Tyne Corridor is accompanied also by an increase in the range of herb types, with the appearance of *Artemisia*, *Plantago* and Ranunculaceae.

Unlike in the lowland areas of the region where declines in tree pollen are accompanied by rises in shrub pollen and increases in herb pollen, in the uplands during this period the decline in tree pollen is accompanied instead by a decline in the range of herb pollen types, as high Ericaceae values spread across the uplands. At many sites across the uplands in this period *Plantago* appears, or rises to higher values than before, but no other herb types apart from Gramineae occur. Even grass pollen values decrease at most upland sites in this period. Even in upper Teesdale the range of herb types declines from previous periods, so that Ranunculaceae and *Rumex* are the only types present. On the acidic soils of the uplands, the Ranunculaceae taxa likely to be represented most likely include Type B Ranunculaceae found in upland meadows although it is possible that some Type A Ranunculaceae found along streams could be present. The *Rumex* species *R. acetosa* and *R.acetosella*, found on acidic grassland are most likely to be the species present in these upland areas. Any of the Plantago species could be present, although most pollen diagrams from the uplands clearly show that in this period *Plantago lanceolata* dominates the Plantago pollen. A picture of open grassland in those areas of the uplands not dominated by Ericaceae is therefore provided.

c) Timing and duration of clearance episodes in the early Bronze Age period

By looking at the sequences of individual pollen cores it is possible to supplement the information provided from the pollen maps with more detailed information about the timing of the increase in the values of disturbance indicators that occur in this period (i.e. whether it occurred at the start of this 500-year period, or at the end, was a gradual increase, or a short rapid increase, one single event or a series of short temporary events). This is information that pollen maps, with their averaged values over 500 years, cannot be used to investigate.

At many sites across the region, particularly in the lowlands, the marked rise in clearance activity occurs in levels dated by interpolation to the very start of this 500 year period, at the end of the Neolithic and start of the early Bronze Age (the Beaker phase). This increase in activity also occurs in the uplands, but is dated slightly later. There are marked peaks in curves of disturbed ground indicators and light demanding taxa, on a much higher level than found in the rest of the Neolithic, and higher than levels found around the *Ulmus*-decline. Even at sites where there is evidence for activity in the later Neolithic, i.e. at sites in the south east of the region, there is a further increase in herb values at this time.

The duration of clearance appears to have been greatest in the south east of the region. The duration of clearance at Bishop Middleham also appears to have been far greater than at other sites from the region: after the major phase of clearance at the start of the period, woodland never reappears at this site in any great quantity. At all other sites in the region where clearance occurs in the early Bronze Age, there is some degree of regeneration and decline in herb pollen levels. At Bishop Middleham peak values for Gramineae and *Plantago lanceolata* (the latter which here reaches 41% tdlp) occur at a level interpolated to 1660 cal. BC, and *Plantago lanceolata* remains at a level around 10% for much of this period. This level of clearance is unusual for pollen sites in Northern England, and is similar to the level of clearance found on the chalklands of Southern England, which were largely deforested by the Bronze Age (Godwin 1962).

At other sites in the lowlands clearance was more temporary as well as being much more moderate. Although at Hutton Henry levels of clearance are almost as high at the start of the early Bronze Age as Bishop Middleham, with peak values reached at a level interpolated to 1915 cal. BC, following this peak there is a period of fluctuations in clearance and agriculture, but always on a level higher than at the highly wooded site of Neasham Fen. At Mordon Carr evidence for clearance is only moderate by comparison; following a clearance phase at the end of the Neolithic, at the start of the early Bronze Age Gramineae and other herb levels drop markedly with an increase in *Betula* and *Corylus*. However, by a level interpolated to 1651 cal. BC levels of clearance indicators increase again gradually up to peak levels in the Middle Bronze Age period. It is clear that on the Magnesian Limestone and surrounding areas of sand and gravels there was almost complete clearance of woodland by the early Bronze Age, increasing through the period. On the drift soils around Hutton Henry there must also have been quite extensive clearance. It appears that the areas of better soils were affected by clearance earliest, whilst this was delayed in the low-lying clay areas, where any clearance in this period was small scale and followed by woodland regeneration.

This phenomenon has also been noted for the Cumberland lowlands (Walker 1966). Here it is argued that the phase of clearance after about 2000 cal. BC was given impetus after about 1750 cal. BC. A similar picture can also be found in the Craven lowlands in north-west Yorkshire (Bartley *et al.* 1990). Here on the limestone, at Eshton Tarn, a parallel picture to the south-east Durham limestone is found, with an increase in clearance activity dated to the Early Neolithic, increasing throughout the period.

At the formerly heavily wooded sites in the Wear and Derwent areas, the low-level clearance activity that occurred right at the start of the period continues at low levels throughout the period. At Hallowell Moss, the slight rise in Gramineae pollen that occurs at the start of the period is permanent, if small, and the very small amounts of taxa associated with forest openings continue through into the Middle Bronze Age period, where there is a further peak.

In Northumberland, in the Tyne region at Fellend Moss, clearance in the Early Bronze Age with peaks in Gramineae, *Plantago lanceolata* and *Rumex* is followed by a period of woodland regeneration and a decline in herb pollen curves, which continues through the next few periods. A slight opening in the forest canopy accompanied by *Plantago lanceolata* occurs slightly later in the Early Bronze Age at Steng Moss than at Fellend Moss. However, there are fewer episodes of these temporary clearances at Fellend Moss than at the sites further north. At Camp Hill Moss also during the later part of the Early Bronze Age Gramineae, *Plantago lanceolata* and *Rumex* increase throughout the period.

At upland sites the late Neolithic/early Bronze Age opening of woodland was on a far smaller scale than found in the lowlands, and soon fell off with the large increase in values of *Calluna* and *Sphagnum* that occur at many sites in the early Bronze Age. At Valley Bog, the late Neolithic peak in Gramineae, with *Plantago, Pteridium* and *Rumex*, drops off at a level interpolated to 2050 cal. BC, with the rise of light-demanding trees such as *Betula* and the sharp increase of *Calluna*. It is likely that as soon as activity dropped, *Betula* quickly regenerated in these areas. Similarly at Weelhead Moss, the peak in Gramineae and open herb types occurring at a level interpolated to 2167 cal. BC, is shortly followed by a sharp increase in *Calluna* and Cyperaceae. During this period, *Calluna* and other taxa found on blanket bog appear for the first time in any large amount at many upland sites, whilst at others where these taxa had been present since the start of the Neolithic, or before (such as Weelhead Moss), there is a further sharp increase. Herb levels decline slightly but remain at a constant low level until the Middle Bronze Age. At Dead Crook also, a peak in Gramineae and open herb types earlier in the Neolithic is followed by a rise in *Calluna* to permanently high levels, and herb pollen remains low until the Middle Bronze Age.

d) Evidence for agriculture

During this period percentages for both arable and pastoral type taxa increase markedly. At some sites, such as in south-east Durham and sites in northern Northumberland, a greater rise in pastoral types leads to a drop in agricultural:arable index from the preceding period (Fig. 7.3.6), whilst at other sites (such as at Hallowell Moss) there is a rise in index scores, associated with slight clearance. At all sites in the region, however, pastoral-type taxa dominate, and all index scores lie below 50% total agricultural pollen. Scores remain highest, despite the slight drop in this period, in south-east Durham, at Neasham Fen and Mordon Carr. Notably low, "pastoral" index scores, however, are found in East Durham at Hutton Henry and Bishop Middleham. However, as has been mentioned above, the pastoral types that occur at these sites on the limestone plateau also include taxa that can occur on cultivated and waste ground, so the purely pastoral interpretation of the pollen at these sites is far from conclusive. The taxa at these sites instead indicate open, disturbed land, although the exact nature of land use of that land, whether predominantly grassland or predominantly cultivated, or both, is not certain.

Many sites see the first appearance of arable type pollen in any great amount, which includes *Cerealia*-type pollen. This occurs towards the middle of the period 2000 - 1500 cal. BC in many pollen diagrams and coincides with a further increase in clearance activity at this point. At Bishop Middleham *Cerealia*-type pollen first appears in this period, and at Hutton Henry *Cerealia*-type pollen and *Cannabis* pollen both appear during this phase. *Cerealia*-type pollen appears at many lowland sites at this point in the period, and also occurs at Trickley Wood in northern Northumberland. This has also been noted in the pollen literature at pollen sites in the Cumberland lowlands (Walker, 1966) and also in the Craven lowlands in Yorkshire (Bartley *et al.* 1990). At Eshton Tarn in the Craven lowlands, there is a rise in "arable types" and *Cerealia*-type pollen which continues into the Middle Bronze Age period. In the uplands, it has already been shown that the range of herb types declines at many sites and the dominant types are pastoral type herb taxa such as *Plantago*, Ranunuculaceae and *Rumex*. However at some sites in Upper Teesdale, such as Cronkley Pastures, Weelhead Moss and Tinkler's Sike, very small amounts of arable type taxa do occur, including *Cerealia*-type pollen. The proportionally greater increase in pastoral type taxa, however, results in low, pastoral agricultural:arable index scores.

7.3.2 The middle Bronze Age period, 1500 - 1000 cal. BC

a) Woodland cover

Tree pollen levels drop further at sites across the region in this period (Fig. 7.3.20). In the south east of the region tree pollen values remain very low at those sites on the East Durham plateau and in this period at these sites shrub pollen levels drop even further down to below 10% (and as low as 1% at Bishop Middleham, Fig. 7.3.21). This suggests that what remaining woodland cover remained in this area, predominantly shrubs, was now cleared almost entirely around these sites. Herb values increase even further at these sites in this period, to 89% tdlp at Bishop Middleham. In this period on the coast at Hartlepool tree and shrub levels drop markedly to the low levels found in the East Durham area, with a corresponding increase in herbs to very high levels (85% tdlp). Elsewhere in the south east of the region, at sites which were not cleared to such a greater degree in the previous period, this period sees a slight drop in tree and shrub values, at Mordon Carr from 21-18% and 39-28% repectively. The high tree and shrub cover at Neasham Fen in the previous period continues in this period.

In the Derwent/Weardale area there is a decline in tree pollen values at several sites (Fig. 7.3.20), with a particularly marked decline in tree levels at Hallowell Moss to a level similar to Neasham Fen, declining from 71% to 49% tdlp. This is accompanied by an increase in shrub values to 30%, but herb pollen values remain low here. At Pow Hill there is also a decline in tree pollen values for this period to similar levels (from 80% to 48%), but unlike at Hallowell Moss, this is not accompanied by a rise in shrub pollen, but instead of herb pollen. At nearby Lamb Shield woodland cover remains high. Further up the Wear valley, at Steward Shield Meadow and Bollihope Bog, which both start their sequences in this period, both sites are well-wooded with high tree cover (particularly at Bollihope Bog, where tree pollen values reach 66% tdlp) but with a greater proportion of shrubs at Steward Shield Meadow.

In northern Northumberland, at those sites at lower elevations, tree pollen levels fall further in this period from the previous period, although tree levels always remain higher here compared to the sites in the south east of the region. For example, at Akeld Steads trees decline slightly to 44% tdlp accompanied by an increase in herb pollen, although at Camp Hill Moss tree pollen values remain very high, on a level only found in the Derwent/Weardale area (71% tdlp). At other sites in the region, however, Ericaceae values remain very high (Fig. 7.3.23) and tree values remain low (under 30%) as in the previous period. These sites continue to resemble the sites in the uplands of the Northern Pennines.

At many upland sites in this period there is a further decline in tree values to 15-30% tdlp, although shrub values remain between 20-30% tdlp. Values for Ericaceae continue to increase, reaching high values of 50% at several sites. In upper Teesdale the highest herb pollen values in the uplands continue to occur and trees and shrubs fall further in this area to lower levels than the surrounding upland areas. Here herb pollen values reach 72% at

Cronkley Pastures (Fig. 7.3.22).

b) Herb pollen evidence for woodland clearance

Values for several disturbance indicator types continue to increase in this period in the south east of the region and also at several sites in upper Teesdale. The highest Gramineae pollen values (Fig. 7.3.25) in this period continue to occur in the south east of the region, rising further in this period in the south east of the region from 17% to 39% tdlp at Bishop Middleham on the East Durham plateau, and up to 70% tdlp on the coast. At sites on the East Durham plateau values for *Plantago* (Fig. 7.3.34), Ranunculaceae (7.3.36), *Rumex* (Fig. 7.3.25) and Compositae (Fig. 7.3.31) increase further from the large values in the preceding period to even higher values in this period, rising to maximum values of 8.4% tdlp for *Plantago*, 1.5% tdlp for Ranunculaceae, 1.4% for *Rumex* and 1% tdlp for Compositae. On the coast, the marked rise in grass pollen is accompanied by a further rise in Chenopodiaceae, which are likely to have been abundant on the coast, to 4% tdlp, and also a marked rise in *Artemisia* pollen. In this period the highest pollen values for Caryophyllaceae occur in the south-east of the region, rather than in northern Northumberland, as before. Values for Cruciferae, like Caryophyllaceae, also increase in the south east of the region, so that the map shifts in emphasis from the north of Northumberland to the south east (Fig. 7.3.32). In this period taxa such as Caryophyllaceae, Cruciferae and Compositae appear at sites outside the East Durham plateau in the south east, at Mordon Carr and Neasham Fen.

In the Derwent/Weardale area, the decline in tree pollen values at Hallowell Moss in this period is accompanied by small amounts of a wider range of herb pollen types including Chenopodiaceae, Compositae, Cruciferae and *Plantago* which occurred here in the previous period associated with a clearance phase. At Pow Hill, the decline in trees is accompanied by a marked rise in grass pollen and the appearance of *Plantago*, but not the wide range of herb types occurring at Hallowell Moss. At all the other sites in the area tree pollen values remain high.

At most sites in northern Northumberland this period sees a marked rise in *Plantago* to values exceeding 1% tdlp at Akeld Steads and Broad Moss, although not as high as the levels found on the East Durham plateau, and *Plantago* occurs at slightly lower levels at other sites in northern Northumberland. Chenopodiaceae and Compositae continue to occur at these sites. *Polygonum* also increases at several sites and appears for the first time at others in small amounts. Further south in Northumberland, *Plantago, Polygonum* and *Rumex* appear at Fellend Moss, whilst *Plantago* rises to 2% tdlp at Coom Rigg Moss and appears at Steng Moss at 1.7% tdlp.

In the uplands most sites continue to be dominated by Ericaceae, with only small amounts of grass pollen and some *Plantago*. In upper Teesdale, however, there is an increase in the range of herb taxa occurring, compared to the previous period. Although *Plantago* dominates at most sites (Fig. 7.3.34) and Ranunculaceae and *Rumex* are present in high amounts (Figs. 7.3.36, 7.3.37), the pollen of *Artemisia*, Caryophyllaceae and Chenopodiaceae reappears at several sites in upper Teesdale (Figs. 7.3.27, 7.3.28, 7.3.30), accompanying the rise in herb pollen that occurs at many of these sites in this period.

If we look at the sequences for individual pollen cores for this period, to supplement the information gained from the pollen maps, it is possible to discern the duration and timing of clearance episodes in this period. At the start of this period, following the clearance in the previous period, there is a small degree of temporary recovery in the tree pollen values at many sites in the region, although this is not seen from the averaged pollen values for the whole of the period 1500 - 1000 cal. BC. This woodland recovery at the start of this period varies in degree from site to site. For example, at Bishop Middleham there is the least evidence for woodland regeneration, although even here *Plantago* and other herb types decline temporarily from the Early Bronze Age peak, and whilst there is little recovery of woodland with no increase in the overall proportion of trees, there is a slight increase in *Betula*. This is however followed by a further decline in tree and shrub pollen values and increase in herb pollen values. At Hutton Henry during this period there is a fluctuation in tree pollen levels and in levels of herb taxa throughout this period. At Mordon Carr, after a period of woodland regeneration following the Early Bronze Age, herb pollen levels pick up again up to a peak at a level interpolated to 1291 cal. BC, after which they maintain levels similar to those in the Neolithic throughout this period. At Neasham Fen, following a recovery of tree values after the slight clearance in the Early Bronze Age period, there is a very small peak in disturbance indicators at a level interpolated to 1450 cal. BC. However this is too small to be discernable from the averaged values for the whole period used for mapping.

At several sites in upper Teesdale the first period of intense clearance occurs in this phase; at Weelhead Moss, at a level interpolated to 1457 cal. BC there is a marked rise in Gramineae to levels higher than ever before, accompanied by a large peak in disturbance indicators. These taxa increase throughout the period into the next. Similarly at Dead Crook, there is a Gramineae peak at a level interpolated to 1432 cal. BC accompanied by the first appearance of *Plantago lanceolata* at this site, plus other disturbed ground and open-ground type herbs. At Tinkler's Sike a peak in *Plantago lanceolata* and Gramineae occurs at a level interpolated to 1413 cal. BC, dropping then peaking again later in this period, before dropping off again.

c) Evidence for agriculture

Agricultural:arable index scores increase at nearly all lowland sites in the south east of the region from the previous period, when low "pastoral" scores predominated at most sites (Fig. 7.3.24). Index scores rise from 49-91% at Neasham Fen, from 55-78% on the coast at Hartlepool and from 30-49% at Mordon Carr. However, scores at Hutton Henry and Bishop Middleham remain low and "pastoral" as in the previous period, although a slight increase in the proportion of arable types at Hutton Henry raises the index score to 8%. At Bishop Middleham the values of pastoral types increase even more in this period, unlike at all the other sites, where arable types increase and pastoral types remain at the same levels as before. As in the previous period, it therefore appears that the most "pastoral" scores continue to occur at the sites on, or around, the East Durham limestone plateau. However, as discussed in the previous section, many of these so-called pastoral indicators include types that can occur on cultivated land, so the purely pastoral interpretation is not secure. In addition, in this period, *Cerealia*-type pollen appears at almost all sites in this area at values ranging from 0.1-0.5% tdlp.

In northern Northumberland index scores also rise as arable values increase, but here the index scores are considerably lower than in south-east Durham (under 35%). Arable types disappear or remain absent at heavily wooded sites in Weardale and the Derwent area. In the uplands there is a further rise in pastoral types resulting in a further drop in index scores from the previous period, although arable types remain at high levels at some sites in Upper Teesdale.

7.3.3 The late Bronze Age period and earliest Iron Age *circa* 1000 - 500 cal. BC

a) Woodland cover and evidence for clearance

Values for trees and shrubs remain similar at most sites across the region, compared to the previous period (Figs. 7.3.39, 7.3.40). The very low tree and shrub values and very high herb values (Fig. 7.3.41) occurring at sites on the East Durham plateau in the previous period, at Hutton Henry and Bishop Middleham, continue in this period almost unchanged. On the coast also, at Hartlepool, herb pollen values remain very high (81% tdlp) with very low tree and shrub pollen values. Tree and shrub pollen values remain higher at Mordon Carr (which is the only site to have high Ericaceae levels in the south east of the region, at 28% tdlp) and at Neasham Fen, although in this period tree levels fall slightly to 36% tdlp and herb pollen increases at this site slightly to 27% tdlp. Of the herb pollen types present in the south east of the region, there is a further increase in Gramineae pollen values at most sites (Fig. 7.3.44), rising to 40-44% tdlp at Bishop Middleham and on the coast at Hartlepool. Values for *Plantago* (Fig. 7.3.53), *Rumex* (Fig. 7.3.55), Ranunculaceae (Fig. 7.3.56) and Compositae (Fig. 7.3.50) increase markedly at several sites in the area and all of these types have their highest values occurring in the south east of the region. At Neasham Fen the decline in trees in this period is accompanied by an increase in grass pollen plus an increase in the range of herb taxa with the appearance of Compositae, Chenopodiaceae, *Polygonum*, *Plantago* and *Rumex*.

Wooded conditions continue at Hallowell Moss, with high tree pollen levels of 60% tdlp (Fig. 7.3.39), increasing slightly from the previous period. Similarly at Bollihope Bog, and also at Pow Hill, well wooded conditions continue through this period, with tree values increasing further at these sites, to 70% tdlp at Bollihope Bog, and to 50% tdlp at Pow Hill). However, despite the high woodland cover at these sites, there is herb pollen evidence for clearance, although this is only temporary at these sites. At Hallowell Moss a wide range of herb types occur, as in the previous period, indicating that despite the high average tree pollen levels for this period, there was some clearance. At Pow Hill also there is the appearance of a wider range of herb pollen types including *Centaurea*, *Artemisia* and a marked rise in *Plantago* to 1.7% tdlp, despite the overall increase in trees for this period compared to the previous period. Tree pollen values lie at much lower levels at the new site of Steward Shield Meadow, with higher shrub values (both trees and shrubs lie around 20-30% tdlp) and much higher herb values around 43% tdlp. This site resembles sites in the south east of the region in its low tree and shrub cover and high herb values.

In Northumberland high tree pollen levels continue to occur at the site of Camp Hill Moss (68%), resembling the sites in the Derwent/Weardale area, but apart from this tree levels are a lot lower at other sites in the area. At Trickley Wood trees decrease further in this period to 12% tdlp with a further increase in herb pollen values to 26% tdlp. There is a rise in Plantago values in this period and also Polygonum values to high levels exceeding 1% tdlp. The dominance of Ericaceae at other sites in northern Northumberland continues, and these sites continue to behave similarly to those in the Durham uplands. At these Ericaceae-dominated sites *Plantago* and *Artemisia* appear in this period, with a slight rise in grass pollen.

In the uplands of the Northern Pennines during this period, although tree pollen values remain the same at most sites, shrub pollen declines to lower levels to between 10-20% tdlp (Fig. 7.3.40). The exception to this is the higher tree and shrub pollen levels which remain at Dufton Moss and Quick Moss, as before. This decline in shrub pollen at many sites is accompanied by a further increase in Ericaceae, to over 40% tdlp at many sites (Fig. 7.3.42). Herb pollen values remain at the same low levels across most of the uplands, with the exception of upper Teesdale. Here trees and shrubs are at their lowest levels in the uplands, both falling below 10% tdlp at Weelhead Moss. The highest levels for grass pollen in the uplands, like that for herbs in general, occurs in upper Teesdale, reaching 29% tdlp at Cronkley Pastures and 10% tdlp at Weelhead Moss. Plantago rises to high levels at some sites in this area, to 4.1% at Weelhead Moss, and appears at many sites for the first time in this period (Fig. 7.3.53). Apart from this, other herb types are rarely found in the uplands, with the exception of *Artemisia* and the occurrence at Cronkley Pastures of Caryophyllaceae, Compositae and Cruciferae.

b) Evidence for agriculture

In this period the highest, most arable, score for the agricultural:arable index continue to occur in the south east of the region (Fig. 7.3.43), although this is accounted for by a very high score at one site, Hutton Henry, where a marked rise in arable type herb pollen values raises the index to 67%. However, elsewhere in the south-east of the region, although arable types increase at most sites in this period, a proportionally greater increase in pastoral types lowers index scores from the previous period. This is due to a marked rise in *Plantago* values at several sites (up to 8.8% tdlp at Bishop Middleham, Fig. 7.3.53) and also *Rumex* and Ranunculaceae, although the arable type Compositae also increase at many sites in this area in this period. Index scores at these sites are lower than at Hutton Henry, but are still higher than elsewhere in the region, lying between 37-46% at Neasham Fen, Mordon Carr and on the coast at Hartlepool. However, at Bishop Middleham scores remain low and "pastoral", as before (18%). Despite the not very high index scores at these sites, *Cerealia*-type pollen is present at all sites, including Bishop Middleham.

In the Derwent/Weardale area index scores remain low, and total herb pollen values continue to remain low in this area, although there is an increase in values for both pastoral and arable types at Pow Hill and Burnhope Burn, raising index scores up to 29%. At Pow Hill the arable types *Cerealia*-type, *Centaurea* and *Artemisia* appear together with high values for *Plantago* (1.7% tdlp). These sites have some of the lowest tree levels of the area, and at other sites herb pollen levels remain very low.

At many sites in northern Northumberland arable types proportionally increase in this period, resulting in a rise in index scores, up to 51% at Trickley Wood, with a marked rise in this period in *Polygonum* and *Cerealia*-type pollen values, although at all sites except this index scores remain below 25%. Arable types are almost absent at sites dominated by Ericaceae, with the exception of Trickley Wood. Further south in Northumberland, arable types are absent at Fellend Moss and Fortherley Moss, and no herbs are present except Gramineae, but at Coom Rigg Moss arable types increase in this period, with a rise in Compositae, Cruciferae and Caryophyllaceae, producing a higher index score of 21%.

Arable type herb taxa remain absent at most sites in the uplands of the Northern Pennines, with the exception of some sites in upper Teesdale, where in this period arable types increase proportionally resulting in a rise in index scores to 40% at Cronkley Pastures but to much lower levels (under 10%) at other sites in this area. At Cronkley Pastures Caryophyllaceae, Cruciferae and Compositae occur, herbs that are rarely found elsewhere in the uplands in this period, as well as *Cerealia*-type pollen. *Cerealia*-type also continues to occur at Weelhead Moss and appears at Dufton Moss. However, at other sites in the uplands pastoral types increase proportionally in this period, resulting in a further drop in index scores from the previous period. This is explained largely by the increase in *Plantago* values (Fig. 7.3.53) at most sites in the uplands.

7.4 The Iron Age and Roman period *circa* 500 cal. BC - cal. AD 500

This section covers both the Iron Age and Roman periods. The two pollen mapping periods dealt with in this section cover the periods 500 cal. BC - cal. AD 70 and cal. AD 70 - 500.

7.4.1 The Iron Age *circa* 500 cal. BC - cal. AD 70

a) Woodland cover and evidence for clearance

The pollen maps for the Iron Age period show that at most sites there is little change from the picture presented in the previous period. In the south east of the region tree and shrub pollen values remain low from the previous period (Figs. 7.4.2, 7.4.3) at Bishop Middleham and on the coast, with very high herb pollen values continuing in this period. There is a further increase in many herb types at both these sites in this period, with *Plantago* (Fig. 7.4.16) rising to 4.6% tdlp on the coast and to 6.9% tdlp at Bishop Middleham and Compositae (Fig. 7.4.13) rising to 1.2% tdlp on the coast and to 1.9% tdlp at Bishop Middleham. However at some sites in the area tree pollen levels recover from the low levels in the previous period; at Hutton Henry, for example, herb pollen values drop and tree pollen values rise to 27%. The values of several herb pollen types decline at this site, including Compositae which drops from high levels over 1% to 0.3% tdlp (Fig. 7.4.13). At Neasham Fen the evidence for clearance in the previous period now disappears; tree pollen levels recover back to 51% tdlp whilst shrub and herb pollen values drop and the range of herb types found at this site in the previous period now disappears.

Unlike at Neasham Fen, in the Derwent/Weardale area a wide range of herb types continues at Hallowell Moss and Bollihope Bog, despite the high tree pollen values which continue in this period. Grass pollen values reach their highest values yet in this area in this period (Fig. 7.4.7). There is a major change at Pow Hill in this period; this formerly tree-dominated site that behaved like other sites in the Derwent/Weardale area now resembles sites in the uplands far more. Ericaceae values climb markedly to 61% tdlp in this period (Fig. 7.4.5), accompanied by a marked rise in *Plantago* (to 1.7% tdlp) and Ranunculaceae (0.9% tdlp). At Steward Shield Meadow there is also a marked decline in tree pollen (to 22% tdlp), although unlike at Pow Hill, this is here accompanied by a marked rise in herb pollen values (to 53% tdlp). This site resembles sites in the south east of the region more. Regardless of the developments at these sites, *Plantago* in particular increases in this period at all sites in the area (Fig. 7.4.16).

At several sites in northern Northumberland in this period there is a marked rise in herb pollen levels, to 52% tdlp at Akeld Steads, to 66% tdlp at Edlingham and to 27% tdlp at Camp Hill Moss, which was formerly dominated by high tree pollen values. Trees and shrubs drop at all these sites down as low as 21% and 11% respectively at Edlingham. These sites resemble sites in the south east of the region in this period in many respects. Low trees and shrubs at other sites in northern Northumberland are accompanied by high Ericaceae values, as in the previous period. Grass pollen values rise at most sites and the range of herb taxa found at these sites increases also. *Artemisia*, Caryophyllaceae and Compositae (exceeding 1% tdlp in this period) appear at several sites, and *Plantago* rises to high values in this period (to 2.5% tdlp at Broad Moss).

At sites further south in the Tyne Corridor, at Fortherley Moss and Fellend Moss tree pollen levels remain higher in this period and Ericaceae pollen values are high, making these sites appear similar to Quick Moss and Dufton Moss in the Northern Pennines and Pow Hill in this period in the upper Derwent area. *Plantago* and Ranunculaceae appear at these sites at values exceeding 1% tdlp in this period.

At most upland sites trees continue to decline further, mostly to below 20%. During this period at many upland sites Ericaceae values see a further massive increase, reaching 76% tdlp at Dead Crook and 68% at Site W, in upper Teesdale. This increase is widespread across the uplands, and has already been demonstrated to occur further north in the Tyne Corridor and in the uplands of northern Northumberland as well as to the north-east in the Derwent area. *Plantago*, Ranunculaceae and *Rumex* are found at almost every site in the uplands. At some sites in Upper Teesdale, however, there are peaks in many herb types and grass and sedges are more important than Ericaceae. Pollen of Caryophyllaceae, Chenopodiaceae, Compositae and *Artemisia* increase as well as grass pollen at several of these sites in upper Teesdale.

b) Evidence for arable agriculture

This period sees an increase in values of both arable and pastoral type herb taxa at many sites, with the appearance of *Cerealia*-type pollen at a larger number of sites across the region than before, including at Steward Shield Meadow in Weardale, other sites in the Derwent/Weardale area and in the Tyne Corridor, whilst it occurs at virtually all the sites in the south east of the region at values between 0.2-0.6% tdlp (Fig. 7.4.8). Values also increase at sites in northern Northumberland. Despite this, the values for pastoral type herb taxa increase proportionally more, with large increases in values for *Plantago* (Fig. 7.4.16) in particular, but also Ranunculaceae (Fig. 7.4.18) and *Rumex* (Fig. 7.4.19), so that lower index scores than before are found at most sites in this period.

The scores for the agricultural:arable index for this period show that index scores fall at most sites, with the exception of a few sites in upper Teesdale, a few sites in northern Northumberland and certain sites in the south east of the region (Fig. 7.4.6). The decreases in the index score in the south east of the region occur at those sites where there is some woodland regeneration in this period, such as at Hutton Henry and Neasham Fen and also in Weardale at Hallowell Moss and Bollihope Bog. With the exception of Hutton Henry and Neasham Fen, all other sites in south-east Durham have increased arable pollen values, but the maximum value of 59% total agricultural pollen suggests that at most sites across the region "pastoral" types dominate the agricultural pollen. Within south east Durham the sites on the limestone plateau have more "pastoral" scores whilst Mordon Carr in the lowlands and Thorpe Bulmer nearer the coast have the highest arable scores. At Neasham Fen, there is only a very small proportion of arable types.

At most sites in Northumberland index scores drop as values for *Plantago* and Ranunculaeae increase markedly at most sites in this period. However at a couple of sites in northern Northumberland where tree pollen values have dropped and herb pollen values risen in this period, index scores increase at some sites as the proportion of arable types at many sites rises, or arable types appear, in this period. However, scores are still not as high as in the south east of the region. The highest index score occurs at Camp Hill Moss (23%), where tree pollen has declined markedly in this period.

7.4.2 The Roman period, cal. AD 70 - 500

a) Woodland cover and evidence for clearance

The major issue in the pollen literature concerning the later Iron Age and Roman period is the timing and nature of a very major decline in tree and shrub pollen values which occurs at a large number of pollen sites from the region. This clearance is not visible on the maps for the Iron Age period at most sites because it is concealed by the averaged values for the whole of the Iron Age. However the maps for the Roman period clearly show a marked change between averaged values for the whole of the Iron Age and for the Roman period. Although more detailed timing cannot be gained from examining the pollen maps, when the averaged pollen values for the Roman period in the pollen maps are compared to the average values for the whole of the Iron Age period, it is clear that at some point during the Iron Age and Roman period, there was a massive increase in herb pollen and decrease in tree and shrub pollen. The exact timing of this clearance, and how the timing varies from site to site has been subject to considerable discussion and will be dealt with later in this section, by examining radiocarbon dates for this clearance event. Firstly we will examine the variation in degree of clearance across the region using the pollen maps.

Although the pollen evidence for this period has been reviewed many times in the archaeological literature for the north-east (Turner 1979; Turner 1983; Wilson 1983; van der Veen 1985; Fenton-Thomas 1992; Ferrell 1992), these studies have tended to focus primarily upon examining the timing of the clearance event, and most studies have tended to overlook the issue of variation in intensity of this clearance and patterns of spread of this clearance phenomenon across the region. Pollen maps are an ideal method to investigate such an issue. Even where pollen maps have been used (Fenton-Thomas 1992), they have only focused upon radiocarbon dated sites and the area between the Tyne and Tees. This section examines variation in tree and shrub values across the whole of the north-east of England during this period.

At many sites this is the first major decline in tree and shrub pollen values that occurs (Figs. 7.4.21, 7.4.22), and tree and shrub values are often as low as found today across the region. This major decline in woodland taxa occurs both at sites which had never seen major clearance before, at those where clearance was minimal and woodland dominated, as well as at those where major clearance had already occurred in the Bronze Age. Even at sites in south-east Durham where herb levels were already very high, herb pollen levels increase further. For example at sites on the East Durham plateau herb pollen values are even higher in this period, rising to 91% tdlp at Hutton Henry and 82% tdlp at Bishop Middleham and 65% tdlp on the coast at Hartlepool (Fig. 7.4.23). At Mordon Carr and Thorpe Bulmer tree and shrub values remain slightly higher than at the other sites in the area, as before, but even here herb pollen values rise in this period, to 60% tdlp and 57% tdlp respectively. Values for grass pollen rise markedly at most sites in the south east, up to 34% tdlp at Hutton Henry and 24% tdlp at Bishop Middleham. *Plantago* occurs at high levels on the East Durham plateau sites, rising to 3.7% tdlp at Hutton Henry (Fig. 7.4.35), and values for Compositae also rise to 3.9% tdlp in this area (Fig. 7.4.32). On the coast values for Chenopodiaceae (Fig. 7.4.31) and Compositae rise further in this period.

The exception to this pattern in the south east of the region occurs at Neasham Fen in the Tees lowlands, where tree and shrub values remain high, together making up 83% of total dry land pollen. Only a small number of herb types are present at this site, only small amounts of pollen of *Plantago*, Ranunculaceae and *Rumex* plus small values for grass pollen.

At sites which were well wooded right up to this period, in the Wear and Derwent, and in the Tyne area (such as Fellend Moss) there is a very marked reduction in tree pollen percentages, so that tree levels resemble those found today. At Hallowell Moss, tree and shrub values for this period are markedly lower than those for the whole of the Iron Age, with tree values falling from 60% tdlp to 18% tdlp (Fig. 7.4.21) and a rise in herb pollen from 2 to 27% tdlp (Fig. 7.4.23). Here there is a marked increase in Gramineae pollen from under 1% tdlp to 17% tdlp (Fig. 7.4.26) accompanied by a rise in *Plantago* to 7% tdlp and the appearance of a wider range of herb taxa, including *Cerealia*-type, Compositae, Cruciferae and *Polygonum*. At this site the change is quite dramatic, from a well-wooded landscape to one largely clear of trees and shrubs. This site now resembles those in the south east of Durham more, although tree pollen levels are not as low. However, at the nearby site of Steward Shield Meadow in mid-Weardale tree and shrub levels are on the same low levels as found in south east Durham, falling to under 5% tdlp for both trees and shrubs, and herb pollen levels very high, at 75% tdlp.

This marked decline in trees and shrubs also occurs at other sites in the area, but here it is accompanied by a marked rise in Ericaceae pollen values instead of herb pollen values. For example, at at Bollihope Bog, tree pollen declines from 60% to 14% tdlp and at Pow Hill from 50% tdlp to 5% tdlp. However, at both sites this is accompanied by a rise in Ericaceae pollen to above 30% tdlp (Fig. 7.4.24). However, not all well wooded areas in the region were cleared at this time; as has already been demonstrated, on the heavier clay lowlands of the Tees at Neasham Fen (as well as further south in Yorkshire at White Moss, Bartley *et al.* 1986) there is no evidence for large scale clearance until after the end of the Roman period.

As across much of the rest of the region, in northern Northumberland tree and shrub pollen values are very low for this period at all sites. Tree pollen values fall below 20% tdlp at all sites including those where tree pollen levels had been quite high in previous periods (for example, Camp Hill Moss, which like the sites in the Derwent and Wear area had formerly been dominated by very high tree pollen levels.) Shrub pollen values remain low from the previous period, under 10% tdlp at all sites (Fig. 7.4.22). Similar to the sites in the Derwent and Weardale area, the sites in northern Northumberland divide according to whether this decline in trees and shrubs is accompanied by an increase in herb pollen to very high values, or Ericaceae to very high values. This distinction between sites with high herbs and Ericaceae has been demonstrated to occur in northern Northumberland in previous periods and continues into this one. Herb pollen values rise to very high values at the sites of Akeld

Steads (to 73% tdlp), Wooler Water (to 90% tdlp) and at Edlingham to 82% tdlp (Fig. 7.4.23). All these sites have in previous periods have had very low Ericaceae levels and herb pollen has risen with declines in trees and shrubs. In contrast, the sites of Trickley Wood, Broad Moss and Camp Hill Moss, as before, have the highest Ericaceae pollen values of the area, and in this period these rise further, to above 40% at several sites (Fig. 7.4.24). Grass pollen levels rise markedly at those sites dominated by herb pollen, up to 49% tdlp at Edlingham. Even at sites dominated by Ericaceae, grass pollen levels rise in this period to over 10% tdlp, although not to such high levels as at the herb dominated sites (Fig. 7.4.26). High values of *Plantago* also occur in the north of Northumberland, reaching 5% tdlp at some sites, almost as high as levels found in the south east of the region (Fig. 7.4.35) and also *Rumex*, which reaches 1% tdlp at some sites (Fig. 7.4.38). Those sites dominated by Ericaceae tend to have only *Plantago* and *Rumex* present in any great amount, as has been demonstrated to occur on upland sites dominated by Ericaceae in the Northern Pennines, whilst at the herb-dominated sites a much greater variety of herb types is present.

Further south, in southern Northumberland, and specifically at sites in the Tyne Corridor, trees fall markedly at Fellend Moss and Fortherley Moss from above 40% to under 15% tdlp, at a level similar to sites in northern Northumberland. Like some of the sites in northern Northumberland and in the Derwent and Weardale area, this decline in trees is accompanied by a marked rise in Ericaceae values to 40%, with the exception of one site, Vindolanda, where very high herb pollen levels are recorded (86% tdlp). However this is unsurprising considering the nature of the deposit from which the pollen samples from Vindolanda were taken; from soil samples from an archaeological site, as opposed to other sites in the area where cores were taken from peat deposits. Grass pollen levels rise at all these sites, to around 15% at Fellend Moss and Fortherley Moss, accompanied by a marked rise in *Plantago*, rising to 3.6% at Fellend Moss and also high values for *Rumex* and Ranunculaceae. Similar developments are recorded as occurring at Coom Rigg to the north west, and Muckle Moss to the east of these sites.

At some upland sites in the Northern Pennines trees and shrubs had reached their lowest values in the Late Bronze Age and earlier Iron Age (under 30% tdlp for trees, and under 20% tdlp for shrubs at most sites), and at this stage rather than in the later Iron Age or Roman period, the major decline in tree and shrub pollen occurs. This is accompanied by a major rise in Ericaceae. However, in periods following the Late Bronze Age there is a rise in grass pollen values following this marked rise in Ericaceae. This rise in grass pollen levels at Ericaceae-dominated sites in this period has also been demonstrated to occur at sites in northern Northumberland and in the Tyne Corridor, and appears to be a phenomenon common across upland sites in this period. It is therefore likely that the late Iron Age or Roman period major clearance event that occurs elsewhere in the region is accompanied by an increase in grassland types in the uplands, which follows an earlier increase in Ericaceae occurring the Late Bronze Age and earlier Iron Age. *Plantago*, Ranunculaceae and *Rumex* remain the dominant herb pollen types in the uplands as before, with *Plantago* rising further to 2.2% tdlp at some sites, and in this period there is a further decline in the range of herb pollen taxa such as Chenopodiaceae and *Cerealia*-type in the uplands. However, the range of herb types remains, as before, higher at sites in upper Teesdale with the continued occurrence of Compositae and Cruciferae at several sites in this area.

b) Timing of the major clearance event: late Iron Age or early Roman period, or both (i.e. varying from site to site)?

To examine the timing of this event, it is necessary to examine individual radiocarbon dates from pollen sites across the region, instead of using the pollen maps. The timing of this major clearance event across the region has been subject to considerable discussion (Turner 1979; van der Veen 1992). Of particular interest is whether this clearance occurred in the later Iron Age or as a result of Roman activity in the region. Radiocarbon dates for this event range from 180-190 cal. BC to cal. AD 190-240 across the region. Depending upon the site and the radiocarbon date obtained, pollen workers have either attributed this event to the later Iron Age (Bartley *et al.* 1976; Chambers 1978), or the Roman occupation of north-east England (Donaldson and Turner 1977). Turner (1979) has investigated the likelihood at each site that its pollen catchment area had been cleared by AD 80. This date is used to represent the first Roman activity in the area. This was done by calculating the probability of obtaining the date concerned by chance, if the clearance had really occurred at AD 80.

To summarise the results produced by Turner, at Thorpe Bulmer and Valley Bog it is extremely unlikely that the clearance occurred as late as AD 80, and at Steward Shield and Steng Moss the chances are small. At Hallowell Moss and Fellend Moss, both more wooded sites previously, there is a 21% and 25% chance respectively that their catchments were cleared later than AD 80, although it is more likely that they were cleared earlier. Hutton Henry and Bollihope Bog are, however, more likely to have been cleared after AD 80, with probabilities of 55% and 90% respectively. It is therefore clear that at most sites clearance was well under way by the time of the Roman occupation, and that throughout the Roman period this clearance most likely extended to areas that had not been cleared on this scale before. This clearance was on a scale totally different to that in previous periods (with the exception of around the site of Bishop Middleham, where major clearance occurred back in the Bronze Age.) This clearance occurred in both the lowlands and the uplands, and on previously well wooded land. The only areas in which this clearance does not appear to have occurred in this period is on the heavy clay lowlands such as at Neasham Fen, as at White Moss in the Craven lowlands of Yorkshire, where major clearance is postponed until well after the end of the Roman period.

c) Timing of clearance activity during the Roman period

Turner's (1990) analysis fails to show that, although initial clearance occurred at most sites in the late Iron Age, it did not reach peak values at many sites until right at the end of the Roman period. At many sites across the region herb values increase throughout the period to peak values in the 5th century AD. This suggests that although this clearance event had its origins in the later Iron Age, it was a gradual process which increased throughout the Roman period.

It appears that "core-sites" in the south-east of Durham witnessed very high herb levels first, back into the Bronze Age at some sites on the East Durham plateau, and that in other areas, although some initial clearance had occurred in the later Iron Age, high levels of clearance such as found in the lowlands did not occur until far later. However, even within the south-east Durham "core-zone" herb pollen values increase even further throughout the period. At Thorpe Bulmer, herb values increase after the initial major clearance in the later Iron Age to peak values radiocarbon dated to cal. AD 372. High herb values at Hutton Henry also increase through the period. At Hallowell Moss, after initial clearance at the start of the period, herb values increase up to a peak interpolated to cal. AD 547. At both Bollihope Bog and Steward Shield, clearance activity reaches its peak around the end of the period cal. AD 70-500. At many upland sites also there is a peak in non-blanket bog herbs late in the period; at Valley Bog there are peaks around the end of the period cal. AD 70-500. Similarly at Weelhead Moss there is a herb peak at a level dated to the early 6th century AD.

The timing of clearance in the sites in the Tyne Corridor is of major importance to examine the impact of the construction of Hadrian's Wall and associated structures during the Roman period in the first part of the second century AD, but dating back to earlier structures associated with the Stanegate frontier in the first century AD, and continuing on throughout the Roman period. Radiocarbon dates available from these sites enable some idea of variations in timing of clearance between sites in the area. At Fellend Moss, which lies within view of Hadrian's Wall, on the escarpment to the north, the radiocarbon date for the first evidence for major clearance has a calibrated midpoint date of cal. AD 54, with a drop in tree pollen and increases in pasture-type herbs. This decrease in tree pollen is not so great as at other sites in the lowlands, but is still substantially lower than in earlier periods. However herb pollen values continue to increase so that there is a marked peak of activity in the later Roman period. Pollen counts from the vicus site on the wall at Vindolanda, which are dated to AD 100-125 from the archaeological context, show that at this time at this site the land surrounding the site was largely treeless, and cereal pollen is recorded with a range of arable and pastoral-type herbs. This picture can also be supplemented by radiocarbon dates from sites studied by Dumayne (1992) precisely to study the timing of clearance and how this relates to the construction of the wall and associated structures, although the pollen data themselves were not available for study. At Walton Moss a calibrated midpoint date of cal. AD 11 is produced to mark the start of a major decline in tree pollen and shrub pollen and a rise in herb pollen values. Herb values continue to increase throughout the first century AD up to the second radiocarbon dated level, producing a midpoint date of cal. AD 79 to mark a recovery in tree pollen values and sharp decline in herb pollen values to formerly low levels. However, unlike at Walton Moss, at Fozy Moss the major phase of clearance occurs later, at a level producing a midpoint date of cal. AD 190. The implications of these dates for discussions of the impact of the wall upon the vegetation of the area will be discussed in Chapter 9.

Radiocarbon dates dating the clearance event in northern Northumberland are far less common than in the south of the region. Although several radiocarbon dated sites exist for this area, none of them have radiocarbon dates for the levels where the first major clearance occurs. Only one radiocarbon date for the region exists to date this event. This is from Steng Moss, where the first level with a marked drop in tree pollen values to 17% tdlp and shrubs to 8% tdlp and a corresponding rise in Ericaceae pollen values to 51% tdlp (herb pollen values remain at around 20% tdlp and are little changed), has a radiocarbon date which produces a calibrated midpoint date of cal. AD 55. This late Iron Age date is consistent with the picture found at other sites. However, it is unfortunate that the timing of clearance at this site, which belongs to the group of Ericaceae dominated sites in northern Northumberland, cannot be compared with the timing of clearance at the herb dominated sites in northern Northumberland, such as Akeld Steads and Edlingham, which are undated sites.

d) Evidence for agricultural activity during the Roman period

During this period percentages for arable type herb taxa increase to peak values at many sites. However, pastoral type herb taxa also increase during this period at most sites (except some in the lowlands) proportionally greater than arable types, resulting in the persistence of "pastoral" scores for the agricultural:arable index (Fig. 7.4.25). This period therefore sees a dramatic rise in pasture-type herbs as well as arable types at most sites. The relative proportions vary from site to site.

In south east Durham there is considerable variation in the agricultural: arable score between sites in different parts of the region. The agricultural:arable score rises at Bishop Middleham and Mordon Carr to high levels, up to 82% and 50% respectively, whilst at Hutton Henry it falls to 24% as the proportion of pastoral types increases. At Bishop Middleham the rise in score is due to a marked rise in Compositae pollen to 3.9% tdlp and *Cerealia*-type also. *Cannabis* pollen appears at this site in this period in large amounts also and has been interpreted by Bartley *et al.* (1976) as indicating hemp cultivation in the close vicinity of the site, or alternatively the use of water at the site location to wash hemp. *Cannabis* pollen reaches up to 19% total pollen at a level radiocarbon dated to cal. AD 220. This is accompanied by the occurrence of taxa such as *Polygonum* and *Centaurea cyanus*, which do not occur earlier at this site. At Mordon Carr very high *Cerealia*-type pollen values of 3% tdlp appear, suggesting that cereal was either cultivated, transported, processed or stored close to the site in this period. The proportion of other arable type taxa at this site also increases. The decline in index score at Hutton Henry is due to the dominance of *Plantago*. At the heavily wooded Neasham Fen arable types disappear completely as the range of herb types present declines. It is therefore likely that the distinction found in the earlier Iron Age between more pastoral types on the drier limestone uplands (such as at Hutton Henry) and a higher proportion of arable types on the lowlands between the escarpment and the heavier river soils (such as at Mordon Carr) continues through the Roman period. The continued high tree and shrub percentages and lack of arable types at Neasham Fen suggest that arable agriculture had not extended onto the heavy clay lowland soils in this period, unlike in southern England where this had been occurring since around 500 cal. BC (van der Veen 1985).

At formerly well-wooded sites in the Derwent and Weardale area and in the Tyne Corridor, such as Hallowell Moss and Fellend Moss, pastoral type herbs taxa dominate, resulting in low index scores. However, even at these sites there is an increase in arable herbs from previous periods. At Hallowell Moss for the first time pollen of *Cerealia*-type and *Polygonum* occur, accompanied by a rise in other arable type taxa such as Compositae and Cruciferae, although *Plantago* values also rise to high levels in this period, and as a result index scores remain low, around 6%. Arable types also appear in small amounts at Lamb Shield in this period, with the appearance of *Cerealia*-type, Compositae, Cruciferae, although there is also a marked rise in *Plantago* and as a result the index score only rises slightly, to 14%. This also occurs at Pow Hill.

However, at Steward Shield Meadow and Bollihope Bog the index scores rise much higher than at other sites in the area, to 59% and 45% respectively, with a very large rise in the values of Compositae at both sites (to 13% tdlp at Steward Shield Meadow). However values of *Plantago* and Ranunculaceae also rise to high values, up to 4% tdlp, which keep the index scores down somewhat.

As in south east Durham, in Northumberland there is considerable variation between sites in the agricultural:arable index scores for this period, ranging from a marked rise in index score at Edlingham to 89% and a somewhat lower index score of 33% at Akeld Steads to low values at Black Lough, Steng Moss and Broad Moss below 15%. Pastoral types such as *Plantago*, Ranunculaceae and *Rumex* dominate at the sites with low index scores and these tend to be the sites with a dominance of Ericaceae. Higher amounts of arable type taxa occur at the more herb dominated sites. To the south, in the Tyne Corridor, arable types are entirely absent at Fortherley Moss and Muckle Moss in this period, and *Plantago* dominates, whilst they appear at Fellend Moss in small amounts, including the appearance of *Centaurea*. *Plantago* also rises to high values at this site, which keeps the index score low, however.

At upland sites pastoral type taxa such as *Plantago*, Ranunculaceae and *Rumex* predominate, as before, with the exception of a few sites in upper Teesdale where there are occurrences of *Cerealia*-type pollen and other arable type taxa such as Compositae and Cruciferae. Elsewhere in the uplands these arable types are absent suggesting that any agriculture in these areas was predominantly pastoral in nature. It is possible that the sites with *Cerealia*-type pollen are picking up cereal pollen blown in from further down the valley; in this period the open conditions at many sites will have increased the catchment areas so that region-wide phenomena such as the peak in herb values will be picked up at the upland sites. However, if this is the case, it seems unusual that all the occurrences of cereal pollen in the uplands in this period are confined to upper Teesdale, and not found at a range of other sites in the uplands where pollen could have been blown in. If arable agriculture were carried out in this area in this period, it was done in very extreme conditions for cereal cultivation, and these occurrences of cereal pollen are unlikely to represent anything very extensive. However, they might represent an agricultural context for nearby archaeological sites dating to this period in Upper Teesdale (Coggins 1986).

e) Duration of the major clearance phase

An interesting point is how long this major clearance lasted at sites across the region before regeneration of woodland occurred. At many sites it can be seen that high herb values continue throughout the Roman period, and in some areas continue well beyond this. Following this there is a period of regeneration at many sites, particularly at those where woodland was always greater in the past.

At several sites across the region this woodland regeneration event has been radiocarbon dated. In those areas which were formerly well wooded, regeneration occurs shortly after the end of the period, and is quite marked. At Hallowell Moss after the end of this period there is a marked decline in Gramineae, the disappearance of all herb types except for small amounts of *Plantago lanceolata*, and an increase in *Betula*, *Quercus* and *Corylus*. Herb pollen levels are low, but still on a higher level than those before the major clearance phase. This event occurs around cal AD 550, between dated levels of cal. AD 470 and cal.AD 625. At Bollihope Bog, woodland regeneration commences following the end of the period cal. AD 70-500, reaching a peak in the 9th century AD. Similarly at Steward Shield nearby, at a level interpolated to cal. AD 426, herb pollen levels decline with an increase in *Corylus*, implying some regeneration of light scrub. After a level dated to cal. AD 902 , however, there is a significant decline in herb values not reached again until the start of the 18th century, and values for trees (*Alnus*, *Betula*, *Quercus*) as well as *Corylus* increase. At most upland sites conditions remain open, dominated by blanket bog and open grassland taxa, depending on the local conditions of the pollen site. However a reappearance of tree and shrub pollen at the end of the period cal. AD 70-500 is noted at several sites, such as at Valley Bog, although this might be a product of the now very large catchment areas of these sites picking up woodland regeneration from more lowland areas.

In the south east of Durham, however, forest regeneration occurs much later than at other sites in the region, and is on a much smaller scale than found elsewhere in the region. This area remains the most agriculturally active of the region. At Thorpe Bulmer, there is no decline in herb values until far later. Here herb values remain high until around cal. AD 1230, although values of arable types such as *Cannabis*, *Centaurea* and *Polygonum* decline from the peak at the end of the Roman period. Here therefore, there is no decline in herb values in the immediate post-Roman period. In those areas where prior to the major clearance woodland was important, forest regeneration is the most marked. At Hutton Henry, peak values for herbs drop only slightly right at the end of the period cal. AD 70-500. At Mordon Carr herb values increase beyond the end of the period, peaking at a level interpolated to cal. AD 869.

f) Timing of woodland regeneration

Of particular interest is whether this woodland regeneration event occurred with the withdrawal of Roman garrisons from the north-east around AD 410, or whether this clearance continued after this. The above discussion suggests that the period of maximum clearance, and highest herb values occurs at most sites towards the end of this major clearance phase, and that woodland regeneration occurs at many sites well after the date of AD 410 quoted as the official Roman withdrawal. Turner (1990) has investigated the likelihood that this woodland regeneration phase coincided at each site where this event was radiocarbon dated with the Roman withdrawal from the north-east at around AD 410 (Table 7.4.4) The results show clearly that woodland regeneration most likely occurred well after the Roman withdrawal. It is likely that open conditions continued at the same levels as before under stable conditions, well into the 6th century, and considerably longer at some sites.

After this period of maximum clearance, there is an abrupt end at several sites. This is particularly marked in those areas outside the south east of Durham, especially those that were formerly well wooded. Around Hallowell Moss, for example, large areas of previously farmed land must have reverted back first to *Corylus* dominated scrub, then woodland, with only small amounts of grassland around the site. Values for light-demanding taxa such as *Betula* and *Corylus* remain high for a while; possibly light woodland was maintained by grazing or coppicing (Donaldson and Turner, 1979). In comparison, the continuity of clearance at Thorpe Bulmer and the only slight decline in herb pollen at Hutton Henry imply some degree of maintenance of activity until after cal. AD 1000. During this period, heavier soils in the lowlands appear to have had their first major clearance; at Neasham the first dramatic decline in tree and shrub pollen and increase in herb pollen is dated to cal. AD 737, and at White Moss in the Craven lowlands in Yorkshire between cal. AD 600-800 (Bartley *et al.* 1990).

For northern Northumberland there are far fewer radiocarbon dates available to date the recovery of woodland. At Steng Moss a recovery in tree pollen levels from 13% to over 20%, shrubs from 9% to 15% and a fall in Ericaceae values to 17% has produced a calibrated midpoint of cal. AD 550. No other radiocarbon dates are available, but at several non-dated sites there is a recovery of tree and shrub values following the end of the Roman period, such as at Black Lough where tree values recover from 13% to 37% tdlp and herb pollen values drop from 45% to 16% tdlp. At Broad Moss also there are levels where tree pollen recovers back from 14% to 23% tdlp and Ericaceae drop from 55% to 35% tdlp. However, at Camp Hill Moss there is no evidence for any recovery in tree and shrub pollen values or for any decline in Ericaceae values. Trees and shrubs continue throughout all the levels following the Roman period to remain under 10% tdlp each. This is also the case at Edlingham and Akeld Steads, where herb pollen levels remain very high. It appears that in northern Northumberland, as in the south east of the region, there was considerable variation between sites, with some sites experiencing woodland recovery whilst at others there is no evidence for any decline in herb levels. The sites with the least evidence for woodland recovery tend to be those with the highest herb pollen levels in the Roman period, or those sites with very high Ericaceae values.

7.5 An area by area summary of the key spatial and temporal trends in the pollen maps from the Mesolithic to the end of the Roman period

7.5.1 The Derwent/Weardale area

The area that shows the least change in pollen values over time is the Derwent/Weardale area. Here tree pollen values remain at extremely high levels for most of the period from 8000 cal. BC - cal. AD 500, with the exception of the late Iron Age and Roman period when tree pollen levels fall at all these sites to very low levels. Throughout the whole of the Mesolithic these sites have very high tree pollen levels and correspondingly very low shrub, herb and Ericaceae values. As a result, sites in this area behave very differently to sites across the whole of the rest of the region, where shrub (mostly *Corylus*) pollen levels are high in the earlier part of the region, and tree pollen levels only increase in the later part of the Mesolithic. In the earlier Neolithic, tree pollen levels increase further at these sites up to 80% tdlp at a couple of sites, increasing yet again in the later Neolithic up to 91% at Hallowell Moss. Shrub, herb and Ericaceae levels continue to be low at these sites throughout the Neolithic, with only a very small range of herb taxa being present. Arable type herb taxa are almost entirely absent from the sites in the Derwent/Weardale area, with those types that are present dominated by Gramineae and Ranunculaceae.

In the early Bronze Age, despite the marked decline in tree pollen values occurring at sites in the south-east of the region in this period, tree pollen values continue to remain very high in the Derwent and Weardale area, actually increasing further at Pow Hill to 80% tdlp, and remaining above 60% tdlp at all sites. The exception to this is at Hallowell Moss, where tree pollen values do drop slightly, down to 71% tdlp, accompanied by a slight increase in shrub values and a small rise in herb pollen values. There is the appearance of small amounts of new herb taxa in this period at Hallowell Moss, including Chenopodiaceae, Compositae, Cruciferae and *Plantago*. Although some members of the Compositae and Cruciferae families can occur today in wooded environments, the decline in trees plus an increase in open disturbed indicators such as Chenopodiaceae and *Plantago* indicate a clearance episode. Radiocarbon dates available for this clearance at Hallowell Moss show that instead of representing one small temporary phase of clearance, there appears to have been more permanent but small scale clearance around the site throughout the Early Bronze Age and into the Middle Bronze Age at this site.

In the middle Bronze Age, although tree pollen values continue to remain the highest from the whole region, there is a decline in tree pollen values at several sites. This is particularly marked at Hallowell Moss, where tree pollen values drop from 71% tdlp to 49% tdlp. This is accompanied by the first major rise in shrub pollen, up to 30% tdlp. Herb pollen levels, however, remain low, but the herbs associated with clearance in the previous period (Chenopodiaceae, Compositae, Cruciferae and *Plantago*) continue to occur. Tree pollen levels also decline at Pow Hill, but here this is accompanied by a rise in herb pollen rather than shrub pollen. However, there is not the wide range of herb types found at Hallowell Moss here. At other sites in the area, such as at Lamb Shield, and at the new site of Bollihope Bog, tree pollen levels remain high (over 60% tdlp).

In the late Bronze Age and earliest Iron Age well-wooded conditions continue at sites in the Derwent and Weardale area, with tree pollen values ranging from 50-70% tdlp. However at Steward Shield, in Weardale, tree pollen values decline in this period to the low level of 20% tdlp with an increase in shrub and herb pollen values and the appearance of *Plantago*. It is in this period that this site begins to resemble sites in the south east of the region rather than other, tree dominated sites in the Derwent and Weardale area. In the following Iron Age period there is some evidence for a recovery of tree values at Hallowell Moss, and other sites in the area remain dominated by trees. However, at Steward Shield tree values continue to decline and herb pollen values reach 53% tdlp, on the same level as found at sites in south-east Durham.

At some time during the late Iron Age and Roman period at most sites in the Derwent and Weardale area formerly high tree pollen levels fall dramatically to tree levels found in the region today. At Hallowell Moss tree pollen values drop from 60% to 18% tdlp and herb pollen level rise from 2-27% tdlp. At Pow Hill, also, tree values drop from 50% to 5%. At most of the sites in the Derwent and Weardale area this decline in trees is accompanied by a marked rise in Ericaceae, so that these sites now resemble sites in the uplands. The exception to this is at Hallowell Moss, where there is a rise in herb pollen levels and an increase in the range of herb taxa, with the appearance of *Cerealia*-type pollen, Compositae, Cruciferae and *Polygonum*, plus a marked rise in *Plantago*. Also at Steward Shield a further decline in tree pollen values in this period down to very low levels only found in south-east Durham (under 5% tdlp) is accompanied by a marked rise in herb pollen levels to 75% tdlp. Unlike at sites in the south-east of the region, where tree levels were always a lot lower, this phase of clearance at radiocarbon dated sites such as Hallowell Moss does not appear to continue long after the Roman period. After cal. AD 500 at Hallowell Moss there is a marked decline in grass pollen values and the disappearance of all herb types except small amounts of *Plantago*, and an increase in light demanding trees and shrubs, implying some degree of woodland regeneration. This also occurs at Bollihope Bog towards the end of the Roman period, and continuing well into the end of the first millennium AD, and also at Steward Shield Meadow where a decline in herbs and an increase in shrubs implies some regeneration of scrub, at a level interpolated to cal. AD 426. This suggests that unlike at some sites in the south-east, where clearance appears to have been maintained following the high herb levels of the Roman period, those areas formerly covered by woodland revert back to scrub cover towards the end of or following the Roman period.

7.5.2 The south-east of the region

This area is particularly notable in that for most of the period, from the Bronze Age, the south-east of the region is marked out as having some of the lowest tree and shrub values and the highest herb pollen values found across the region. In addition, from the Bronze Age onwards the highest values for most individual herb taxa occur in the south-east of the region, including Gramineae pollen, whereas before the Bronze Age the highest values tended to occur in the uplands of the region. As a result it is difficult to avoid letting discussion of the trends occurring in this area dominate the discussion of the whole region.

Throughout the Mesolithic period, as across most of the region, trees and shrubs together make up virtually all pollen at sites in the south-east of the region, with very little herb pollen and no Ericaceae pollen. (In fact, these sites continue to have no or very little Ericaceae pollen throughout the entire period from 8000 cal. BC - cal. AD 70, with the exception of Mordon Carr, where it is always present in higher amounts). Shrub pollen, dominated by *Corylus*, dominates for the first two Mesolithic periods, 7800 - 7300 and 6800 - 6300 cal. BC, increasing in the second period to its highest levels, before dropping off in the period 5500 - 5000 cal. BC, and being replaced by trees. In the final Mesolithic period sites in the south-east resemble the tree dominated sites in the Derwent/Weardale area (tree pollen values of 40-50% tdlp are common in this period). The exception to this pattern is Bishop Middleham, the only site to have high herb pollen levels, which is due throughout this period to very high Cyperaceae (sedge) pollen dominating the very local pollen rain.

In the south-east in the Mesolithic there are only a few indications of forest disturbance, although due to the lower density of pollen cores in the lowlands compared to the uplands and the denser tree cover compared to the uplands in this period, and therefore the smaller catchment area of sites in the lowlands, it is less likely that any clearance activity would be picked up from these cores, unless it happened to occur close to a core site. During the final Mesolithic period there is an increase in values for disturbance herb taxa in this area and also an increase in the range of herb taxa. These include *Artemisia*, Chenopodiacae and *Plantago* which tend to be accompanied by peaks in the curve for *Corylus* and other light demanding trees and shrubs.

In the earlier Neolithic period, 3800 - 3300 cal. BC tree cover remains little changed from the preceding period, but there is a marked decline in shrub pollen values down to between 20-30% tdlp. This shrub decline is accompanied at many sites in the area by an increase in herb pollen values, rising to between 30-40% tdlp at a couple of sites in the area. There is also an increase in the range of herb taxa present in the south-east, with several disturbance and open ground indicator types that had previously only occurred in the uplands of the region now appearing in this area. For example Caryophyllaceae and Leguminosae appear in the lowlands for the first time, joining Chenopodiaceae, Compositae and Ranunculaceae, which had already spread into the lowlands in the previous period. Compositae values increase at many sites in this period. *Plantago* and *Rumex* also appear for the first time in small amounts in this area. This supports a picture of increased woodland disturbance. *Cerealia*-type pollen also makes its first appearance in this period at Mordon Carr and Neasham Fen. The highest agricultural:arable scores for this period occur in the south east of the region, largely because of the extremely high score at Hartlepool which is due to the dominance of Chenopodicaceae, Compositae and Cruciferae. Since all these families include taxa which can occur in natural coastal vegetation communities today, this dominance of arable type taxa at this site need not necessarily imply arable agriculture. Much lower, more pastoral scores occur at other sites in the south east, since values for *Plantago* and Ranunculaceae are quite high, so despite the occurrence of *Cerealia*-type pollen, open grassland type indicators are present at most of the sites. Of all the sites in this area, the highest tree and shrub pollen values occur at Neasham Fen.

In the later Neolithic, the decline in herb pollen levels observed at other sites across the region in this period is not as marked in south-east of the region, and certain herb pollen types actually increase. Agricultural:arable scores continue to remain highest in this area, rising to 99% at Neasham Fen and 80% on the coast and above 50% on the East Durham Plateau. Both arable and pastoral type herb taxa increase at most sites, although arable types increase proportionally more. The particularly high value at Neasham Fen is due to the occurrence of only one herb type, *Artemisia* at this otherwise tree and shrub dominated site.

It is during the early Bronze Age that the difference between the south-east of the region and the rest of the north-east of England becomes more marked. Tree values fall below 15% tdlp from levels previously above 50% tdlp and shrub values falling below 10% tdlp at some sites and herb pollen reaches unprecedented high levels above 80% tdlp. However at other sites in the south-east this decline in trees and shrubs and rise in herbs is not so marked. At Mordon Carr trees and shrubs only decline slightly, whilst at Neasham Fen tree

and shrub values remain little changed.
The maps for many individual herb taxa for this period show a shift in emphasis towards the south-east and away from the uplands, where the highest values formerly occurred. This includes grass pollen, which now reaches its highest values of 20% tdlp in the south east on the East Durham Plateau and on the coast. Chenopodiaceae, *Polygonum*, *Plantago* and *Rumex* also now appear in their highest amounts in the south-east of the region. The rise in these types is consistent with an increase in open, disturbed land in this area, although from the taxa present it is not possible to tell whether this land was predominantly cultivated or under grassland, since members of *Plantago* and *Rumex*, usually pastoral indicators, can occur on cultivated land in limestone areas.

In the middle Bronze Age period shrub pollen drops further at the sites on the East Durham Plateau, suggesting that remaining woodland was further cleared in this period, and herb values climb even further at these sites from the previous period, up to 89% tdlp. Elsewhere in the area, tree and shrub values remain higher, as before, but do drop slightly in this period, with the exception of Neasham Fen, where levels remain high. In this period grass pollen levels rise further on the East Durham Plateau accompanied by the appearance of very high values for *Plantago*, Ranunculacae, *Rumex* and Compositae, rising up to 8% tdlp for *Plantago*. The maps for Caryophyllaceae and Cruciferae also shift emphasis in this period so that the highest values occur in the south east. Many of these taxa now appear away from the East Durham Plateau, at Mordon Carr, for the first time. Whilst low, pastoral scores for the agricultural:arable index occur on the limestone plateau, there is an increase in arable scores at Mordon Carr.

In the late Bronze Age and earliest Iron Age period there is a further increase in herb pollen values on the limestone plateau and the greatest evidence for clearance so far at Neasham Fen. Pastoral type herb taxa increase further at most sites in this area, although agricultural: arable scores are still higher than in any other area of the region.

In the Iron Age there is little change on the already highly cleared limestone plateau in East Durham. However at Mordon Carr, there is an increase in herb pollen, whilst at Neasham Fen there is some woodland regeneration following the previous period. The proportion of arable types decreases in this period with the exception of Mordon Carr and Thorpe Bulmer where the agricultural:arable score increases to 53% and 59% respectively. Lower, more pastoral scores continue to occur at Hutton Henry and Bishop Middleham. The high tree and shrub pollen levels at Neasham Fen in this period are accompanied by a decline in the range of herb types present. In this area in the late Iron Age and Roman period, herb pollen levels are already low at many sites and so the decrease in trees and shrubs and rise in herb pollen levels that occurs at many sites across the region at this time is not so dramatic in the already well cleared south east. However, even on the East Durham Plateau there is a further increase in herb pollen levels in this period, rising to 91% tdlp at Hutton Henry and 82% tdlp at Bishop Middleham. This increase in herb pollen levels has produced calibrated midpoint dates which place this event in the south-east of Durham in the late Iron Age. At most sites, herb pollen values increase steadily throughout the Roman period to peak values towards the end of the period. At some sites in this area arable taxa reach very high values in this period. The highest agricultural:arable scores in this period occur at Mordon Carr where cereal pollen rises to large levels accompanied by a large increase in other arable types, whilst at Bishop Middleham *Cannabis* pollen appears in large amounts. However at Hutton Henry in East Durham pastoral type herbs dominate. Arable types continue to be absent in the Tees lowlands at Neasham Fen. There therefore is a distinction between predominantly grassland types on the limestone platueau, more arable types on the lowlands between the plateau and the Tees, and greater woodland cover along the river itself. This suggests that arable farming had not extended onto the heavy, but potentially very fertile, clay lowlands along the river in this period.

It is interesting that unlike elsewhere in the region following the Roman period, that regeneration of woodland is not as marked in the south-east. There is no decline in herb values and increase in shrubs at Thorpe Bulmer and Mordon Carr (and only a slight decline in herbs at Hutton Henry) until right at the end of the first millennium AD, rather than in around cal. AD 500. This continuity of clearance in the south-east, whilst in other areas there is some degree of regeneration of scrub, implies some degree of maintenance of activity until the end of the millennium. In addition, during this period the heavier clay soils around Neasham Fen are cleared for the first time, with the first major decline in trees and shrubs and increase in herbs at this site in the period between cal. AD 600-800. It appears that in the south-east, the area with the earliest and most permanent evidence for clearance, regeneration of woodland does not occur until far later. The exception to this is on the fertile, but heavy soils in the Tees lowlands, which were not cleared in the late Iron Age and Roman period, but which experienced major clearance for the first time in the later first millennium AD.

7.5.3 Northumberland

In the Mesolithic most sites in the north of Northumberland behave very similarly to sites in the south-east of the region by having a high overall tree and shrub pollen cover, but most of this being made up of shrub pollen. Tree pollen levels do vary from site to site, however, with higher levels remaining at a couple of sites in the lowlands of northern Northumberland. As in the south-east of the region, herb pollen levels are low at most sites, with the exception of one site where Cyperaceae levels dominate (Akeld Steads). However, unlike in the south-east, Ericaceae levels are higher at most sites in Northumberland, rising to 14% tdlp. As in the rest of the region, shrub values increase to maximum levels in the period 6800 - 6300 cal. BC, falling off in the period 5500 - 5000 cal. BC, when tree pollen levels recover. At most sites in northern Northumberland tree and shrub pollen make up equal percentages in this period. As in the south east of the region, there is only limited evidence for woodland disturbance, although the pollen of *Artemisia*, Chenopodiaceae and Ranunculaceae appear at some sites in the area with high values, even in the earlier periods of the Mesolithic. As has been observed in other areas, by the later Mesolithic many herb taxa formerly confined to the uplands now occur in other areas, or if they already occur, they increase in value. In northern Northumberland in this period values for *Artemisia*, Ranunculaceae, Chenopodiaceae, Cruciferae and *Polygonum* increase slightly, all of which were present in the area in the earlier Mesolithic, but in this period these occur at a wider range of sites than before in northern Northumberland. It is likely that, as further south in the region, disturbance indicators spread out from the uplands to occur at a wide range of sites by the later Mesolithic.

In the earlier Neolithic the shrub decline occurring at most sites across the region is accompanied at some sites in northern Northumberland by an increase in herbs, as at some sites in the south-east. This increase in herbs occurs at Akeld Steads and Trickley Wood, where in this period herb levels exceed 40% tdlp. Grass pollen increases markedly at these sites. In this period there is also an increase in *Artemisia* pollen at sites in northern Northumberland and the appearance for the first time in this area of Caryophyllaceae and Leguminosae pollen. Values for Chenopodiaceae, Compositae and *Rumex* also increase further at sites in this area in this period. The trend observed elsewhere, that there is an increase in both the amounts and range of herb types occurring across the region, also can be seen in northern Northumberland. *Cerealia*-type pollen and *Centaurea* also appear for the first time in this period, as elsewhere, occurring at unusually high values of 1% tdlp at Trickley Wood. However, despite the appearance of new types of arable type herb taxa and the appearance of *Cerealia*-type pollen in this period, the agricultural:arable score is very low, and non-arable. This is because there is a proportionally greater increase in *Plantago* and *Rumex* at sites in this period.

As found elsewhere in the region (although to a lesser extent in south east Durham) the decline in herb pollen in the later Neolithic also occurs at sites in northern Northumberland, particularly at Akeld Steads and Trickley Wood where herb values decline to around 20% tdlp and tree pollen values rise sharply to levels above 60% tdlp. Particularly high tree pollen levels are now found at Akeld Steads and at Camp Hill Moss, where tree pollen values are at 83% tdlp. At other sites in northern Northumberland and further south in Northumberland tree values are lower, but accompanied by high levels of Ericaceae.

It is in this later Neolithic period that the distinction found in Northumberland between those sites where clearance is accompanied by an increase in herbs and those where it is accompanied by an increase in Ericaceae, first appears. Grass pollen values fall to very low levels in the north of Northumberland at sites where the tree pollen increases markedly. The values for many other herb taxa also decline. However, in the Tyne Corridor there is a rise in grass pollen values as well as a rise in Ericaceae pollen values. *Artemisia* occurs at far lower levels than before in this area, in particular, and Chenopodiaceae and Compositae disappear from sites in northern Northumberland. Cruciferae also disappears from northern Northumberland but remains present in the Tyne Corridor. Leguminosae and *Plantago* occur at lower values, whilst Ranunculaceae and *Rumex* continue to be the only herb types that remain in any amount at these sites. Pastoral type taxa predominate across the whole of Northumberland, resulting in low index scores, with the exception of Trickley Wood, where arable taxa remain proportionally higher.

In the early Bronze Age, the distinctions between the different sites in Northumberland become more marked. At certain sites in Northumberland, as in the south east of the region, herb pollen levels increase markedly, such as in the Tyne Corridor and further north at Steng Moss. This is accompanied by an increase in the range of herb taxa at these sites. However, in northern Northumberland tree pollen values remain high at Akeld Steads and Camp Hill Moss although there is slight evidence for woodland disturbance. At other sites, Ericaceae values continue to increase from the previous period, so that these sites closely resemble sites in the uplands in other areas of the region. *Plantago* increases at most sites in the region, whether dominated by trees, herbs or Ericaceae. By the Middle Bronze Age the high tree pollen values occurring at some sites in northern Northumberland now fall slightly, with an increase in herb pollen values. Ericaceae values remain very high at the other sites. There is a further rise in *Plantago* in this period to values exceeding 1% tdlp at many sites and *Polygonum* pollen also increases. *Plantago* values also increase markedly at sites further south in Northumberland. These trends continue in the Late Bronze Age and earliest Iron Age period, with high tree levels resembling those in the Derwent and Weardale area continuing at Camp Hill Moss and high Ericaceae values at most other sites in the area. However, the new site of Edlingham that appears in this period has far higher herb pollen levels than at other sites in the area, and resembles sites in the south east of the region far more.

Herb pollen values increase markedly during the Iron Age period at a couple of sites in northern Northumberland, reaching 66% tdlp at Edlingham and 52% tdlp at Akeld Steads, levels only reached elsewhere in the region in the south east. Trees and shrubs drop below 20% tdlp at these sites. At those sites previously dominated by Ericaceae, Ericaceae values continue to increase in this period as tree and shrub levels decline slightly at these sites. Further south, in the Tyne Corridor, trees and shrubs remain on a slightly higher level, with Ericaceae values exceeding 15% tdlp, but not as high as levels further north in Northumberland. Grass pollen values rise at most sites in Northumberland, particularly at those sites with high values for herbs, with the appearance at these sites of higher values of arable type herb taxa, such as Compositae, *Artemisia*, Caryophyllaceae and *Cerealia*-type. *Plantago* values increase at virtually all the sites in the area, with *Plantago*, Ranunculaceae and *Rumex* being the only herb types to occur in any abundance at the Ericaceae dominated sites. As a result, index scores are low for most Ericaceae dominated sites, whilst they rise to 23% at the herb dominated sites.

At some point in the late Iron Age and Roman periods, as observed elsewhere across the region, there is a further rise in herb pollen values at sites in northern Northumberland which already had high herb values, such as at Akeld Steads and Edlingham, where herb pollen values now reach 82% tdlp. There is a marked rise in index scores at such sites, up to 89% at Edlingham. Other sites in the region, however, continue to have high Ericaceae values and low index scores, as *Plantago*, Ranunculaceae and *Rumex* values continue to dominate. Tree and shrub values are very low across the whole region, having declined at those sites where they were formerly still at high levels. Further south, in the Tyne Corridor, tree values fall markedly at Fellend Moss and Fortherley Moss to below 15% from levels previously around 30-50% tdlp. At these sites the value for *Plantago* increases markedly up to 3.6% tdlp, accompanied by a wider range of herb taxa than before. Ericaceae values at these sites rise correspondingly, up to 40% in places. These sites resemble the sites in the uplands of the rest of the region very closely.

Pollen sites in Northumberland therefore fall into three main groups; firstly, those that have very high tree pollen percentages for much of the period under study (and which behave very similarly to sites in the Derwent/Weardale area), secondly sites which tend to have higher herb pollen percentages (and which therefore behave similarly to sites in the south-east of the region), and thirdly sites which tend to have high Ericaceae values (and behave like sites in the uplands of the Northern Pennines). Most of the sites from Northumberland fall into the first group, the tree dominated group, with tree pollen percentages over 50% tdlp, in the period from the Mesolithic to the later Neolithic. In these periods high tree pollen percentages can be found at sites both in the lowlands of northern Northumberland, such as Akeld Steads and Camp Hill Moss, as well as more upland sites in northern Northumberland such as Black Lough and Broad Moss, and further south in the uplands north of the Tyne. However, tree pollen percentages only remain high at Camp Hill Moss and to a lesser extent in the Tyne Corridor, throughout the whole period until the Roman period, when at all these sites high tree pollen values are replaced by high Ericaceae values. At the sites in northern Northumberland at high elevations, initially high tree levels in the Mesolithic and Neolithic are replaced by high Ericaceae values from the early Bronze Age onwards, at Trickley Wood, Broad Moss and Black Lough. At northern Northumberland sites at lower elevations, such as Akeld Steads, Edlingham and Wooler Water, Ericaceae values are very low throughout the whole period, and tree pollen values decline from initially high levels in the Mesolithic and Neolithic to below 50% tdlp in the Bronze Age. By the Iron Age period at these sites herb pollen levels have risen above 50% tdlp and rise even further in the Roman period.

7.5.4 The uplands of the Northern Pennines

In the earlier part of the period under study the highest values for most herb taxa occur in the uplands. However, throughout the Mesolithic and Neolithic these herb types begin to appear at other sites across the region and by the Bronze Age period there is a shift in emphasis in most maps for herbs away from the highest values occurring in the uplands to the highest values occurring in the south-east of the region.

Unlike at other sites in the region during the Mesolithic, in the uplands tree and shrub pollen together do not totally dominate the pollen from sites in this area, and here herb pollen values are higher. If pre-Mesolithic levels from pollen sites in the uplands are examined, it can be seen that upland sites always have higher herbaceous pollen levels compared to other areas of the region, particularly on the more exposed upland tops. It seems, therefore, that the uplands always had, for environmental reasons, more open woodland than other areas of the region, particularly on the more exposed upland tops, and it is not the case that the woodland in the uplands prior to the Mesolithic was dense and unbroken. Shrub pollen (dominated by *Corylus*) is more important than tree pollen in the uplands, with tree pollen rarely exceeding 30% tdlp. Ericaceae values are highest on the upland tops. As elsewhere, *Corylus* values increase through the Mesolithic to its highest levels in the period 6800 - 6300 cal. BC and decline in the period 5500 - 5000 cal. BC although tree values do not recover to such high levels in the uplands as elsewhere, and shrub pollen remains proportionally more important. Throughout the Mesolithic period Ericaceae values increase at upland sites, although the occurrence of Ericaceae remains largely confined to the highest elevations. Certain herb taxa that are good indicators of disturbed and open conditions, including *Artemisia*, Caryophyllaceae and Leguminosae, occur only at the highest elevations in the earlier Mesolithic, but spread to other sites across the uplands by the later Mesolithic. In upper Teesdale, and at lower elevations in the uplands, Ericaceae pollen levels are low, and grass pollen levels correspondingly higher, and this is accompanied by a different suite of herb taxa, including Chenopodiaceae, Compositae, Cruciferae and *Plantago*. By the third Mesolithic period these taxa also occur in areas outside the uplands and also at some sites at higher elevations in the uplands. Through the Mesolithic, therefore, there is an expansion in habitats where these open, disturbed ground type taxa flourish.

During the earlier Neolithic, as elsewhere, shrub values fall at most sites in the uplands, although here the decline is not so marked as in other areas, so that in this period the highest shrub levels across the entire region (20-30% tdlp) can be found in the uplands. At most upland sites in this period there is an increase in Ericaceae from the previous periods, although at a couple of sites in upper Teesdale high herb pollen levels occur. Grass pollen values increase at many sites in the uplands also, and many of the herb taxa previously only occurring in the uplands continue to spread to other areas of the region. Many of the herb taxa formerly confined to the highest elevations also continue to spread, like Ericaceae, across sites in the uplands and also appear for the first time in other areas of the region. Index scores are low for most sites in the uplands, with the exception of high arable scores at a small number of sites in upper Teesdale, where types such as Compositae, Chenopodiaceae and Cruciferae are present, and values for *Plantago* and *Rumex* are lower than elsewhere in the uplands. *Cerealia*-type appears for the first time at a couple of sites. In the later Neolithic period herb pollen levels drop at sites in upper Teesdale, whilst at other sites across the uplands Ericaceae pollen values continue to increase, with values over 30% tdlp occurring at several sites. There is a notable decline in the values for several herb taxa and certain taxa disappear, most notably Compositae, which no longer occurs in upper Teesdale, and values for Cruciferae and Caryophyllaceae also decline. *Plantago*, *Rumex* and Ranunculaceae continue to occur little changed in the uplands.

The increase in Ericaceae that has occurred progressively in each period continues to occur in the early Bronze Age in the uplands, accompanied by a further decline in tree and shrub values to between 20-30% tdlp each. Herb pollen levels drop at many upland sites in this period to below 10% tdlp as Ericaceae values rise, although as before herb levels remain higher in upper Teesdale, rising to 30% tdlp at some sites. With this decline in herb pollen values in the uplands in this period, and the rise in herb pollen values in the south east of the region, there is a major shift in emphasis in the early Bronze Age from the highest herb values being in the uplands of the region to the highest values occurring in the lowlands. In the uplands the range of herb types now decreases so that *Plantago* is the only major herb type present at most sites. *Plantago* increases further at most sites in the uplands in this period. Even in upper Teesdale, the range of herb types present declines from the previous periods, with the disappearance of most arable type herb taxa, leaving Ranunculaceae, *Rumex* and *Plantago* to dominate. Arable type taxa do occur in small values at a small number of sites in upper Teesdale still, such as at Cronkley Pastures and Weelhead Moss and very small amounts of *Cerealia*-type pollen continues to occur. The proportionally greater increase of pastoral type herb taxa, however, results in a very low agricultural: arable index score at most upland sites.

During the middle Bronze Age period at most sites in the uplands there is a further decline in tree values to around 15-30% tdlp, although shrub values remain very similar to the previous period. Ericaceae continue to increase at most sites, reaching 50% tdlp at several sites. Herb pollen values continue to be highest in upper Teesdale, where tree and shrub levels are lower than on the surrounding uplands, and herb pollen values increase further in this period. Here, compared to the previous period, there is an increase in the range of herb taxa; although *Plantago*, Ranunculaceae and *Rumex* continue to dominate at most sites, *Artemisia*, Caryophyllaceae and Chenopodiaceae appear at several sites. The proportionally greater increase in pastoral type herb taxa in this period, however, results in a further drop in index scores at most sites in the uplands, although higher, more arable scores, do continue to exist at some sites in upper Teesdale.

In the late Bronze Age and earliest Iron Age period, tree and shrub levels decline further at several sites in the uplands, accompanied by a further increase in Ericaceae and pastoral types such as *Plantago*, Ranunculaceae and *Rumex*. Herb values continue to increase at sites in upper Teesdale. Index scores continue to remain low across most of the uplands, but scores rise at some sites in upper Teesdale as there is a proportionally greater increase in arable type herb taxa, raising the index to 40% at selected sites. However, even within upper Teesdale there is considerable variation, because at other sites pastoral types increase proportionally more, resulting in a drop in index scores.

In the Iron Age period tree values continue to drop further from previous periods, so that it occurs below 20% tdlp at most sites, and Ericaceae pollen increases even further, exceeding 60% tdlp at a couple of sites. Sites in upper Teesdale continue to have higher herb pollen values and the presence of arable type taxa that do not occur commonly across the rest of the uplands. Interestingly, grass pollen values increase at most sites across the uplands, whether they are dominated by Ericaceae or are herb dominated, in upper Teesdale. As before, *Plantago*, Ranunculaceae and *Rumex* are found at almost every site in the uplands, although there is an increase in arable types at several sites in upper Teesdale, including Caryophyllaceae, Chenopodiaceae, Compositae and *Artemisia*.

Unlike at most other sites in the region, the major decline in tree and shrub levels in the uplands had already occurred in the Late Bronze Age and earliest Iron Age period, rather than in the Late Iron Age and Roman periods. Following this major decline, tree and shrub pollen values continue to lie at low levels between 15-30% tdlp at most sites, but are never at levels as low as those occurring in the south east of the region or in parts of northern Northumberland in this period. Ericaceae values continue to rise even further in this period, up to 70% in places. *Plantago*, Ranunculaceae and *Rumex* continue to occur at virtually all sites in the uplands as the dominant herb taxa and as a result, low scores for the agricultural:arable index continue to occur throughout most of the uplands.

8 Results II:

Combined pollen and archaeological approaches for reconstructing settlement and land-use

This second part of the results section presents results of the combined archaeological and pollen approaches described in Chapter 6. The first approach, the "catchment approach", is used to fill in the gaps in archaeological evidence for settlement and land-use, by identifying areas where pollen evidence indicates activity but archaeological evidence is scant or absent. The second approach, the "interpolation approach", uses pollen interpolation to shed light upon the vegetation most likely to be associated with different types of archaeological site types. This is done by producing a typical "pollen diagram" for each category of archaeological site. The results for both approaches will be presented together for each period. At the end of this chapter the results of the interpolation approach will be looked at in a different way; instead of looking at them period by period, each category of archaeological evidence (for example settlement sites, lithic findspots) will be looked at individually to see how the interpolated pollen values for trees, shrubs, Ericaceae and agricultural: arable scores change over time.

8.1 The Mesolithic

8.1.1 The catchment approach (Fig. 8.1)

The triangular ordination plot for this period shows clearly that most pollen sites are dominated by tree and shrub pollen, as expected for the Mesolithic period, on the basis of the pollen maps for the Mesolithic presented in Chapter 7. Most of the sites with no recorded archaeological activity in their catchments have have high tree and shrub pollen, as would be expected. However, there are still many sites with high tree and shrub pollen that do have recorded archaeological sites within their catchment areas. These sites are concentrated in the uplands and tend to be sites with small amounts of isolated flint finds occurring within openly wooded landscapes dominated by *Corylus*, such as at Arngill Head

Brocks, Bellow Moss, Dufton Moss and Knock Ridge. Although total tree and shrub pollen percentages are high for these sites, there is a high proportion of shrub pollen, which indicates that woodland cover was more open than at first suggested by the high overall tree and shrub percentages.

As herb pollen values rise, indicating more open conditions around pollen core sites, the number of archaeological findspots within the catchments tends to increase. At Dufton Moss, Fox Earth Gill and Howden Moss in Upper Teesdale, higher herb pollen percentages are accompanied by up to thirteen Mesolithic artefact findspots within each catchment. Also, at Moss Mire, very high herb pollen percentages of 86% tdlp accompanied by eight flint findspots suggest that at this site the pollen sampling point may have coincided with a cleared area. However, at Akeld Steads and Coom Rigg, despite high herb pollen percentages and lower tree and shrub values, there are no recorded flint finds, and this could indicate lack of survey, or alternatively the presence of natural clearances. Sites with the highest Ericaceae values in the uplands also all have flint finds within their catchment areas, such as at Knoutberry, John's Burn, James' Hill and Great Eggleshope Beck. These sites tend to be on the exposed upland tops rather than in the valleys, and it is here that *Calluna* pollen levels are highest.

Very few lowland sites have recorded flint finds in their catchments, and this combines with very high tree pollen values, and high overall tree and shrub pollen values. An exception is Mordon Carr, which has five findspots within its catchment and Hartlepool Bay and West Hartlepool 3 which have 3 and 6 findspots respectively. All these sites have very high tree and shrub pollen. It is most likely that at these sites very local dominance of trees and shrubs, and the higher proportion of tree cover in the lowlands as opposed to shrub dominance in the uplands, means that in this period the catchment area of these sites could have been smaller than 100 metres, the smallest catchment area used in this study. The distribution of recorded flint finds in the lowlands is patchy, reflecting strongly the location of field walking and survey projects (such as the traditional concentration of research in the coastal zone and also the location of survey areas in the Durham Archaeological Survey are clearly visible in the distribution map of Mesolithic archaeological sites (Figure 4.3). It is highly likely that the density of flints in the lowlands is far greater than has been previously stated and that the amount of activity in the lowlands in this period has been understated, particularly since this view has been traditionally supported by a picture of high tree cover in the lowlands. The presence of numbers of flint finds in the vicinity of several tree dominated cores in the lowlands suggests that activity in this area was greater than has been traditionally proposed. Due to the nature of the vegetation cover, activity in the lowlands, if it were on the same scale as that in the uplands, would tend to be underrepresented in the pollen rain. In the tree dominated lowlands, compared to the more open, shrub dominated uplands (which still have a high overall tree and shrub percentage, but this is almost entirely made up of *Corylus*), clearances would be less likely to be detected by pollen sites, unless they occurred very close to a pollen core site. An alternative explanation is that the time resolution of sampling levels in many cores from the lowlands are too coarse to pick up short clearance events. However, when compared to upland cores, the time resolution of lowland cores is little different (very few cores have been studied for the Mesolithic period to the fine level of temporal resolution studied at the North Gill cores) and it is unkely that the greater incidence of recorded clearance events in upland cores is due solely to the sample levels from upland cores purely by chance happening to occur at the same time as clearance events.

8.1.2 The pollen interpolation approach (Fig. 8.2, a-e)

Since lithic artefacts dominate the available archaeological evidence for the Mesolithic, it is not possible to compare the interpolated pollen values for lithics with many other types of evidence. Some faunal finds, mostly *Bos* horn, do exist, although sample numbers are so low as to make any comparison with the large numbers of lithic finds of limited value. The mean interpolated tree pollen value (Fig. 8.2, a) for lithic findspots is 55%, whilst for faunal finds it is a much lower 38%. However, the large error bar for lithics suggests that some lithic findspots could have a similar low tree cover as the finds of *Bos* horn, even though on average lithic finds are found in more heavily wooded landscapes. Mean shrub values (Fig. 8.2, b) are lower for lithics than faunal finds, which again suggests a more open landscape for faunal finds compared with the average lithic findspot. As expected, the average faunal findspot has higher herb pollen (Fig. 8.2, c) than the average lithic findspot (16% compared to 10%), and also higher Ericaceae pollen (Fig. 8.2, d) than the average lithic findspot (8% compared to 3%). This is due to the distribution of recorded *Bos* horn findspots in the uplands (Figure 4.3) whilst recorded lithic findspots are concentrated along the coastal region as well as in the dales. This accounts for the wider error bars for the lithic finds. The agricultural:arable index scores (Fig. 8.2, e) would seem to have little relevance for the Mesolithic. However, the higher mean index score for lithics compared to *Bos* horn findspots indicates a higher proportion of "arable-type" taxa, which might suggest a greater predominance of disturbed soils as opposed to grassland types.

8.2 The Neolithic

8.2.1 The catchment approach (Fig. 8.3)

As for the Mesolithic period, the majority of pollen sites in this period have high overall tree and shrub pollen exceeding 50% tdlp, and as expected most sites with no archaeological evidence recorded within their catchments occur in this tree and shrub dominated group. However, there are several sites with high tree and shrub pollen which, contrary to expectation, do have archaeological evidence for the Neolithic in their catchments. These include Steng Moss, with two stone axe finds, Quick Moss with four stone axes, one lithic findspot and a Neolithic burial site and Camp Hill Moss with five stone axes and one lithic findspot dating to the Neolithic. Hartlepool Slake, on the coast, has eleven Neolithic archaeological records, made up of lithics, stone axes and two burial sites. At these sites, high local tree and shrub levels might have filtered out any evidence for clearance, and the catchment areas of these sites in this period was probably smaller than estimated, or clearance in these catchments during the Neolithic was too short lived to be registered in pollen diagrams. As the proportion of trees and shrubs decrease at sites, more pollen sites have recorded archaeological evidence within their catchments, whether the pollen is dominated by herbs or Ericaceae. There are, however, some sites with high herb values with no archaeological evidence. These include the Upper Teesdale site Cronkley Pastures, where herb pollen reaches 86% tdlp, and tree and shrub pollen only makes up 8%, and the Durham lowland sites of Hutton Henry and Bishop Middleham, where herb pollen exceeds 40%. The upland sites at Knoutberry and Trickley Wood in Northumberland have low tree and shrub pollen, and higher herb and Ericaceae values, but no archaeological records in their catchment. This may indicate the local dominance of non-anthropogenic taxa associated with bog or moorland, or alternatively may indicate a gap in archaeological survey.

8.2.2 The pollen interpolation approach (Fig. 8.4, a-e)

Mean values for trees, shrubs, herbs and Ericaceae are very similar between all Neolithic archaeological site types. However, stone circles/ henges do have a slightly higher mean for Ericaceae (15%) and a high herb mean (27%) with the lowest mean tree value (39%). This, in the light of the pollen map for Neolithic archaeological site distributions (Figure 4.4), supports the statement made in Chapter 4 that stone circles are associated with more open conditions in the uplands. Standing stones on average are associated with higher tree and shrub cover (43% and 20%tdlp respectively) than stone circles/ henges and have low mean herb pollen values (16%). This is because as a whole recorded standing stone locations are more common at lower elevations in the east of the region than stone circles/ henges which tend to be located almost exclusively in upland situations in the region (Figure 4.4). The lowest mean scores for the agricultural:arable index are for stone circles/henges (14%) and then forstanding stones (20%), which would fit in with their predominantly upland distribution where "pastoral" types are more dominant. Stone/flint implement and arrowhead findspots have some of the highest mean tree values (43-45%) and shrub values (20-21%), whilst lithic findspots have very slightly lower values for trees (41%) and shrubs (19%). This suggests that stone axes and arrowheads are associated with very slightly higher woodland cover on average than other lithic artefacts. Lithic findspots also have the highest mean agricultural:arable scores of all site types (40%) and arrowheads (41%). The higher tree and shrub percentages interpolated for lithic findspots and high agricultural: arable scores are consistent with their predominantly lowland distribution in the region (Figure 4.4). Stone/flint axe findspots have a slightly lower mean agricultural: arable score (33%). This is consistent with the slightly more upland distribution of stone axes compared to other lithics. There are however large error bars associated with all these mean values, which show that lithic findspots of all types occur in a wide range of different environments across the region.

8.3 The Bronze Age and earliest Iron Age

8.3.1 The catchment approach

a) The early Bronze Age (Fig. 8.5)

The early Bronze Age triangular ordination plot shows that during this period most upland pollen sites see a decline in tree and shrub pollen (to between 40-70% tdlp) and increase in Ericaceae, and that these sites are split into those with no archaeological records in their catchments, and those with archaeological evidence. The majority of sites with archaeological records occur in Upper Teesdale, where survey has been most extensive of the upland areas (Coggins 1986), with the sites particularly rich in archaeological records tending to have the lowest tree and shrub percentages and highest values for Ericaceae. This group includes Dead Crook, Mire Holes, Fox Earth Gill and Weelhead Moss, but also some sites in Northumberland, including Black Lough, Steng Moss and Muckle Moss. Since there are other sites that are very similar in pollen to these, but have no archaeological evidence, it is highly likely that the absence of archaeology at these sites is due to gaps in research rather than lack of activity. These sites include Coom Rigg, Cold Fell, High Banks Moss, Shot Moss and Woldgill Burn, mostly sites on the upland tops. Alternatively, activity was not so great on the upland tops as in the Upper Tees valley, but the tops look as "cleared" as the other sites due to their more exposed, high elevation locations.

The second group of sites are those with very high tree and shrub pollen, and these again divide into those with archaeological evidence in their catchments (such as Camp Hill Moss, Hedleyhope, Lamb Shield and Hartlepool Slake) and those with no archaeological records (such as Neasham Fen, Hallowell Moss, Pow Hill and Cowpen Marsh.) The very high trees and shrubs at these sites most probably means that the catchment areas of these sites was smaller than 100m, and therefore would not pick up any pollen evidence for disturbance or clearance unless it was located very close to the pollen site.

The third group of sites are those with higher herb pollen levels, and lower tree and shrub pollen levels, and all of these have recorded archaeological evidence within their catchments, with the exception of Hutton Henry (which has 80% herb pollen.) These include Cronkley

Pastures, with a cairnfield and open settlement, and a high herb pollen levels of 72% tdlp, Fellend Moss, with field systems and an early Bronze Age monument, and Bishop Middleham with a burial site. The low numbers of archaeological records around these sites seem disproportionately small for their high herb pollen levels, when compared with the site of Wooler Water, however. Here there are 80 archaeological records for the surrounding catchment of this site, and a herb pollen level of only 43% tdlp. This site gives some idea of the potential density of archaeological sites and findspots that might have occurred in other areas with high herb pollen.

b) The middle Bronze Age (Fig. 8.6)

Many pollen sites with high herb pollen in this period do not have any archaeological evidence within their catchment areas. These include Bishop Middleham (with 90% herb pollen), Hutton Henry (79% herbs), and Hartlepool Bay 4 (85% herbs). Of the sites with high herb pollen, only Cronkley Pastures, with one open settlement, and Fellend Moss, with field systems, have any archaeological evidence. It seems likely that the lack of archaeological evidence in these pollen site catchments is a product of lack of survey or differential survival/visibility rather than lack of activity. There are gaps in the distributions of archaeological sites from all periods in these areas which would support this. Most of the upland sites with low tree and shrub pollen (under 50%) and higher Ericaceae values do have archaeological evidence in their catchments for this period, and these are mostly in Upper Teesdale, but also include some Northumberland sites such as Muckle Moss and Steng Moss. The majority of sites with tree and shrub pollen over 50% tdlp have no archaeological sites in their catchments. Considering that many of the sites with tree and shrub pollen over 50% for the previous period, the early Bronze Age, had archaeological sites in their catchments, it seems unlikely that there was no activity around these sites in this period. The exception to this lack of sites is at Dufton Moss, with 22 recorded sites, but a very high tree and shrub pollen value of 85%. This however is mostly made up of open sites, which may have been only occupied during the early Bronze Age, and there are only two solely middle Bronze Age records, of lithics and metalwork. Even so, it is likely that the very high trees and shrubs at Dufton Moss filter out the pollen rain from nearby activity.

c) The late Bronze Age and earliest Iron Age (Fig. 8.7)

Most pollen sites with low tree and shrub percentages (under 50% tdlp) have archaeological evidence within their catchment areas for the late Bronze Age and earliest Iron Age period. Of those sites with high herb pollen, Wooler Water has some 62 archaeological records, mostly made up of curvilinear settlements and enclosed settlements, and Cronkley Pastures in Upper Teesdale has two curvilinear settlements in its catchment. Bishop Middleham and Hutton Henry, as in previous periods, have no archaeological records, and this continued lack of evidence, but very high herb pollen strongly suggests a gap in survey, or preservational/ discovery biases in this area of east Durham. Most sites with tree and shrub pollen levels under 70% and Ericaceae pollen levels over 20% have archaeological sites in their catchments, including most sites in Upper Teesdale, several of which have over 20 records in their catchment area, most of which are curvilinear settlements. Most sites in Northumberland also fit into this group, but with far lower numbers of recorded settlements, due most likely to the lower intensity of survey compared to Upper Teesdale. The exceptions to this, with no archaeological sites recorded, are at Kilhope Law, Knoutberry and High Banks Moss, all upland top sites, where the lower tree and shrub pollen levels and higher Ericaceae values may be a result of elevated, exposed conditions as much as indicating human activity. Pollen sites with tree and shrub levels above 70% tdlp have no archaeological records for their catchment areas, with the exception of Camp Hill Moss, with an enclosed settlement and curvilinear settlement, and Dufton Moss, with 23 nearby sites, mostly curvilinear settlements. It is likely that at both sites there is a very local dominance of trees and shrubs which makes the sites in this period have very small catchment areas which cannot pick up pollen evidence for nearby activity. All other sites in the Wear and Derwent area dominated by high tree and shrub levels have no archaeological records in their catchments, as would be expected.

8.3.2 The pollen interpolation approach

a) The early Bronze Age (Fig. 8.8, a-e)

The interpolated pollen values for early Bronze Age archaeological sites indicate a distinction between cairnfields, field systems and settlement sites (mostly "open" settlements) on the one hand, and pottery, lithic and metalwork findspots and burial sites on the other. Cairnfields, field systems and settlement sites have higher mean Ericaceae values (24-27% tdlp), lower mean herb pollen values (down to 15% for settlement sites), lower mean shrub values (as low as 17%) and tree values lie between 37-39% (higher than pottery or burial sites, but lower than metalwork findspots). Mean agricultural:arable index scores for these sites are lower than other site types, with mean values of 10 and 12% for cairnfields and field systems, and only 9% for settlement sites. Interpreting these interpolated pollen values in the light of the pollen maps for this period in Chapter 7, and the distribution map of archaeological sites for the early Bronze Age, the high Ericaceae values, low shrubs and herbs and intermediate tree values support the picture of a predominantly upland distribution of cairnfields, field systems and open sites.

In comparison, pottery, lithic and metalwork findspots and burial sites have the highest mean agricultural:arable index scores (up to 30% for pottery, around 20% for the other types). Mean Ericaceae values are lower for these sites: at 15% for lithic and metal findspots and between 7-8% for burial sites and pottery findspots. Mean herb values are highest for burial and pottery sites (37 and 39%) and somewhat lower for lithic and metalwork findspots (24% and 19%) Mean shrub values are also higher, rising to 20-22%. Tree values vary; mean tree values are highest for metalwork findspots (44%) and for lithics (39%), but pottery findspots and burial sites have lower mean tree values than other site types (28% and 30%). This supports the pattern observed in Figure 4.5 that the distribution of artefact findspots and burial sites recorded in the database for the early Bronze Age is biased towards lowland locations on the whole, where higher herb pollen values and higher agricultural: arable scores are more common (according to the pollen maps for this period).

This suggests that settlement sites, cairnfields and field systems on average are associated with higher values for blanket bog taxa and grassland types whilst burial sites and pottery finds (which are mostly found in barrow contexts) on average are associated with the greatest evidence for clearance (higher shrubs and herbs and lower trees) and the highest proportions of disturbance indicators. Metalwork and lithic findspots on average occur in more wooded conditions with higher tree pollen values and higher shrub pollen than other site types.

b) The middle Bronze Age (Fig. 8.9, a-e)

The distinction between settlement sites, cairnfields and field systems on the one hand, and pottery, metalwork and lithic findspots on the other continues into this period. Settlement sites, cairnfields and field systems continue to have the highest mean Ericaceae values (20-24%), with mean tree values between 33-34% and mean herb values are the lowest of all site types (24-25%). Mean agricultural:arable index scores are lowest for settlement sites, cairnfields and field systems (12-14%) In comparison, mean agricultural:arable index scores are highest for lithic findspots (37%), pottery findspots (27%) and metalwork findspots. Lithic findspots have the highest mean herb values (41%) (although there is a large amount of variation around this mean) and lowest Ericaceae and tree values (11% and 26%). Metalwork findspots similarly have low mean Ericaceae values (15%) and high herbs (31%) but like the previous period have the highest mean tree value (37%). Therefore as before, cairnfields, field systems and settlement sites are associated with the lowest pollen scores for arable type taxa, the lowest herb pollen values and highest Ericaceae values in more upland locations, whilst artefact findspots are typically found in more lowland locations with higher herb pollen levels and higher agricultural: arable scores.

c) The late Bronze Age and earliest Iron Age (Fig. 8.10, a-e)

The distinction noted for the previous two periods continues into this period. Mean scores for the agricultural:arable index are highest at quern (saddle quern in this period), pottery and metalwork findspots (28%, 24% and 20% respectively) and lower for settlement sites and field systems (16% each). Mean herb values are highest at quern and pottery findspots (up to 35%), and here Ericaceae values are very low (under 1%), accompanied by some of the highest tree and shrub values. In contrast settlement sites have the lowest mean herb values, the highest mean values for Ericaceae and the lowest mean values for trees (although the large error bars indicate that there is considerable variability in vegetation around settlement sites). The fact that these site types now have the highest tree pollen values rather than the settlement sites and field systems, as before, is due to the decline in tree pollen in the uplands associated with the rise in blanket bog taxa. The highest tree and shrub percentages now occur in the lowlands.

8.4 The Iron Age and Roman period (500 cal. BC - cal. AD 500)

8.4.1 The catchment approach

a) The Iron Age period (Fig. 8.11)

As would be expected, the pollen sites with the highest herb pollen percentages for this period, with low trees and low Ericaceae, have archaeological evidence for Iron Age activity within their catchment areas. Wooler Water, a lake site with a large catchment area, has six rectilinear settlements within its catchment, and Hartlepool Bay 4 has one rectilinear site and one Iron Age pottery find. Bishop Middleham has one Iron Age burial within its catchment area. However, there is a group of sites with high herb pollen which do not have any Iron Age archaeological evidence noted within their catchment areas. These sites include Edlingham, Hutton Henry, Akeld Steads and Cronkley Pastures. It is possible that the lack of Iron Age type evidence in their catchments is because sites typically attributed to the Bronze Age, such as curvilinear or open sites, persisted in use in these areas in this period. However there are no records for any Bronze Age type archaeological evidence at these sites either. Another possibility is that the high herb pollen at these sites is accounted for by non-anthropogenic types dominating the local pollen rain (such as sedges and grasses). However, the high amounts of pollen types associated with agriculture rules this out. It is possible that there were no settlement sites within the catchments of these sites, or discard of artefacts, but there was considerable clearance activity in these areas, for agriculture or grazing. These areas would benefit from further archaeological survey.

As expected those pollen sites with the highest woodland cover have no recorded Iron Age archaeological evidence within their catchments. However there are some sites with fairly high tree and shrub pollen values over 50% tdlp, but which do have archaeological sites within their catchments. These include Neasham Fen (73% trees and shrubs) and Dufton Moss. In the case of Dufton Moss it is most likely that the catchment area was smaller than 100m in this period, the minimum size used in this study, and there was a very local dominance of trees and shrubs around each core site which swamped out other pollen types occurring further afield. Eight archaeological sites are recorded within this pollen core's catchment area, and it is most likely the well wooded nature of the site means that any pollen associated with the eight sites in the vicinity did not reach the core site. However, at Neasham Fen, a different explanation is likely. Here, although the site has high overall tree and shrub pollen (73% tdlp), this is in this period mostly made up of shrub pollen, indicating a more open woodland cover. Tree cover opens out temporarily in this period, shrubs increase correspondingly, and the slightly higher herb pollen at this time could well be related to the two rectilinear sites lying within its catchment area.

Most other sites in Upper Teesdale, dominated by high Ericaceae, and low tree and shrub cover, have relatively high amounts of archaeological evidence in their catchments, recorded by the extensive survey by Coggins (1986). However, most of these pollen sites are close together and their open, blanket bog dominated vegetation gives them large, overlapping catchments, which means they share many archaeological sites. Other upland sites with the highest Ericaceae values, however, do not have any recorded archaeological sites. Either this is because there is a local dominance of peat which has more to do with local conditions than human activity, for example at Dead Crook in Upper Teesdale which unlike other nearby sites has no recorded archaeological evidence in this period, or because archaeological sites remain to be found, which may be the case in the Derwent area at Pow Hill and Burnhope Burn.

b) The Roman period (Fig. 8.12)

The triangular ordination plot for the Roman period clearly shows that, as expected from the discussion of the distribution of Roman period sites and findspots in Chapter 4 (Figure 4.9), those pollen sites with the highest amounts of archaeological evidence lie near to Hadrian's Wall, where there are large amounts of recorded turrets, milecastles, forts and other types of "military" evidence. These include Muckle Moss and Fellend Moss, and also Vindolanda. The majority of these sites have high Ericaceae values, as expected from their predominantly upland locations. Those other sites with high amounts of recorded archaeological evidence come from Upper Teesdale, where there are a large number of recorded querns and other artefact finds. However, there are also a lot of other pollen sites with high Ericaceae values which have no recorded archaeological finds, in Northumberland (such as Broad Moss, Trickley Wood) and the Derwent area (Burnhope Burn, Pow Hill). The open upland here could be due to the landscape already having been opened up in previous periods and trees prevented from regeneration owing to waterlogging and blanket peat. However, the large number of finds recorded from Upper Teesdale suggest that this did not prevent activity in all parts of the uplands, so it may be that further archaeological survey is needed in these areas.

Most pollen sites with very high herb pollen values for this period unexpectedly have no recorded archaeological sites. These include Edlingham, Akeld Steads, Bishop Middleham, Hutton Henry, Thorpe Bulmer, Steward Shield Meadow, and Cronkley Pastures in Upper Teesdale. Most of these are lowland sites, with high values for agricultural indicators, and in many cases high values for arable indicators. At most of these sites there is no recorded archaeological evidence for either the Bronze Age, Iron Age or Roman periods. It is likely therefore that the absence of archaeological evidence is due to the absence of survey in these particular areas. Only a few sites with high herb pollen do have archaeological evidence within their catchments; at Mordon Carr where there are four recorded rectilinear sites which might have continued occupation into the Roman period, at Steng Moss, with six rectilinear sites and at Hartlepool Bay where there are two querns recorded for the Roman period.

8.4.2 The interpolation approach

a) The Iron Age period (Fig. 8.13, a-e)

The results for the interpolation of pollen values for Iron Age archaeological site types show that there is a distinction between settlement sites and querns on one hand, and pottery and metalwork findspots and burial sites on the other. Pottery findspots have the highest mean score for the agricultural:arable index (33%), one of the lowest mean tree values (23%) and Ericaceae values (8%), and one of the highest mean herb values (46%). Burial sites have the highest mean herb values (47%), lowest Ericaceae (4%) and lower mean tree and slightly lower mean shrub values than other site types. Metalwork findspots have the lowest mean tree values, low Ericaceae (6%) and high herbs (45%). In comparison, quern findspots and settlement sites have the highest mean tree (31 and 35%) and shrub values (17% for both), lower herb scores (41 and 35%) and highest Ericaceae scores (up to 13%) of all the site types for this period. Mean scores for the agricultural:arable index are lowest for settlement sites (20%) but high for quern findspots (29%). The higher mean Ericaceae values and tree and shrub values for settlement sites and quern findspots is most likely explained by the larger number and wider distribution of recorded rectilinear settlement types and quern findspots, extending into the uplands, when compared to the smaller numbers of entries for pottery, metalwork and burial sites in the database.

b) The Roman period (Fig. 8.14, a-e)

Site types divide into "military" sites on the one hand and "settlement" sites, roads and quern findspots on the other in terms of their interpolated pollen values. "Military" sites such as camps and fortlets have low mean tree values (17%), slightly higher for milecastles, signal towers and turrets (18%). There is very little variation around the mean for milecastles, signal towers and turrets, whilst there is greater variation around the mean for forts/ fortlets and camps. Military sites have the highest mean Ericaceae values (27% for camps, 25% for forts/fortlets, 23% for signal towers, slightly lower for milecastles and turrets (21%), with a greater variation for milecastles, turrets and forts/fortlets. Mean herb values for military sites lie between 48-51%, with the greatest variation being for milecastles, turrets and forts/fortlets. Military sites have some of the lowest mean scores for the agricultural:arable index (18% for camps, rising to 24% for forts/fortlets). The greater variation around the mean for tree values for camps and forts is probably due to their wider distribution across the region, compared to milecastles and turrets, which are confined to the Hadrian's Wall area (as shown in Figure 4.9, which shows the distribution of Roman period sites entered in the database across north east England). The low average tree and shrub values for military sites and low agricultural:arable scores reflect their predominantly upland distributions (Figure 4.9).

Settlement sites (mostly rectilinear) have lower mean tree values than military sites (16%), although mean shrub value very similar to other site types (8%). Mean herb values are higher (53%) and Ericaceae values slightly lower than military sites (21%). The mean agricultural:arable index score is higher than any other site type (28%) except roads (also 28%). The wide variation around the mean for settlement sites suggests that they are found in a wide range of environments, although the lower mean Ericaceae values and higher mean herb values than military sites suggests that on average rectilinear sites are located at lower elevations. This is supported by Figure 4.9 which shows that on the whole rectilinear settlement sites do occur in the lowlands and main valleys of the region, compared to military sites which are found across the uplands. This is also supported by comparing the mean elevations of rectilinear settlement sites with military sites. This information was gained by using Arc/Info to extract elevations for all military and rectilinear site locations from the digital terrain model (TIN) constructed as part of the map making process discussed in Chapter 5. Contrary to what would be expected for quern findspots, that they would have the most "arable" scores, the highest herb values and lowest tree and shrub values, it is interesting to discover that mean agricultural:arable index scores for querns are no more "arable" than other site types. This is probably due to the restricted sample of Roman period quern findspots used in this study from areas where woodland cover remains slightly higher, and herb pollen levels lower. A typical area from which quern findspots have been entered into the database is in the Tees lowlands between the East Durham plateau and the river, which is the only type of area in this period not to undergo extensive clearance. In addition, the presence of querns need not necessarily imply the cultivation of cereals at these locations, only the processing of cereals for consumption, and it may be the case that grain was transported from arable areas for use in other areas of the region such as the Tees lowlands where tree cover remained greater and pastoral scores remained higher.

9 Discussion:

Settlement and Land-use in North-east England from the Mesolithic to the end of the Roman period.

In this chapter the implications of the results described in the previous chapters for existing views in the archaeological and palynological literature about the past settlement and land-use of the north-east of England will be discussed.

9.1 Settlement and land-use during the Mesolithic

The commonly held view of Mesolithic activity portrayed in the pollen literature is that forest clearance was primarily carried out to promote the growth of leaf browse to attract cattle and other herbivores, and clearances were mostly small-scale and short-term and created by burning (Jacobi *et al.* 1976; Mellars 1976, Simmons 1969). This type of activity is held to have occurred mostly in the uplands, where woodland cover was more open, compared to the more heavily wooded, tree dominated lowlands, where activity is traditionally held to have been minimal, with the exception of the coastal strip. The various elements of this traditional Mesolithic land-use hypothesis will be considered in turn in the light of the results presented in Chapter 7.

This traditionally-held Mesolithic land-use hypothesis would at first glance appear to be supported by the pollen map results which show open woodland in the uplands, dominated by shrubs, with peaks of light-demanding herb types and disturbance indicators, as opposed to the more heavily wooded, tree dominated lowland woodlands which persist throughout the Mesolithic with little evidence of breaks in the woodland cover. However, when looked at in more detail, there is evidence to suggest that there is considerable variation between sites in the type of clearance, and the nature of vegetation occurring in clearances, as well as duration of clearance and methods of clearance used. The traditionally assumed function of clearance, for the creation of browse to attract herbivores, will also be critically examined.

9.1.1 Function of clearances

It is commonly assumed that woodland clearances, when created by human activity rather than occurring naturally, were created primarily for the purpose of attracting herbivores through the creation of shrub browse, in order to localize herds for improved hunting. However, this hypothesis overlooks a wide range of other possible uses for clearances. Firstly the degree of control and management of animal and plant resources in the Mesolithic may have been greater than suggested by traditional hunting and gathering hypotheses. Clearances may have been created to encourage growth of edible plants, or for the long-term intensive grazing of partly controlled herds. Additionally, clearances could be created for the purposes of settlement or by trackways. There has been little attempt to consider the implications of the different possible functions of clearances for the pollen record, firstly in terms of duration of clearances, and secondly in terms of the types of taxa that will occur. Williams (1985) has divided clearance events at sites during the Mesolithic into several types: short clearance events for the grazing of herbivores for shrub and leaf browse, and longer-term clearances for trackways, settlement, encouragement of shrub growth for nuts or timber, or for edible plants, or for intensive grazing. In the first type of clearance there is an increase in shrubs, mostly *Corylus*, and light demanding trees, plus an increase in light demanding herbs and disturbance indicators (the majority of clearance events).

For longer duration clearances there would be in most cases a decline in shrubs and light demanding trees, and an increase in grass and disturbance indicators. In the case of settlement nitrophilous plants such as *Urtica* may be encouraged. The clearance of trees and shrubs would also encourage the proliferation of many edible herbaceous types. Trackways would tend to be dominated by types resistant to trampling. Williams has argued that maintenance of long-term clearances for herbivores would be unlikely unless some form of confinement were practised, or the animals were controlled in some way. This is because grass, which would dominate in the clearance, is on the whole less palatable than leaf and shrub browse, and animals would preferentially move out of the area. However, it will be argued that confinement is unnecessary, because clearances with declines in shrubs are a very rare phenomenon in the Mesolithic, not yet found in the pollen of north-east England, or in the North York Moors and only noted on one occasion at Williams' pollen site at Soyland Moor in the central Pennines. Long term clearance events do occur, but they are very different in nature to those proposed by Williams.

9.1.2 Duration of clearances

The duration of clearance events is difficult to ascertain, even when radiocarbon dating is plentiful. At most sites in north-east England sampling intervals are too broad to be able to distinguish many small individual clearance episodes from one longer clearance event, and radiocarbon dates are sparse. However, in the North York Moors, where sampling intervals are finer, it can be ascertained that the majority of clearance events were fairly short. At Ewe Crag Slack (Jones 1978), West House Moss (Jones 1976 b) and Glaisdale Moor (Simmons and Cundill 1974 a) clearances appear to be quite short, and also *Corylus* values do not decline. At Bonfield Gill Head (Simmons and Innes 1981) there are also repeated short clearances. However, without radiocarbon dates it is impossible to tell whether the pollen evidence is compressed due to slow peat growth.

At the closely dated North Gill sites in the North York Moors, in comparison, disturbances vary quite considerably in duration, even allowing for quite a large error in radiocarbon dates. Here there are both long as well as short term clearances. Disturbance events vary in length from less than a decade to several hundred years or more (Turner *et al.* 1993). However, unlike Williams' suggestions, in the longer clearances here shrubs do not decline. Throughout the period of clearance shrub levels are maintained at high levels. Turner *et al.* state that the grassy ground flora of the clearances would be most likely maintained by regular lopping of trees, by leaf-shredding, pollarding or coppicing, and by burning of the ground vegetation. They argue that such situations would provide an attractive grazing opportunity for herbivores without the need for confinement, since lopping would create an abundance of newly sprouted leaf shoots. Clearances would be especially attractive if they contained a spring, where the animals could drink. The maintenance of such clearances would be part of the hunting strategy to increase the carrying capacity of the landscape, and localise herbivores in specific places.

9.1.3 Evidence for burning

The occurrence of charcoal in soil and peat profiles has been used as a major source of evidence for the use of fire to clear woodland (Patterson et al. 1987). Charcoal has been identified from pollen cores at many upland sites in the North York Moors and Central Pennines, although not in the north-east due to lack of sampling, and has led pollen workers to propose that burning played an important role in creation of clearances in these areas (Jacobi *et al.* 1976; Simmons and Innes 1985). The occurrence of several herb taxa would be promoted if fire were used to create clearances. *Melampyrum* is often associated with burning, and occurs in the early phases of clearance in the North York Moor sites. Herb taxa such as Leguminosae, Chenopodiaceae, Compositae, *Potentilla* and *Urtica* would be encouraged, and after a short period, *Corylus* would invade the clearances. At North Gill, charcoal is repeatedly found in levels where the pollen data indicate a woodland disturbance, and sometimes this is accompanied by an increase in minerogenic material, implying some degree of soil disturbance.

The idea that fire was used to create and maintain clearances in the Mesolithic is generally accepted in the literature, to temporarily increase the amount of nutrients in the soil, increase the amount of light to the clearing, and stimulate new growth of understorey herbs and shrubs. Selective burning is a traditional method of environmental management practiced by hunters and gatherers and pastoralists in many parts of the world (Mellars 1976). However, as Turner *et al.* (1983) have suggested, burning is not the only feasible way to clear vegetation, and it may only have been one component in woodland clearance. Ring-barking, lopping and felling could all also have been used, and would be particularly useful to maintain shrub growth in longer term clearances, as discussed above. This might help explain those instances of clearance where no charcoal has been found. The lack of charcoal at lowland sites has been used to suggest that different methods of forest clearance than burning were carried out in the lowlands, or that clearance was on a much lower scale altogether. Of course, the lack of charcoal at lowland sites might be due the lack of studies concerning Mesolithic activity in the lowlands. However, in the Craven lowlands in Yorkshire, despite searching for charcoal, none was found, unlike in the Craven uplands (Bartley *et al.* 1990). The lack of burning evidence might suggest that clearance was not carried out in the more densely wooded lowlands by burning, but by other means, such as lopping, ring-barking or felling of trees. Mature trees would require considerable and repeated firing to clear, and burning would be more suited to the clearance of more open, shrub dominated woodland. Burning would also be useful for the clearance of trees already killed by ring-barking.

9.1.4 Spatial extent of clearances

Like the issue of duration of clearances, another important question, the spatial extent of clearances, can only be addressed at certain sites, ideally where there are several sites in a close area, where large clearances will be picked up by more than one pollen core, and small ones about the size of pollen catchment areas only by individual cores. This technique of using several closely spaced cores to investigate the spatial extent of disturbances has been termed the "Three -dimensional" approach (Turner 1975) At North Gill, it appears that individual disturbance events were confined to individual sites, and on the basis of their small catchment area, are likely to have been under one hundred rather than several hundreds of metres in size. Mellars (1976) has argued that if clearances were created to attract herbivores, then the ideal size of clearance would not be too large, ideally being around 200-250m maximum in diameter. If too large, herbivores would avoid the centre as being too far from cover, and if too small, the proximity of cover would make hunting too difficult. Clearances would either be for habitation or for encouraging the growth of vegetable resources, or for herbivores, as animals would tend to avoid areas near to human habitation.

9.1.5 Mesolithic activity in the lowlands

From the pollen evidence alone a picture is produced of activity predominantly occurring in the uplands, where most evidence of woodland disturbance has been noted, and where woodland cover is more open. The lack of disturbance events at most lowland sites and the almost total dominance of tree and shrub pollen, would seem to suggest that woodland clearance was less widespread here. This would certainly seem to support at first glance traditional views that Mesolithic activity did not penetrate dense woodland across the lowlands, instead concentrating upon the coastline, or upon more open uplands. However, for the first two Mesolithic periods studied here, 7800-7300 cal. BC and 6800 - 6300 cal. BC, shrub pollen is as high in the lowlands of the south-east of the region and at sites in northern Northumberland as at sites in the uplands, although herb pollen levels are far lower than in the uplands. The only area dominated by tree pollen is the area around the Wear and upper Derwent in these periods. It is only in the final period, 5500 - 5000 cal. BC, that this shrub pollen is replaced by tree pollen, which dominates the pollen record of all lowland sites by the later Mesolithic. Therefore in the earlier periods of the Mesolithic the hypothesis that woodland cover was heavy in the lowlands does not stand up; woodland cover appears to have been made up of shrubs. However, this shrub cover appears to have been continuous, with little evidence for open ground. There are very few indications of instability in woodland cover in the lowlands for the Mesolithic, although evidence for disturbance does increase in the third period, 5500 - 5000 cal. BC, when disturbance and light-demanding herb indicator taxa appear in greater amounts in the lowlands, whereas in previous periods they were largely confined to the uplands. These peaks in disturbance indicators are, however, small and there is little change in the tree and shrub pollen curves until pollen levels immediately prior to the *Ulmus*-decline, when there is an increase in many pollen taxa indicating woodland disturbance, an increase in shrub pollen and decline in tree pollen values at many sites in the lowlands. Similarly in northern Northumberland tree and shrub pollen makes up virtually all pollen at sites in this area throughout the Mesolithic, and it is only in the period 5500 - 5000 cal. BC that the occurrence and values of disturbance indicator types increase, whereas before only a small range of herb taxa had been present.

The lack of noted woodland disturbances might just be a product of pollen site location; owing to the greater woodland cover, catchments of pollen sites would be smaller, and disturbances would only be picked up if they were very close to the core site. This is supported by the archaeological evidence. The results of the catchment approach show that no Mesolithic archaeological evidence is recorded in the catchments of Bishop Middleham, Hutton Henry, Neasham Fen or Cranberry Bog, all of which have little evidence for woodland disturbance in the Mesolithic. However, absence of pollen evidence for disturbance need not mean that there was no activity in the lowlands and the lack of archaeological evidence at these sites could indicate a lack of survey in these areas. These sites have a lack of archaeological evidence within their catchment areas for other periods also, which does seem to suggest that the lack of evidence is due to a lack of fieldwork in the particular areas around these sites. Although fieldwalking projects have been carried out in the Durham lowlands, for example the Durham Archaeological Survey (Haselgrove *et al.*

1988), the location of survey areas unfortunately has not coincided with these particular pollen sites. The high number of Mesolithic archaeological records for nearby Mordon Carr - five lithic finds, despite the dominance of arboreal pollen here, supports this conclusion that lack of pollen evidence for disturbance does not necessarily mean lack of activity in the lowlands. Instead, the high tree cover around the available pollen core sites means that any activity is less likely to be picked up than at upland sites, which are more open and have larger catchment areas.

Pollen sites on the coast consistently have flint finds recorded in their catchments, with three recorded at Hartlepool Bay 4, six at West Hartlepool 3 and one at West Hartlepool 19. At first sight this would seem to support traditional views of Mesolithic activity being confined to the coastlines. However, this might just be a product of concentration of research and survey along the coastline. Where fieldwalking has been carried out further inland, similar densities of flint finds have been found (Haselgrove and Healey 1992).

To summarise, evidence for woodland disturbance from pollen diagrams for the Mesolithic is greatest in the uplands of the region, where herb pollen values are always at their highest and shrub pollen always dominates over tree pollen. The pollen of many herb pollen taxa which are good indicators of disturbance only occur in the earliest periods in the uplands of the region. In these earliest periods many areas of the lowlands also have high shrub pollen values but very low herb pollen values, and together trees and shrubs make up virtually all the pollen at sites in these areas. The range of herb types present at lowland sites in the earlier periods of the Mesolithic is also very low. Throughout the periods 7800-7300 cal. BC and 6800-6300 cal. BC there is a spread across the uplands of disturbance indicators. To start of with these mostly only occurred at the highest elevations, where tree and shrub cover was the most open and conditions the most exposed and disturbed. However, by 6800-6300 cal. BC they had spread to sites at lower elevations and by 5500-5000 cal. BC many of these disturbance indicators had appeared at lowland sites both in south-east Durham and northern Northumberland. The period 5500-5000 cal. BC is the first period with any evidence for woodland disturbance at lowland sites from the region, with the appearance of these disturbance indicators, but never on the scale as that found in the uplands. Tree and shrub pollen continues to dominate at most lowland sites and rises in disturbance indicators are small and temporary, little affecting the tree and shrub cover. It is not until the period immediately prior to the Ulmus-decline that tree and shrub cover appears to have been affected in the lowlands, and disturbance indicators occur in any great amount. However, the amount of woodland disturbance in the lowlands may have been underestimated owing to the high tree and shrub pollen values at most lowland sites. Since there are far fewer available pollen sites in the lowlands compared to the uplands for the Mesolithic, it is possible that they just happened to miss out on those areas where disturbance occurred, or the pollen core sites are located in areas which tended to be highly wooded and which would block out any pollen associated with disturbance from elsewhere.

9.2 Settlement and land-use during the Neolithic

9.2.1 The earlier Neolithic

The rise in herb taxa associated with clearance in levels immediately preceding and around the *Ulmus*-decline is a much discussed phenomenon noted at many sites across Britain. Those theories attributing the *Ulmus*-decline, at least in part, to human activity will be discussed briefly here, since they have relevance to land-use in the Neolithic. However, before reviewing the anthropogenic theories for the *Ulmus* decline, it is important to review the range of non-anthropogenic theories proposed to account for this phenomenon. Sudden declines in pollen taxa may be a result of climatic change or changes in competetive interactions between taxa. However, they can also be associated with the outbreak of disease.Following the outbreak of Dutch elm disease in north-west Europe from the 1960s (Rackham 1980) the disease hypothesis found increasing favour (Watts 1961; Huntley and Birks 1983) and similarly the recent decline of chestnut in the United States caused by a pathogen has been used as an analogy for the Neolithic by Davis (1981 b). Other sudden declines in tree taxa have also been interpreted in terms of disease, such as for example the decline in *Tsuga* in north-east of the United States (Allison *et al.* 1986).

A particularly convincing argument to account for the *Ulmus* decline in Britain proposes that a fungal disease was spread by a beetle species *Scolytus scolytus*, the elm-bark beetle (Girling and Greig 1985; Perry and Moore 1987). The disease hypothesis has gained support from the consideration that human activity alone is unlikely to have been responsible for the *Ulmus* decline; purely anthropogenic interpretations have proposed that the *Ulmus* decline resulted from the destruction of trees to clear the land, or grazing and removal of foliage for livestock fodder, or a combination of both (Iversen 1941; Troels-Smith 1960). However Rowley-Conwy (1982) has ruled out a purely anthropogenic explanation on the basis of scale; that impossibly high numbers of livestock are implied for the early Neolithic if the *Ulmus* decline is to be accounted for solely by the removal of foliage for fodder. Rackham (1980) has similarly calculated that "..a population much larger and more elm-centred than any archaeologist has hitherto proposed" (266) would be required to account for the scale of the *Ulmus* decline.

The non-synchronicity of timing of the *Ulmus* decline at different pollen sites, even within a small area (Turner *et al.* 1993), has been used to argue against purely climatic explanations (Young 1989), and to support both the anthropogenic and disease hypotheses, or a combination of both (whereby human activity promotes the spread of the disease or decreases the ability of elms to resist the disease). The *Ulmus* decline has been radiocarbon dated at a large number of sites. Even allowing for errors in the radiocarbon dates, the *Ulmus*-decline is clearly earlier in the east of the region than in the uplands. Another point in favour of human activity and disease hypothesis is that apart from *Ulmus* and *Tilia*, there was very little effect upon the composition of the forest in this period. However, it is unlikely that any one "prime mover", whether climate, disease or human activity, was solely responsible for the *Ulmus* decline phenomenon. Instead the timing of the event and severity of the *Ulmus* decline, or indeed the number of *Ulmus* declines that occurred at a single site (more than one *Ulmus* decline has been noted at several pollen sites, for example in County Tyrone in Northern Ireland, Hirons and Edwards 1986), is related to a complex group of factors, including local climatic conditions, soil type, local topography, and is further complicated by the possibility of human activity affecting woodland extent and woodland composition.

A number of archaeologists discussing the *Ulmus* decline phenomenon have linked evidence for the decline with the distribution patterns of stone axes, and therefore interpreted the decline in terms of initial woodland clearance in the early Neolithic for agriculture or to promote grazing for livestock. This is an interesting possibility, although it may actually be the case that human activity promoted the spread of elm disease and that other factors such as climate, topography and soils resulted in elm being unable to survive in environments which were already marginal to its growth in the uplands. Hence, the appearance of stone axes, if this does indicate early Neolithic clearance activity, could very well have heralded the demise of the elm in many upland areas. Bradley (1972) discussing the nature of Neolithic land-use in Cumbria has noted that local evidence for the *Ulmus* decline is accompanied at many pollen sites by the occurrence of isolated stone axes. He argues this "..would at least be consistent with the thinning of the tree cover and lopping of leaf fodder well beyond the limit of domestic settlement" (p 200).

Young (1989) has interpreted the localised *Ulmus*-decline, and the occurrence of stone axes in the uplands, as an indicator of the spread of early agriculture into the uplands. He has argued that it is consistent with the idea of "the moving frontier" (Alexander 1977) that may have existed between farming groups and hunter-gatherers. It would also be consistent with Zvelebil and Rowley-Conwy's (1986) "Availability and Substitution" phases of the farmer/forager frontier. According to this model the adoption of farming by hunter-gatherers was a gradual process over a contact zone with farmers. In the initial "availability" phase, the hunter-gatherers would have the option of pursuing agriculture, but may choose not to. If they do choose agriculture, there follows a "substitution" phase where agriculture is substituted for hunting and gathering. The final phase, the "consolidation" phase, begins once the local environment is altered through clearance, and with this stage, the "frontier" moves on. The occurrence of stone axes is interpreted as indicating initial exploratory activity by farmers. Since the majority of provenanced axes in Weardale come from the fell tops and upper valley slopes over 300 metres, it is possible that axes were used to thin out tree cover away from the main areas of settlement, as part of a strategy of increased commitment to agriculture in the uplands (Young 1988). Although distribution patterns of artefacts have to be interpreted with caution, it is interesting to note that the upland distribution of axes is in contrast to the distribution of Neolithic flint scatters, which are confined to the valley bottoms and lowlands. It is argued that these may indicate settlement areas, whilst the axes indicate exploratory activity in upland woodlands.

This interpretation fits in well with White and Modjeska's (1978) work on stone axe deposition in New Guinea, which suggests that most stone axes would be deposited in gardens and forests as opposed to settlements and trade routes. This argument is explained in more detail in Young (1994). This interpretation of stone axe distribution in terms of initial clearance for agricultural activity provides a fresh perspective compared to traditional explanations of stone axe distributions marking hypothetical trade routes. However, in the light of the *Ulmus* decline, even if stone axes were being traded or exchanged, rather than their point of discard indicating woodland clearance, the spread of elm disease could still have been facilitated by human activity in these areas.

The increased levels of pollen types associated with clearance, including many agricultural-indicator types at many sites in the early Neolithic has commonly been interpreted as indicating the presence of early agriculture. The predominance at most sites of pollen of pastoral-type taxa plus an increase in the occurrence of arable-type pollen taxa, including the appearance of *Cerealia*-type pollen at several sites, could be used to suggest a mixed agricultural economy. However, as discussed in Chapter 5, the importance of arable agriculture in the economy is difficult to ascertain from pollen evidence alone, and may be underestimated if pollen sites happen to be located away from areas of arable activity, and also due to poor pollen production and dispersal of *Cerealia*-type pollen. Problems with identifying *Cerealia*-type pollen, contamination problems, problems with its underrepresentation in the pollen record owing to poor pollen production and dispersal, and the implications of these problems for identifying early arable activity have been reviewed in Edwards (1989).

Despite these problems, it is interesting to note that an increasingly large number of *Cerealia*-type pollen grains have been recovered from pre-*Ulmus* decline deposits (Edwards and Hirons 1984). Edwards (1989) has mapped the occurrence of *Cerealia*-type pollen at 22 pollen sites from across Britain and Ireland from pre-*Ulmus* decline deposits, including at North Gill IA in the North York Moors (Simmons and Innes 1987). No cereal-type pollen has as yet been recorded in these early levels at any site from north-east England unfortunately. However, since most cereal pollen is identified without using any rigorous pre-defined criteria, and pollen analysts tend not to expect to find cereals in pre-*Ulmus* decline levels, the lack of cereal pollen should not necessarily be seen as indicating lack of cereal cultivation in this early period. The occurrence of cereal-type pollen in pre-*Ulmus* decline levels is supported by the notable increase in disturbance indicators already noted above as occurring in pre-*Ulmus* decline levels at many pollen sites in north-east England, including many arable-type herb pollen taxa. Such supporting evidence from a whole range of other pollen taxa is valuable to lend credence to claims for early cereal-type pollen:

"If the presence of cereal-type pollen grains with all the associated uncertainties represents our most convincing single piece of evidence for possible cultivation, then a suite of appropriate weed flora in the pollen spectra..will lend strong support." (Edwards 1989 122)

It is therefore likely that the appearance of cereal at sites across Britain is parallelled in the north-east by a rise in arable type herb taxa, and that more careful examination of pre-*Ulmus* decline levels in future may indeed reveal cereal pollen. Cereal-type pollen is already present at several sites from north-east England from post-*Ulmus* decline early Neolithic levels, as has been noted in Chapter 7.

Archaeological evidence for early Neolithic agricultural activity is virtually absent from the north-east, owing to preservational problems for faunal and botanical remains and the lack of settlement sites. Evidence from elsewhere in Britain suggests that there was a mixed economy of wheat and barley cultivation with cattle, ovicaprids and pigs, supplemented by hunting (Chappell 1987), although the applicability of evidence from southern England to north-east England is questionable. Certainly cereal-type pollen is present at five sites from north-east England for the earlier Neolithic mapping period 3800-3300 cal. BC, ranging from sites in upper Teesdale to sites in northern Northumberland and lowland Durham and Cleveland. However, the majority of sites have a low, pastoral, index score, with the exception of a small number of sites in upper Teesdale and on the coast (and here on the coast the occurrence of arable type herb taxa can be explained away as indicating the occurrence of naturally occurring Chenopodiaceae and Compositae in coastal plant communities). These pastoral scores are due to the large increase in *Plantago* and *Rumex* pollen noted at many sites in this period; in fact pollen values for both pastoral and arable types increase in this period, it is just that pollen of pastoral types increases proportionally more, thus resulting in misleadingly low index scores. The rise in *Plantago* and *Rumex* suggests an increase across the region in open grassland conditions, although the occurrence of cereal and arable-type indicators suggests some disturbed ground which could indicate cultivation. This is consistent with the hypothesis of mixed farming proposed for southern Britain, and suggests that this might also have been the case in the north-east. In the absence of early Neolithic carbonised seed assemblages it is unfortunately not possible to tell whether the crops grown in the north-east in this period were different to those grown in the south.

A number of theories about early Neolithic society in the archaeological literature have implications for early Neolithic land-use. Bradley (1978 a) and Bradley and Hodder (1979) argue that over the course of the early Neolithic there was over-exploitation of the soils most suited for agriculture, resulting in declining soil fertility and reduced yields, which may have been accompanied by increased competition over good agricultural land. This explanation is proposed to account for the appearance of Neolithic monumental mortuary facilities, including earthen long barrows, round barrows and megalithic tombs. It is argued that the existence of mortuary facilities indicates a need by locally based lineages to reinforce their rights to use the resources in their territories, by marking their territories with barrows and tombs. Their existence therefore is used to indicate some degree of population pressure and stress on resources, and that populations were having to operate in a "..heavily used and radically altered landscape.." (Bradley and Hodder 1979). The appearance of causewayed enclosures is also explained in this way by Bradley and Hodder, although other workers see them as evidence of more supra-local integration, acting as foci for social, political, economic, religious and defensive activities for people normally living in dispersed settlements (Renfrew 1973).

The applicability of these theories for north-east England, however, must be questioned, owing to the paucity of definitely identified causewayed enclosures, unlike southern England, and the small number of definite Neolithic mortuary facilities in the region. However, as is suggested by these theories, there is some evidence to suggest that soils in the north-east that are best suited for agriculture were exploited preferentially in the early Neolithic. Firstly, if the *Ulmus*-decline is to be seen as evidence for a first "wave" of agriculture across the region, then the earliest dates occur in south-east Durham, which has some of the best soils for agriculture in the region, rather than in the uplands. Secondly, those sites with the highest herb values and most continuous evidence of clearance activity occur on the limestone of East Durham, at Bishop Middleham and Hutton Henry. This is supported by other lowland pollen sites from the north of England. At Eshton Tarn, on the limestone, in the Craven lowlands, Bartley *et al.* (1990) note that there are a series of small scale clearances in the Neolithic, culminating in the appearance of *Cerealia*-type pollen, whilst at White Moss, on the heavier clays, the pollen record is dominated by woodland with limited evidence for woodland disturbance. An analogy can be drawn between this site and Neasham Fen on the clay lowlands of the Tees, and with Hallowell Moss in the Wear lowlands, and sites on the Millstone Grit uplands around the Derwent, where tree values remain very high throughout the Neolithic. Similarly in the dales, in Upper Teesdale sites have far higher herb values than on the surrounding fell tops, and it is possible that the more sheltered limestone soils were preferred for early agricultural activity compared to the higher, more exposed and increasingly peat covered fell tops and sides.

9.2.2 The later Neolithic

The subsequent decline in herb values, with an increase in shrub and tree values at some sites, dating to around the early - middle of the third millenium cal. BC has been shown to occur at many sites in north-east England. This phenomenon has been noted at other pollen sites and in molluscan analyses from southern England. At these sites, a number of clearances which had been open for some time, now reverted back to woodland or forest, and new clearances were not immediately created to take their place (Bradley 1978a, b; Whittle 1978, 1980). In addition, values for arable-type taxa decline or disappear at many sites. Bradley (1978 a) has show how the regeneration of earlier Neolithic clearances matches the final stages of use of causewayed enclosures and Neolithic burial monuments, by comparing radiocarbon dates. From this he has suggested that the decline in enclosures and barrows was accompanied by a phase of less intensive land-use. This change is seen to have been less pronounced in lowland areas, such as in Wessex, which remained more open, although even here pollen evidence shows that there was a decline in intensity with which clearances were used and a shift in emphasis towards more "pastoral-type" herb taxa.

It is argued that this decline in clearance and drop in intensity of land-use was accompanied by a shift to a more extensive type of land-use, exploiting a more diverse range of resources. This is supported by archaeological evidence - unfortunately none of which is available for the north-east - suggesting a widening of the subsistence base. The few faunal reports available for this phase suggest an increase in animals found in wooded environments. Elsewhere in Britain there is archaeological evidence that indicates settlement began to spread on to secondary soils, and environments that had been little used in the earlier Neolithic, including uplands, heathlands and moorlands, fenlands and along the coast (Bradley 1978 a; Bradley and Hodder 1979). This evidence has been used to suggest a shift away from the proposed early Neolithic reliance upon cereals and towards the use of a wider variety of resources, some of which were only seasonally available. The discovery of restricted lithic tool kits on sites from this phase could suggest specialised use of sites, and the reworking of patinated flint may suggest intermittent, temporary use of these sites.

In many ways the type of land-use suggested by this evidence recalls that proposed for the Mesolithic period. Indeed, one common interpretation of this evidence has been in terms of a "Secondary Neolithic" when a Mesolithic element in the population made an impact upon farming communities. However, Bradley (1978 a) has suggested an alternative explanation, connected to the disappearance of large scale public monuments such as causewayed enclosures and burial mounds. The shift to reliance upon resources which might only be seasonally available and restricted to certain areas, plus the appearance of less spatially-restricted pottery styles suggest greater mobility or greater contact between groups. It is possible that the increased reliance upon more varied and risky resources encouraged greater contact for exchange. During this period of the Neolithic there is also evidence for an increase in the volume and area over which stone axes were exchanged (Chappell 1987). The need for contact between groups exploiting different resources has even been proposed to account for the appearance of henge monuments and stone circles in this period in some parts of Britain. Burl (1976) has suggested that both henges and stone circles were used for the exchange of stone axes and as foci for communal activities.

Bradley (1978 a) is cautious in proposing one single stimulus for this change, but suggests that several factors might have checked early Neolithic agriculture, including climatic change, declining soil fertility, and perhaps disease or adverse harvests. Factors such as these might have posed threats to the stability of early agriculture. Bradley and Hodder (1979) have suggested these changes took place as a result of increasing stress upon the subsistence system of the earlier Neolithic (Bradley and Hodder 1979). In the earlier Neolithic it is argued that causewayed enclosures and burial mounds served an important purpose by symbolically marking territories. This became necessary as pressure on good agricultural land increased. It is argued that further increasing stress on agricultural land precipitated the changes in the later Neolithic. The movement into formerly marginal areas and exploitation of a broader range of resources would be one solution to reduce pressure on, and reduce competition over, land. As a result, this would reduce the need to symbolically mark out territories with burial monuments or causewayed enclosures. However, some form of contact between groups either through exchange or movement would be necessary to reduce the risk involved by exploiting seasonal resources. Either groups moved from season to season between specialized camps for the exploitation of specific resources, or alternatively specialized groups existed in different areas and broadened their subsistence base through exchange.

In north-east England the decline in herb curves seen at several pollen sites in this period, described above, would seem to support this theory. The suggested decline in arable activity is however, little supported by the agricultural:arable index values for this period. Values for the index increase at many sites, particularly in the lowlands, whilst they decrease at many upland sites. However, the increase in arable types in this period in the lowlands can be explained by the averaging of values from across the period 2800 - 2300 cal. BC. At many lowland sites values of arable types begin to increase again before the end of the period, and this increase is being picked up in the index values. The decrease in the index in the uplands is because, unlike the lowland sites, there is no increase in values at the end of the period - the increase does not occur until well into the Bronze Age here. The use of averaged values is problematic when trying to investigate phenomena which lasted for less than 500 years in duration. Archaeological evidence to support this theory from north-east England in the form of settlement sites and henges or stone circles is scarce. There is also scant evidence for a shift in activity onto soils less suitable for agriculture in the north-east.

In addition, the proposed decline in activity does not occur at all sites in this period. At some sites levels of herb taxa associated with clearance and agricultural activity continue up to the end of the Neolithic, instead of declining. At Bishop Middleham, there is no real evidence for a difference between earlier and later Neolithic; evidence for further small scale clearance events continues during the third millenium. Here most herb types continue at low but constant levels until the end of the Neolithic whilst *Betula* pollen increases at intervals and *Corylus* remains high until the end of the Neolithic. At Hutton Henry, although grass pollen decreases for most of the period 2800 - 2300 cal. BC, there are peaks of *Plantago* *lanceolata*, and *Rumex acetosa*, *Cerealia*-type and Chenopodiaceae appear with *Corylus* at a level interpolated to 2556 cal. BC, and continue to the end of the period, before increasing further at the start of the Bronze Age period. At Neasham Fen also the picture is more complex, with small peaks in herb types at lower levels than at the *Ulmus*-decline, and *Cerealia*-type values almost continuously present in very small values. *Corylus* values increase with these peaks. Interestingly one peak at the start of the period 2800 - 2300 cal. BC only has *Cerealia*-type, *Artemisia*, Chenopodiaceae and *Polygonum*, and no *Plantago*, *Rumex* or Ranunculaceae, unlike all other herb peaks at the sites. According to Bartley *et al.* (1976) there is no evidence for clearance during the Neolithic here, but these small peaks in herb types might suggest a small degree of opening in the canopy around the site, but not on the scale found at other sites in this area. At many Northumberland sites small scale clearance activity dates to the third millennium; at Fellend Moss during the period 2800-2300 cal. BC *Plantago lanceolata* makes its first appearance, with *Rumex*, *Plantago major/media* and a peak in Cruciferae and Ranunculaceae. At Steng Moss in this phase there are small but sporadic peaks of Gramineae, *Urtica*, *Rumex* and the first appearance of *Plantago lanceolata*, whilst at Camp Hill Moss, *Rumex acetosa* appears around in this period. At Black Lough there is a peak in Gramineae, the start of a continuous curve for *Plantago lanceolata* and and increase in *Pteridium*, Chenopodiaceae and *Senecio* dated to this period.

As a result, it is evident that in the north-east, the proposed change towards decreased agricultural activity was not a uniform phenomenon.This may be because stress on the landscape was not as important as was proposed, so that at many sites on the better soils clearances continued on a small scale, little changed from before. Certainly this seems to have been the case at Bishop Middleham, on the limestone. If it were the case that the best agricultural land was under pressure, and that during this period pressure was reduced owing to the removal of populations onto secondary soils, then this is not reflected by any changes at this site. Similarly at Eshton Tarn in the Craven limestone lowlands, there seems to have been no decline in activity, with a series of clearances, and increased evidence of arable types through the Neolithic. If anything, the proportion of arable types increases at many lowland sites, as the earlier peaks in *Plantago lanceolata* and *Rumex* decline. It is in the uplands that the proportions of arable types decline during this period, and that *Plantago*, Ranunculaceae and *Rumex* continue in small amounts, whilst the proportion of heather increases at most upland sites. It is possible that in the uplands early agricultural activity fell off as soil fertility declined, since in these areas of more acidic soils and higher rainfall, less disturbance would be required to instigate blanket peat formation. It is possible that populations were forced to utilise a wider range of resources as pressure on the available remaining good land increased, and that in the uplands the use of henges and stone circles were of value for the distribution of resources, as Bradley and Hodder (1979) suggest. There is little evidence however for exploitation of poorer soils on the Millstone Grit around the upper Derwent or heavy lowland soils; at these sites tree values remain high during this period.

9.3 The Bronze Age and earliest Iron Age

9.3.1 The early Bronze Age period

During the period 2000 - 1500 cal. BC a marked increase in herb types associated with clearance and agricultural activity has been demonstrated at many pollen sites in the region, associated with a marked decline in woodland. This occurs not only at sites where there was a decline in activity in the later Neolithic, but also at those sites where activity continued throughout the period. At these sites, herb taxa reach values higher than in any previous level. This phenomenon has also been noted at pollen sites from other areas of Britain (Bradley 1978 a; Whittle 1980). Unlike the repeated temporary clearances found earlier in the Neolithic, this activity continues at a relatively high level into the first half of the next period (2000 - 1500 cal. BC).

This has been seen as a "phase of renewed economic growth" by Bradley and Hodder (1979), with an increase in cereal cultivation. This is seen as having occurred earliest in the south of Britain, where patterns of land-use are argued to have changed the least (Bradley 1978 a). Similarly, for the north-east of England, this change could be expected to occur earlier on the better soils in the lowland, where as explained above, there were likely to have been fewer changes in land-use. However, even in the lowlands, where clearance had been more continuous throughout the Neolithic, the clearance in this period is on a much higher order of magnitude than earlier, particularly at Bishop Middleham. The percentage of total arable types increases at many sites in this period, although the index values do not become more "arable"; in fact they are lower at many sites. This is due to a massive increase in *Plantago lanceolata* and *Rumex* (both "pastoral-type" indicators) which swamp out the increases in arable pollen types. In this period, the differences in vegetation cover at sites on different soil types become even more apparent. On the limestone of the East Durham Plateau the increase in herb pollen in this period is the most marked, whilst on the heavy clay soils at Neasham there is no evidence for intensive, more permanent clearance until far later (in the post -Roman period.) This phenomenon has also been noted at White Moss in the Craven lowlands. In Weardale at Hallowell Moss and in the Derwent area at Pow Hill and Lamb Shield, there is the first evidence for forest disturbance in this period, although it is only low level, and by no means on the same level of magnitude as in the south-east of Durham. At these sites intensive clearance does not occur until much later, in the late Iron Age/Roman period. In the uplands, in Teesdale, intensive clearances on this scale do not occur until later in the middle to later Bronze Age. However, despite the variations in intensity, at most sites there is an increase in activity at this period.

The variation in duration of clearances between different parts of the region is interesting. In the uplands evidence for clearance is on a smaller scale than found in the lowlands, and peaks in herbs are soon replaced by a large increase in taxa associated with blanket bog. This clearance phase is limited at most upland sites right to the very beginning of the period 2000 - 1500 cal. BC, and this is sharply followed in subsequent early Bronze Age levels by a rise in heather, sedges and *Sphagnum*. This massive rise in blanket bog taxa occurs both at sites where blanket bog had already occurred from the Neolithic or earlier, and at sites where it is new. The widespread clearance phase could easily be interpreted in terms of population growth. However, the rapid spread of blanket bog following this clearance phase suggests that initial intensive use had to be abandoned on these poorer soils, and so clearance moved across the uplands as each area became exhausted.

The purpose of these clearances is of considerable interest. Most upland pollen sites in this period see a massive rise in pastoral-type taxa, and the agricultural:arable index scores show a dominance of pastoral types. However, this hides an accompanying increase of arable-type taxa at many upland sites. Arable-type taxa appear for the first time in any great amount at the start of the period in the uplands, particularly in the more sheltered Upper Teesdale, rather than the upland tops, and this includes cereal pollen. It is likely therefore that at least some of these initial intensive clearances were used for cultivation purposes. It is possible that if this initial cultivation phase was only short lived, it would not be represented in the pollen at every site. If so, it would only be picked up at some sites where the sample level happened to coincide with this activity. In addition the location of pollen core sites might not always coincide with areas of cultivation. It is likely therefore that at least part of the reason for this phase of intensive clearance was to carry out cultivation. This is supported by Fleming's suggestion (1971) that intensive forest clearance is unlikely to be undertaken for purely pastoral use. The occurrence of querns and sickle blades in upland contexts would also seem to support this (Bradley 1978 a). If there was a phase of cultivation, however, it was probably short lived, since arable types do not occur in many levels or at every site. This brief, intensive cultivation period could possibly explain the location of cairnfields at elevations between 250-300m a.s.l., if their common interpretation as clearance cairns is to be accepted. The occurrence of early Bronze Age barrows in upland areas shows that activity in this period extended into areas formerly marginal for agricultural production. Examination of soils under barrows shows that in upland areas they tended to be placed on land that had not been previously used since the Mesolithic, in contrast with lowland barrows, where there is considerable evidence for activity during the Neolithic (Bradley 1978 a). It is likely that the construction of barrows followed an initial phase of woodland clearance, use and decline in use.

In summary, evidence for increased activity occurs at many sites across the region, with the first small scale clearances in formerly well wooded areas, and the appearance of intensive, more permanent clearance on the East Durham Plateau. The appearance of clearances in well wooded areas implies that new areas were opened up for exploitation in this period in the north-east. Also at many well wooded sites in Northumberland, the first evidence of clearance activity dates to this period. In the uplands whilst Ericaceae values continue to increase at most sites, at some sites in Upper Teesdale there is evidence for increased activity in this period after a period of reduced activity in the later Neolithic, although not on the scale found in south-east Durham, and more temporary in nature.

9.3.2 The middle and late Bronze Age and earliest Iron Age periods

Much of the archaeological literature for these periods concerns the transition from earlier Bronze Age archaeological evidence, dominated by barrows and ceremonial monuments and discussion of ritual, ceremonial and mortuary practices, to later Bronze Age and earliest Iron Age archaeological evidence dominated by settlement evidence, field-systems and land boundaries. This change has been subject to considerable discussion in the archaeological literature, and the start of the later Bronze Age has been seen as one of the fundamental transformations in British prehistory (Bradley 1978 b). The nature of these changes in southern England will first be considered, and then compared with available evidence from north-east England, both palynological and archaeological, to consider whether these changes also occurred here. Here the periods 1500-1000 and 1000-500 cal. BC will be considered together, to look at developments from the end of the earlier Bronze Age period onwards.

A problem with these time-periods is that much of the discussion in the archaeological literature about this transition has been restricted to southern England, in particular focusing upon the end of the "Wessex culture" of the earlier Bronze Age, and the question of how the extensive field systems and settlements of the later Bronze Age developed. In contrast there is a lack of synthesis or discussion of developments in north-east England. Most archaeological work from the region for this period is confined to descriptions of evidence (Challis and Harding 1975; Annable 1987). Here the developments occurring in southern Britain in the archaeological, carbonised seed and palynological evidence for the later Bronze Age and earliest Iron Age will be reviewed, and then the evidence for north-east England will be reviewed, to see if these developments occur in this period in the north-east.

In southern England the later Bronze Age period is a period of marked change, claimed to be a period of intensification in the landscape, in food production and in metalwork production (Bradley 1978 b). Settlement studies in southern England have revealed a preference for more nutrient rich soils which however were more difficult to work . There is also evidence for a massive organisation of the landscape in several areas of England. In Wessex very large field systems were laid out of complex structure. These often incorporate existing early Bronze Age barrows. An extensive system of land-boundaries also showing respect to earlier cairns exists in Dartmoor (Fleming 1977). These field systems are on a scale not equalled until the Roman period.

In addition, in southern England, the first half of the first millenium BC is seen as a period of innovation with crops such as emmer (*Triticum dicoccum*) and naked barley (*Hordeum vulgare* var. *nudum*) being replaced by crop plants such as hulled barley (*Hordeum vulgare*), spelt wheat (*Triticum spelta*), bread wheat (*Triticum aestivum*/ *T. compactum*), Celtic bean (*Vicia faba*), rye (*Secale cereale*) and oats (*Avena* spp.). Jones (1984) has shown that emmer wheat declines in abundance and naked barley disappears at sites in the Upper Thames Valley in the first half of the first millennium BC, to be replaced by spelt wheat and bread wheat.

The appearance of spelt wheat and disappearance of emmer has commonly been interpreted in the archaeological literature as indicating a shift onto heavier and wetter soils, which often tend to be more productive. Emmer is commonly interpreted as being a crop well-suited to light soils, whilst spelt is seen as a crop more suited to heavier soils (Jones 1981; Gregg 1988). However, this common interpretation is simplistic, and overlooks the wide range of types of both emmer and spelt which can occur in a wide range of types of environment (Hillman 1981; van der Veen 1982). However, in general it can be said that spelt wheat can be grown on a wider range of soils and tends to be hardier when compared to emmer wheat.

These crop innovations agree well with the available pollen evidence from southern England for the first half of the first millennium BC. At pollen sites from this region in early first millennium BC there is a large increase in the number of clearances and more evidence for weeds of cultivation (Turner 1981 a, 1981 b). There is also pollen evidence suggesting that new areas were cleared of trees at this time in these areas.

These changes have traditionally been thought not to have occurred in the north and west of Britain, unlike further south. Jones (1981) stated that the decline in emmer and introduction of spelt wheat did not occur in the Highland zone of Britain. The division of Britain into a Lowland Zone dominated by arable agriculture, new innovations and new crops and a Highland zone with predominantly pastoral agriculture has traditionally been used to describe the nature of land-use in the first millennium BC (Fox 1932; Piggot 1958;

Wheeler 1954). Fowler (1975) has stated that this traditional contrast between Highland and Lowland develops for the first time in the later Bronze Age. Owing to climatic changes in the late second millennium BC, it is argued that soils in upland areas would no longer be able to support cultivation, and therefore arable agriculture became restricted to the lowlands. The restriction of cultivation to the lowlands is argued to have precipitated reorganisation of the best farming land, an increase in clearance in these areas, the development of organised field systems and land boundaries and the clearance of fertile but difficult to cultivate soils on lower ground by rivers. Bradley (1978 b) has argued that climatic change has been given too much weight in arguments as a "prime mover". He argues that the changes culminating in the major reorganisation of the landscape in the later Bronze Age can be traced back to the earlier Bronze Age. The history of earlier Bronze Age intensive clearance of upland soils contributed towards making them unsuitable for later Bronze Age cultivation, and combined with climatic deterioration the spread of blanket bog forced these areas out of cultivation. Without the earlier clearance and use of upland soils, the deleterious effects on the landscape of the climatic changes occurring later in the Bronze Age might have been reduced. The consequence was to prevent the uplands from ever being used on such a scale again, and cultivation was henceforth restricted to lowland areas.

It will be demonstrated below that this traditional distinction between Highland and Lowland zones is simplistic and hides a great deal of regional variation in the timing of and degree to which these developments occurred across Britain. Contrary to traditional views, it will be shown that many of these developments do occur in north-east England, but at a later date than found in southern Britain. In addition, even within north-east England there is considerable variation between different areas in the timing and extent of these developments.

This section looks for evidence for these developments in north-east England in the later Bronze Age and earliest Iron Age period, to see whether the developments occurred here at the same time as in southern Britain. If these developments do occur at the same time, we should expect an increased focus of settlement and activity upon lowland areas, preferably on the better agricultural soils, possibly with evidence for land boundaries and field systems. From the carbonised seed evidence we should expect the appearance of spelt wheat, hulled barley and a range of other new crop types, and the disappearance of emmer and naked barley. From the pollen evidence we would expect a decline in arable activity in the uplands, an increase in the spread of blanket bog and a rise in pastoral-type herbs, accompanied by an intensification in clearance and agricultural activity in the lowlands. There should also be evidence for the first opening up of areas with heavy, fertile soils.

The period 1500-1000 cal. BC sees a marked increase in blanket bog and at most upland sites in north-east England, accompanied by a rise in pastoral-type taxa and drop in arable-type herb taxa. Arable types only continue to be present at some sites in Upper Teesdale. The increase in blanket bog taxa continues further into the period 1000-500 cal. BC and woodland cover drops to its lowest levels in this period in the uplands. This trend is also found in more upland locations in northern Northumberland, such as at Black Lough. The pollen evidence from the uplands, therefore, would appear to agree with the views proposed above that this period saw a deterioration in soil quality associated with the spread of blanket bog, and that activity was now predominantly pastoral in nature.

Evidence from lowland sites does suggest greater woodland clearance and an increase in the proportion of arable types and there is some evidence suggesting some limited exploitation of heavier lowland soils, although this is not on the scale suggested for southern England. The most open areas are on the "lowland uplands" of the Magnesian Limestone Plateau in East Durham, at Bishop Middleham and at Hutton Henry. A picture of open grassland similar to that found on the chalklands in southern England and in the Wolds can be put forward. During the period 1500-1000 cal. BC woodland opens up further at Mordon Carr and there is small scale clearance at Neasham Fen, on the heavier clays. There is evidence for a rise in the proportion of arable type taxa at lowland sites such as Mordon Carr and Neasham Fen, with Bishop Middleham on the limestone having more pastoral scores, and behaving like the uplands. Neasham Fen, on the heavier clays, remains the most wooded area, with only limited clearance, although the presence of cereals and arable types suggests this was arable in nature. In the subsequent period, 1000-500 cal. BC, clearance occurs on a larger scale at Neasham Fen, but still not on a scale comparable to the limestone plateau, it is still temporary in nature, declining again at the end of the later Bronze Age, and the surrounding area remains wooded. Cereals and a wide range of arable types occur here in this period and at Mordon Carr. The limestone plateau remains open, if anything seeing a further increase of clearance in this period and an increase in the range of pastoral-type herbs. Sites in the Wear and Derwent areas remain well wooded, with some temporary clearance in these periods.

The picture further north in Northumberland shows that in the Tyne Corridor most sites are well wooded, behaving similarly to those in the Wear and Derwent areas, whilst further north, at Steng Moss there is considerably more clearance. Some areas of north Northumberland resemble sites in the Wear and Derwent with their high woodland cover, such as at Camp Hill Moss, whilst others show considerably greater clearance and evidence for arable activity, such as at Trickley Wood, and at Edlingham where clearance approaches levels found in south-east Durham. At all other Northumberland sites pastoral-type herbs dominate and the higher levels of blanket bog taxa at most sites here make most sites resemble those in the Durham uplands.

The archaeological evidence for this period in the north-east shows that sites in the later Bronze Age occupy the margins of upland areas, well situated to take advantage of resources in both the lowlands and uplands. In the Yorkshire Wolds later Bronze Age sites such as at Grimthorpe and Thwing (Haselgrove 1982) are well sited to exploit both the chalklands and the lowlands. Some evidence for field systems dating to this period is available. Manby (1980) suggests that some of the linear bank and ditch systems across the Wolds have later Bronze Age origins, and proposes that large areas of the Wolds were divided up by these boundaries. This is similar to the organisation of the landscape proposed for the hills north of the Vale of Pickering, in the North York Moors. Similarly, in the North York Moors, later Bronze Age sites are located in marginal areas, such as at Eston Nab. Spratt (1982) has suggested that the landscape was divided by linear earthworks augmenting the lines of natural boundaries such as valleys or watersheds. Once again here sites seem to be distributed to exploit both extensive grazing land on the moors and lower ground more suited to cultivation or cattle grazing. Haselgrove (1982) has proposed a similar location of sites in the Tyne-Tees area for the early first millennium BC. There is no evidence in the archaeological record for more intensive utilisation of heavy, clay lowland soils by rivers in this period.

The results actually do seem to support the main trends observed in the south of England in the later Bronze Age that deterioration of upland soils was accompanied by an increased focus upon cultivation in lowland areas, rather than the earlier Bronze Age evidence for cultivation in the uplands. These areas now appear to be the focus of predominantly pastoral activity. Pastoral activity also was focused on those areas of "lowland upland" which were, like the uplands, predominantly open in this period, or even more so than the uplands. A major difference between these "lowland upland" areas and upland areas is in the extent of blanket peat. Pollen evidence indicates that the lowland uplands had no Ericaceae, and here limestone grassland vegetation most probably predominated.

However, a major difference between southern and north-eastern England lies in the extent to which heavier lowland soils near rivers were exploited. There is only limited evidence for clearance at Neasham Fen in the Tees lowlands and on the heavy soils at White Moss in the Craven lowlands to the south, outside the region, in Yorkshire (Bartley *et al.* 1990). In these areas woodland remains dominant, unlike further south in Britain where in the early first millennium BC there was clearance of such areas. However, despite the woodland cover, it is these sites on the heavier soils in the north-east which do have the highest proportions of arable taxa in the region, and it seems certain that this period saw an increase in activity in the lowlands, if not on the scale and with the innovations associated with southern England. Most importantly, there is no evidence for the adoption of new types of crop or technology in the first half of the first millennium BC in north-east England to facilitate cultivation of heavier soils. Van der Veen's (1985) carbonised seed study of a later Bronze Age site at Halsill Farm, near Steng Moss in Northumberland, shows that this later Bronze Age site has a very "conservative" plant assemblage, i.e. a plant assemblage little changed from those found on earlier Bronze Age sites in southern England, with emmer and hulled barley dominating. Although one site can hardly be seen as representative of the whole of the region in the later Bronze Age, it is interesting that here, at least, the innovations found in southern England, i.e. the dominance of hulled barley and spelt wheat appear to be delayed in the north-east. Spelt wheat does actually occur at Halsill, radiocarbon dated to the early first millennium BC (van der Veen 1992), but only in very small amounts, and emmer dominates. Van der Veen demonstrates from her study of carbonised seed assemblages from north-east England that these innovations do occur in north-east England, but not until the later first millennium BC, around 300 cal. BC, in the Iron Age, and so these developments in the north-east will be discussed in the following section on the Iron Age.

To summarise, there is considerable pollen evidence showing the spread of blanket bog across most upland areas in the north-east and a disappearance of arable type herb taxa at upland sites in the later Bronze Age. There is evidence for increased clearance at many lowland sites, although not on the scale found at pollen sites from southern Britain (with the exception of Bishop Middleham in East Durham). There is only limited evidence for clearance on the heavier soils in the lowlands, unlike the considerable evidence for clearance on heavy soils in southern Britain in the early first millennium BC. Although spelt wheat appears in small amounts, there is no evidence in the north-east in the earlier first millennium BC for the decline in importance of emmer and naked barley and dominance of spelt that occurs in southern Britain. The traditional distinction between Highland and Lowland zones of Britain hides considerable variation within north-east England; the upland areas of the north-east do indeed seem to behave as indicated for the Highland zone, but the lowland areas of the north-east do show increased clearance and evidence for arable activity, although not on the scale of the developments in southern Britain. These developments do not occur in the north-east until the later first millennium BC, as will be shown below.

9.4 The Iron Age and Roman period

9.4.1 The Iron Age

Pollen evidence indicates that the landscape across much of the region during the earlier Iron Age was relatively wooded, with fairly small scale clearances, with the exception of parts of south-east Durham where the landscape was more open and more continuously maintained. Haselgrove (1982) argues that the most common settlement form for this period, the rectilinear enclosure, was appropriate for a dispersed population in a relatively wooded landscape. There are few sites with defensive circuits, and there is little to suggest anything like the hierarchically structured hillfort type settlement patterns found elsewhere in Britain at this time (Cunliffe 1991). The majority of rectilinear settlements appear to have been single-unit settlements. It is argued that the variation in size of enclosures between different rectilinear settlements may be related to the numbers of cattle which were overwintered, and whether they were out of doors or in stalls (Haselgrove 1982; Reynolds 1982).

It is now generally accepted that the role of arable agriculture in the Iron Age in north-east England has been greatly understated in the past, particularly in the lowlands of the region (Haselgrove 1982; van der Veen 1985, 1992). This view contradicts the long-held view of Iron Age settlement and agriculture north of the Humber as being predominantly pastoral in nature. As stated above, the traditional division of Britain into a "Lowland" zone with settled arable agriculture and a "Highland" zone marked by shifting settlement and pastoralism has obscured considerable variation on a regional level. As a result the lowlands of the region have been overlooked and lumped together with upland areas. Haselgrove (1984) has argued that the lowlands of the region behave climatically and in terms of soils very similarly to much of the Midlands.

Van der Veen (1985, 1987, 1992), in her study of carbonised seed assemblages, has argued strongly against the old pastoral model for north-east England, and has produced clear evidence for the presence of cereals at several archaeological sites from across the region, including Northumberland, from the late Neolithic onwards, as has already been demonstrated. Haselgrove (1984) has argued for a mixed agricultural economy for the Iron Age with stock-rearing playing a particularly important role in the earlier Iron Age. Although there are few pastorally-associated artefacts, and few faunal assemblages for the region, those that do exist show that in the earlier Iron Age cattle predominate over sheep and goat. It is argued that stock-rearing may have influenced settlement location; almost 50% of rectilinear settlement enclosures between the Tees and Tyne are on or close to the 125m contour. This would allow access both to wet, low-lying pasture for cattle, and to the uplands for sheep grazing. Linear features associated with many settlements are interpreted as trackways for the movement of animals.

In this period, the second half of the first millennium BC, there is a clear distinction in carbonised seed assemblages from sites in the south-east of the region, on the one hand, and from Northumberland, on the other hand (van der Veen 1992). It is in this period that the south-east of the region, the lowlands of Durham and Cleveland, really stand out. It is in the Iron Age period that the developments that occurred in southern Britain in the first half of the first millennium BC first appear in north-east England. These developments appear first and to the greatest extent in the south-east of the region, whilst at sites in Northumberland to the north, these developments do not occur, or occur later and to a lesser extent. Van der Veen (1992) has distinguished between Group A assemblages, with emmer, barley and a little spelt which occur at her sites in Northumberland, and Group B assemblages, with spelt, no emmer, and barley, at sites in the south-east of the region.

It appears, therefore that the dominance of spelt, which occurs in southern Britain in the earlier first millennium BC, now occurs in north-east England, but is restricted to the south-east of the region only. This development has been radiocarbon dated as occurring in the south-east of the region around 300 cal. BC. On the basis of the weed species present at Group B sites in the south-east of the region, it is deduced that these sites had low nitrogen levels, and soil fertility was not kept up, which suggests that fields were intensively cropped without any replacement of nutrients by fallowing or manuring. This implies intensive arable agriculture. In comparison, at Group A sites, in Northumberland, the cultivation of emmer is accompanied by weed species found on nitrogen rich soils, which implies that soil fertility was maintained, either by fallowing or manuring. The presence of annuals at these sites, tends to support manuring as the method of soil maintenance, since fallowing promotes the growth of perennial weeds. The Group A assemblages in Northumberland are interpreted as indicating small-scale subsistence agriculture, whilst the Group B assemblages are interpreted as indicating arable expansion.

It is interesting to consider to what extent this distinction between the south-east of the region and Northumberland seen in the carbonised seed evidence exists in the pollen record for the Iron Age. Van der Veen has only studied a small number of sites from across the region, and it would be interesting to see whether intensive arable activity is restricted only to the south-east, or whether there is evidence for arable activity and intensive clearance in areas of Northumberland that she has not studied, or in the uplands of the region. If so, it might be possible to suggest areas where carbonised seed studies would be most fruitfully carried out in the future.

It is evident from the pollen maps for the Iron Age period, that the greatest evidence for clearance occurs at sites in south-east Durham, as predicted from the carbonised seed evidence, and also that the highest, most arable, index scores occur in this area. However, what the carbonised seed evidence does not show, is the considerable variation between sites in the south east of Durham in index scores. Sites on or around the limestone East Durham plateau are dominated by "pastoral-types", whilst those sites on the lowlands, between the wet clay soils by the Tees and the plateau, such as Mordon Carr, are dominated by "arable-types". By the Tees, at Neasham Fen, in the Iron Age period "pastoral-type" taxa dominate, with a predominantly wooded landscape. This suggests that the limestone plateau was mostly dry limestone grassland, most probably used for grazing, whilst agriculture was concentrated in the lowland areas between the plateau and the river (Fenton-Thomas 1992). This area, lying between the drier limestone uplands of the East Durham Plateau and the poorly drained clay lowlands around Neasham Fen was probably the most suitable area for cultivation during this period. Today the area around Neasham Fen is heavily cultivated due to the use of drainage and ploughing technology able to make the most of the high fertility of the soil. However in this period poor drainage would have restricted this area to wet grazing, if agricultural activity was carried out at all in the area, since woodland cover was very high here in this period. The higher arable proportions at Thorpe Bulmer than the rest of the East Durham Plateau might be due to its position closer to the coast. Fenton-Thomas has suggested that the Tees lowlands, despite its still considerable woodland cover in this period when compared with the limestone plateau, might have been a focus for considerable activity in this period. The woodland may have been a valuable resource for stock grazing on the wetter lowland soils. He has argued that the importance of lowland grazing may have been played down in the literature owing to the "filtering out" effect of woodland on clearances, and that they may have been more numerous than is suggested.

The location of sites on the margins of upland areas in the earlier Iron Age is also seen in other areas of Northern England, such as in the Yorkshire Wolds, the North York Moors and West Yorkshire (Haselgrove 1984). In all these areas sites are well placed to exploit upland pastures and lowland grazing, and although querns at these sites attest to cereal consumption, it is likely that stock-rearing played an important part in settlement location. The importance of pastoral activity in the economy is backed up by the predominance of pastoral-type herbs over arable at most sites in the region. That arable activity also occurred is supported by carbonised cereals at Coxhoe and Thorpe Thewles, and the common occurrence of querns on sites from this period supports cereal consumption. The lack of storage pits need not imply that arable farming was unimportant, but merely that suitable soils for storage pits were not available (Bradley 1978 a). Through the Iron Age pollen evidence indicates that clearance increased in the lowlands, and it is possible that there was a slow infilling of the landscape in the lowlands, which had already seen substantial clearance. This is supported by the addition of enclosures to pre-existing sites (Haselgrove 1982).

The picture at pollen sites in the south-east of the region is already well known from several reviews of the pollen record for the later prehistoric period for this area (Wilson 1983; Fenton-Thomas 1992; van der Veen 1985, 1992). However, far less is known of the developments in the later prehistoric period for Northumberland or the uplands. It is therefore interesting to consider whether the pollen from these areas agrees with van der Veen's (1992) suggestion that the developments occurring in the south-east did not occur in Northumberland, and whether or not they also occurred in the uplands.

It might be expected from van der Veen's suggestion that intensive clearance on the scale of that in south-east Durham did not occur in Northumberland in the second half of the first millennium. However, contrary to expectation, several pollen sites from northern Northumberland show a marked rise in herb pollen levels in this period, up to 52% tdlp at Akeld Steads and up to 66% tdlp at Edlingham. The formerly well wooded site of Camp Hill Moss also experiences considerable clearance, with trees and shrubs dropping to below 20% tdlp in this period. In many respects, these sites resemble those in south-east Durham, although herb pollen levels are slightly lower than the extremely high values on the East Durham Plateau (over 80% tdlp). At these sites the proportion of arable-type herb taxa increases in this period, although index scores are never as high as those found at Mordon Carr in south east Durham. At most other pollen sites across Northumberland high values for Ericaceae dominate, and these sites behave very similarly to those in the Northern Pennine uplands in having high values for blanket bog taxa and low, pastoral index scores.

Intensive clearance therefore did occur at some sites in the northern Northumberland lowlands in the second half of the first millennium BC, although arable scores are never as high as in the south east of the region. Van der Veen has three sites from the northern Northumberland lowlands, Murton, Dod Law and Chester House, all of which are dominated by emmer and naked barley. It appears therefore that intensive clearance in northern Northumberland was not accompanied by a change in crop types, and that emmer and naked barley continued to be used in this period in this area.

Unfortunately there are no sites with studied carbonised seed assemblages from the uplands of the region. There is a further decline in tree pollen values at most sites in the uplands in this period accompanied by a further increase in Ericaceae and other blanket bog taxa, as seen at some sites in Northumberland in this period. Pastoral-type herb taxa dominate at most upland sites, particularly *Plantago*, Ranunculaceae and *Rumex*, with the exception of a small number of sites in upper Teesdale, where arable-type herb taxa and cereal pollen remains in small amounts. It would be very interesting to see whether the cereal present at these sites (if it was indeed grown in the upper dales as opposed to the pollen being blown in from further down the valleys) was emmer, or barley, or rye, and whether the upland dales behave in the Iron Age like the sites in Northumberland, i.e. intensively cleared but dominated by emmer and naked barley. There is obviously the need for more carbonised seed assemblages to be studied from upland sites to address this issue.

There appears therefore to be considerable variation across the region in land-use in second half of the first millennium BC, with pollen sites in the uplands, on the "lowland uplands" of the Magnesian Limestone Plateau in East Durham and on the heavy soils along the rivers being dominated by pastoral-type herb pollen, but areas between the uplands and rivers in the south-east of the region being dominated by arable-type pollen taxa. The south-east of the region really stands out in this period as being the area with the greatest clearance and highest arable scores.

9.4.2 The later Iron Age and Roman period

The later Iron Age is grouped together with the Roman period in this section since the main issue, the major clearance occurring at many sites across the region at this time, varies in timing from the later Iron Age to during the Roman period. The north-east of England differs from southern Britain in that pollen sites from the south indicate major clearance occurring in the earlier first millennium BC. In the north-east, this major clearance does not occur at most sites until right at the end of the first millennium BC and first few centuries AD. The exception to this pattern, as already shown, is in the south-east of the region, where large scale clearance dates back to the Bronze Age at sites in East Durham. In the later Iron Age and Roman period sites that had previously been heavily wooded throughout prehistory, such as those in the Derwent and Wear area, experience clearance for the first time. Across the region, tree and shrub levels at many sites fall to levels as low as those found today.

Traditional archaeological explanations for the major expansion of clearance and agriculture in this period have seen the exaction of tribute for Rome as a direct stimulus to native agriculture (Manning 1975), and that the arrival of Roman military presence around AD 70 was a major point of change in the organisation of the landscape. However, it has been demonstrated that at many sites this major clearance occurs before Roman military activity in terms of forts and garrisons appear in the region. Reece (1980) has argued that the importance of the start of the Roman period is overemphasised as the beginning of an era in settlement and economy. It is instead possible that the spread in clearance occurred as a result of indigenous developments in the region. This is most likely to have started in the "core-zone" in south-east Durham, where archaeological evidence suggests affluent communities.

The last two centuries of the Iron Age are generally thought to be a period of great social and economic change, particularly in the south-east of the region, with the abandonment of elevated settlements such as Coxhoe and West Brandon, whilst low-lying sites such as Thorpe Thewles show continued occupation into the Roman period. At this site, the settlement expanded beyond its old boundaries, which were filled in, forming a new class of "open-settlement". This has also been found at Catcote and Ingleby Barwick, and a similar change from enclosure to open settlement may pre-date the massive fortifications found at Stanwick. These settlements are in many ways similar to those found in southern England. Other changes during this period include the appearance of storage pits at Catcote, and the appearance of more efficient beehive querns, both suggesting a greater importance of arable production. This parallels the increase in arable-types at many sites in the region in the pollen record. The predominance of sheep in faunal remains from Catcote may reflect its proximity to limestone pasture, suggesting that on the East Durham Plateau sheep-grazing was important during this period, as has been proposed on the Yorkshire Wolds. Here thinner limestone soils would have been less suited to arable cultivation than in the rest of the lowlands. In comparison, at Stanwick the higher proportions of cattle and pig might reflect proximity to low-lying wet grazing and woodland clearances for pigs.

Haselgrove (1982) has argued that settlement and agricultural activity was able to extend beyond the limits adhered to during most of the Iron Age because there was a form of economic inter-dependence between the different parts of the region. It is argued that during this period settlements became specialized in particular parts of the agricultural economy, and that a network of inter-dependent settlements developed to supply resources that any single settlement could not supply for itself. In this way settlements on the more marginal land of the uplands could be supported. In these areas settlements cease to be so self-sufficient and to produce their own iron implements and pottery, and there is an increase in evidence for exchange of goods. In these areas also pastoral-type herbs predominate, indicating that here there continued to be a greater emphasis on pasture. However, many upland and foothill areas still see a major clearance during this period, like sites in the lowlands. It is possible that this clearance reflects major changes in stock-farming in these areas, with the creation of more open land. Haselgrove (1984) has suggested that upland pastures may have been used for summer grazing and that some degree of transhumance was practiced, which might explain some of the settlements at extreme altitudes, such as those above 450m in Teesdale. However, an additional explanation for the decline in arboreal pollen in upland pollen sites in this period could be that the very large catchment areas of these sites are picking up the major clearances over most of the lowlands in this period, and that in fact these areas had been open well before this period.

It is clear therefore that south-east Durham was a "core-zone" (Fenton-Thomas 1992) where major clearance first occurred, and where subsequent woodland regeneration was postponed until much later, and on a far smaller scale, than elsewhere in the region. In this area, activity continued on a scale found in the Roman period until the end of the millennium, and at some sites there is no great woodland regeneration. In those areas that were formerly well wooded, such as at Bollihope Bog and Hallowell Moss, regeneration tended to occur earliest and was most complete. In the uplands there was some increase in woodland taxa, but overall high values for blanket bog types and open grassland indicate a predominantly open landscape continued up until the present day.

During the Roman period it is likely that the system developed by the later Iron Age continued to be maintained and expanded. The pollen record shows that there was an increase in agricultural activity and clearance throughout the period up to a peak towards the end of the period, and beyond at many sites. The pollen record also suggests there was no increase over time in the importance of arable over pastoral types. This suggests that although there was no change in the importance of arable agriculture through the period, there was an expansion in the overall levels of agricultural activity; a change in scale rather than economic emphasis. Van der Veen (1992) has also argued for an increase in the scale of arable production based on her study of carbonised seed assemblages.

Reviews of the pollen evidence for this period, as for the late prehistoric period, have concentrated upon the area between the Tyne and the Tees, and in this period there is a focus in interest upon Hadrian's Wall (discussed below), and as a result, developments during the late Iron Age and Roman period in northern Northumberland have been largely overlooked. Continuing from the Iron Age, herb pollen values increase further for the Roman period, up to 82% at Edlingham and 73% tdlp at Akeld Steads and at all other sites in Northumberland, including those where tree pollen had formerly been very high, tree and shrub pollen levels both fall below 20% tdlp. Very high arable index scores appear for the first time in northern Northumberland, at Edlingham reaching 89%, although at other sites scores do not exceed 35%. At most sites in Northumberland, pastoral-type herb taxa continue to dominate, as in the previous period. These very high arable scores and high levels of clearance are very similar to those found south of the Tyne, which suggests a similar level of arable activity and clearance was occurring in the lowlands of Northumberland and in the lowlands to the south. Clearance had already been considerable in the Iron Age at those sites with the highest levels of clearance in the Roman period; in the Roman period this trend increases further. It is particularly interesting, in the light of the increased evidence for clearance to levels found in south-east Durham at some sites in northern Northumberland, to consider whether the clearance was accompanied by any changes in the type of arable crops grown, particularly whether emmer was finally replaced by spelt in Northumberland in this period. This will be considered below.

The paucity of carbonised seed assemblages from native sites dated to the Roman period makes it difficult to assess the importance of different crop types across the region, unlike for the Iron Age period. It would be particularly interesting to see whether spelt increases importance and takes over from emmer at sites in Northumberland in this period. One development which is known, is the first appearance of free-threshing wheat, bread/ club wheat in north-east England. As for spelt wheat, this development occurs only at sites in the south-east of the region, at Rock Castle and Catcote (van der Veen 1992). The first record of bread/ club wheat in the north-east has been radiocarbon dated at Rock Castle to the first century cal. AD. Bread/ club wheat has been recorded at the Roman fort at South Shields, but it cannot be established where this comes from within the region, unfortunately. In Scotland both spelt and bread/ club wheat have been found at Roman forts, such as at Bearsden, Castlecary, Rough Castle and Newstead (van der Veen 1992), but neither have been found at any Iron Age or Roman native sites. Instead barley dominates, and emmer is rare. It is possible, therefore, that emmer and barley continue to be cultivated in Northumberland, as evidence for clearance increases, although without any Roman period carbonised seed assemblages this is impossible to investigate.

A topic of major importance in this period is the impact of Roman military activity upon the landscape, and in particular around the area of Hadrian's Wall. Several pollen sites are available in the area between the Tyne and the Solway to address this issue. Those used in this study include Fellend Moss, Coom Rigg Moss and Muckle Moss. Additional pollen sites from Cumbria or for which pollen data were not available for the purposes of this study include Fozy Moss, Walton Moss and Glasson Moss (Dumayne 1994), Bolton Moss and Scaleby Moss. Two issues are of particular interest. Firstly, whether the arrival of Roman garrisons around AD 70 or the building of the Wall had any impact upon pollen diagrams from this area, and whether it was the first major impact on these diagrams. Secondly, whether there is a relationship between degree of clearance and amount of agricultural indicators and number of Roman sites in the catchment area. The first issue, of timing of major clearance, cannot be answered with any degree of temporal precision, owing to the lack of close dating at all sites, and wide sampling intervals at some sites. However, radiocarbon dates are available for the first major clearance event at Fellend Moss, Bolton Moss, Fozy Moss, Walton Moss and Glasson Moss, and the last three sites are more closely dated.

During the Iron Age period, at Fellend Moss, as at sites further south such as Fortherley Moss, Pow Hill, Lamb Shield and Hallowell Moss, tree pollen levels are high. Woodland cover at this site appears to have been very high from the start of the sequence in the Neolithic, with almost a complete lack of woodland clearance. In the Iron Age period at

Fellend Moss there is the appearance of small amounts of *Plantago* and Ranunculaceae, but no arable-type taxa. A similar picture has been proposed for Fozy Moss, to the east of Fellend Moss, where there are only slight signs of activity in this period, with a slight drop in *Betula* pollen and a slight rise in Gramineae (Dumayne: 1994). This tree dominated picture is completely different to that found at other sites in the area. At Walton Moss to the west a major clearance event occurs in this period, involving a marked drop in arboreal pollen plus the appearance of *Cerealia*-type pollen, *Artemisia* and Chenopodiaceae, plus "pastoral-type" indicators such as *Plantago*, *Rumex* and Ranunculaceae. The end of this clearance phase is dated to cal. AD 65. Further west again, at Glasson Moss, a major clearance event occurs in the Iron Age period, dated to between 295 cal. BC and cal. AD 125, with a rise in Gramineae, *Plantago* and the appearance of *Cerealia*-type pollen. Further north at Steng Moss and Broad Moss, clearance appears to be on a greater scale during the Iron Age than at Fellend or Fozy Mosses, with the appearance of *Cerealia*-type pollen and other arable-types, and a rise in *Plantago* at Broad Moss, and a rise in *Plantago* and other herb types at Steng Moss. These sites also resemble sites further south such as Steward Shield Meadow, and in south-east Durham, and in the north of Northumberland such as at Edlingham, Akeld Steads and Trickley Wood where clearance during the Iron Age was greater. Fellend Moss and Fozy Moss group together with the tree-dominated sites in the Derwent and Wear area, and with Neasham Fen to the south, by only having limited evidence for clearance during the Iron Age period. Dumayne (1994) under-emphasizes the amount of clearance in the Iron Age in the area by only comparing her sites with those in the Derwent-Wear area, which are dominated by trees.

At all these sites in the Wall area, whether well wooded or already cleared to some degree in the Iron Age, there was a marked rise in clearance during the Roman period. It is interesting to note that the calibrated midpoint date given by Dumayne (1994) for major clearance at Fozy Moss (*circa* cal. AD 130) differs from the calibrated midpoint date of cal. AD 230 produced using the calibration method used in this study. Dates range from cal. AD 61 for Hallowell Moss and cal. AD 74 for Fellend Moss to cal. AD 230 for Fellend Moss and cal. AD 270 for Bollihope Bog. Radiocarbon dates for this event are not precise enough to confirm synchroneity of clearance with the building of the Wall c. AD 122-130 (Dumayne 1993), but it is clear that sometime between the late Iron Age and the end of the Roman period that there was the first marked clearance of formerly well wooded areas in the Wall area at Fozy Moss and Fellend Moss, just as has been demonstrated at similar sites further south in the Derwent-Wear area. Fozy Moss and Fellend Moss behave particularly closely to sites in the Derwent area in that they have higher Ericaceae levels than in Weardale at Hallowell Moss. This major clearance also occurs on sites where clearance had been greater earlier in the Iron Age, at Walton Moss, Glasson Moss. The results of the catchment approach show that sites in the Wall area have large numbers of Roman military structures in their catchments, and it seems likely that the marked clearance at these sites in this period is related to this. However, the fact that large scale clearance occurs in other areas of the region where Roman military structures are far less dense or absent, confirms that this increase in clearance was a region-wide phenomenon, not solely explained by the presence of Roman garrisons. Many other factors such as the distribution of rural settlement as well as local conditions such as soil type would have affected the degree of clearance at any given site.

9.5 Developments after the Roman period

In the post-Roman period, there appears to be a definite distinction in the pollen evidence between the lowlands in the south-east and further north-west in formerly well-wooded areas such as Weardale, in terms of the degree of woodland regeneration. This woodland regeneration occurred earlier and more completely in more marginal areas for agriculture, with the exception of the uplands where conditions prevented regeneration of woodland. In the south-east this regeneration did not occur until after the end of the millennium. At all areas the regeneration occurred after the official withdrawal of Roman military force in AD 410. Reece (1980) has argued that the importance of this date, like the date for the arrival of Roman garrisons, has been over-emphasised as marking a change in settlement and economy. If anything, there appears to have been some degree of stability across the region until at least the 6th/7th centuries AD.

In south-east Durham the continuation well into the post-Roman period of agriculture and clearance on levels found during the Roman period is not well supported by the archaeological evidence. The pollen record for this area clearly shows that there was little change in scale or economic emphasis in the agriculture of the area, little woodland regeneration, and that abandonment of settlement here was unlikely. There is no archaeological evidence for settlement in this area until at least the 7th century AD. However, Bede, writing in the early 8th century, states that there was a period of great prosperity in the north after the separation from Rome. This apparent agricultural stability might suggest that Romano-British estates based upon villas and vici persisted into the early Medieval period, as Clack (1982) has argued.

The regeneration of woodland at sites which were formerly well-wooded is supported by place-name evidence, which refers to the presence of woodland in Weardale (Watts 1976). They refer in particular either to existing settlements within woodland clearings or to new clearings for settlement. It is therefore likely that in the post-Roman period this area in Weardale, which had always been more forested than elsewhere in the region, was one of the first areas to undergo woodland regeneration. This need not, however, imply an abandonment of settlement in this area, but perhaps a change in economic emphasis towards woodland resources. Arable cultivation may have continued, but with the increased tree cover, catchment areas of pollen sites would have been smaller, and cereal pollen less likely to be represented at the site, unless by chance the pollen site happened to be located right on the site of cereal cultivation. At Hallowell Moss, some degree of continued management is suggested by the high levels of hazel pollen, and this is interpreted by Donaldson and Turner (1977) as coppicing or woodland grazing.

One possible contribution to woodland regeneration in this period at many sites on the more marginal soils in the region, is that of climatic change. During the sixth and seventh centuries there was the start of a renewed deterioration in climatic conditions across Britain (Lamb 1981). As a result, settlements in the Pennines which already were unable to be totally self-sufficient may have been pushed to the brink by these developments. As a result, this may have led to a change in economic emphasis in these areas, and possibly in a contraction of settlement. In comparison, in the south-east, where soils were more fertile, rainfall lower and growing season longer, settlements would have been better able to cope with these changes.

This woodland regeneration in the post-Roman period can also be explained in terms of Haselgrove's (1982) views on Roman settlement and economy. The regeneration of woodland and contraction of settlement in more marginal areas of the region could have occured because the network of interdependent settlements in operation during the Roman period might have broken down. As a result, settlements in marginal areas could no longer rely upon procuring specialized resources only, and would have to move to a more generalised, more self-sufficient economy in order to survive. This could have lead to a contraction in settlement in these areas, or a diversification of the economy to include other resources. In the light of this argument, an increased reliance upon woodland resources might fit in. In comparison, the south-east of the region would undergo less change, and the stability of agriculture and settlement here could continue, since here agricultural land was of a better quality and a more diverse range of resources was available.

It is unfortunate that there are no radiocarbon dates available for the post-Roman period from sites in Northumberland to investigate the timing of woodland regeneration here.

A particularly interesting feature of the pollen record from the post-Roman period is the first occurrence of major clearance at sites on the heavier, wet soils along the rivers, such as at Neasham Fen by the Tees, and further south in Yorkshire in the Craven lowlands at White Moss (Barley *et al.* 1990). At both sites this clearance appears to have occurred around cal. AD 600-800. Since these areas were the only areas not to experience major clearance in the late Iron Age/ Roman period, a time when even heavily wooded areas were cleared for the first time, this suggests that the soils along the rivers were hard to work and that deep ploughs and drainage was necessary to exploit the potential of these fertile, but difficult to work, soils.

Both the pollen evidence and archaeological and place-name evidence show that there is a distinction between the south-east of the region, and further north and west. In the south-east there is evidence for adaptation to new cultural influences, whilst further north and west there is a continuation of more conservative cultural traits, such as the continued use of British place-names. This distinction between the two areas can be seen to go back at least into the Iron Age, or beyond, with pollen evidence indicating earlier and more major clearance in the south-east, but also it has been demonstrated by Roberts (1972) that the two areas continue to differ through the Middle Ages.

Part IV

Conclusions

10 Conclusions and prospects for further work

10.1 Conclusions

This study has investigated various methods for using pollen data from large numbers of pollen cores to investigate settlement and land-use. These methods were then applied to the investigation of settlement and land-use in north-east England from the Mesolithic period to the end of the Roman period.

The pollen database compiled for this study, the North-east England Pollen Database, is the only comprehensive pollen database existing for the region; to date no other attempt has been made to collect together the very large amount of pollen data available for the region, consisting of some 140 pollen cores, both radiocarbon dated and undated cores. This database has great value, not only as a source of pollen data to investigate the aims of this study, but also has value outside of the specific aims of this study; firstly as an archive of pollen data only previously existing in the form of original pollen count sheets,compiled from a wide range of sources and presented in a form which enables easy retrieval and display of pollen data, but secondly also as a research tool which could be used for a wide range of different projects. A range of possible future applications of the North-east England Pollen Database will be discussed in the next section, "Prospects for further research".

The archaeological database, containing a range of different sorts of evidence for settlement and land-use for north-east England from the Mesolithic to the end of the Roman period is, to the author's knowledge, the first attempt to compile such evidence for the whole of the north-east of England for the whole of this period, apart from the"Archaeology in the North" gazetteer (Clack and Gosling 1976), which covers a wider region and a longer time period, but which is now somewhat out of date, and county Sites and Monuments Records, which are constructed from a range of gazetteers, surveys and published data.

Part II of this study, Chapters 5 and 6, evaluated a range of different methods for using pollen data to shed light upon settlement and land-use, including methods already used in the pollen literature and new approaches. In Chapter 5 and Appendix B it was demonstrated that indicator types have tended to be used in the pollen literature without a detailed, critical study of the ecological conditions in which each indicator type occurs. It was concluded that very few of the traditionally used indicator types can, without complications, be used as secure indicators of human activity, let alone specific types of land-use. However, when the evidence from several indicator types is used together, a more reliable picture can be gained of the members of each indicator taxon that are likely to have been present, especially if the ecological interpretations from the different indicator taxa present all agree.

The evaluation of different arable: pastoral indices in Chapter 5 demonstrated that the arable: pastoral indices created by Steckhan (1961), Lange (1975), Kramm (1978) and Riezebos and Slotboom (1978) do not distinguish well between sites in predominantly arable areas from those in predominantly pastoral areas. This is because these indices depend heavily upon the occurrence of *Cerealia*-type pollen to produce an arable score. Because of its low pollen production and dispersal, it is unlikely to show up in large quantities, even in arable areas. However, the indices created by Turner (1964), Donaldson and Turner (1977), Brown (1977), Roberts *et al.* (1973) and the agricultural: arable index created by Fenton-Thomas (1992) produced scores which compared favourably with the known pattern of modern land-use across the region, and distinguished well between those areas dominated by arable land cover and those dominated by grassland. Of these indices, the index produced by Fenton-Thomas is technically the best to use, since firstly it differentiated between different pollen sites the most clearly of all the indices, and secondly because the choice of pollen taxa to include in his arable and agricultural categories is the most consistent of all the indices with the conclusions reached in Appendix B. On the basis of this, it was decided to use Fenton-Thomas' index to produce the agricultural: arable maps for Chapter 7.

The review in Chapter 5 of modern studies investigating the pollen rain associated with agriculture and different types of land-use (the comparative approach to using pollen to reconstruct past land-use) has revealed that there has been surprisingly little work carried out into understanding the relationship between pollen, vegetation and land-use. Since there has been so little work, it was decided not to carry out such a study since a considerable amount of modern surface sampling work and vegetation survey would have to be carried out. Suggestions for how such work could be carried out are provided in the next section and a detailed research proposal is given in Appendix C.

Chapter 6 reviewed possible methods to shed light upon past settlement and land-use using a combination of pollen and archaeological data. The catchment approach identifies gaps in the archaeological record for settlement and land-use by comparing, for each archaeological period, the number of archaeological sites within the catchment area of each pollen site with the averaged pollen values for trees and shrubs, herbs and Ericaceae for that period at that site. Where the pollen evidence suggests clearance but there are no, or few, archaeological sites in the catchment, it is suggested that there may be a gap in the archaeological record around this pollen site. This approach is very simple and straightforward and overlooks a lot of information about clearance that could be provided by individual herb taxa. In addition, the lack of trees and shrubs in an area may not necessarily be due to human activity, particularly in upland areas where the development of blanket bog may prevent tree growth. However, this approach is useful for highlighting pollen cores which have an unusual number of archaeological sites in their catchments and these pollen cores can then be investigated in more detail. The interpolation approach sheds light upon the types of land-use associated with different types of archaeological evidence. For each period, pollen values are extracted for trees, shrubs, herbs and Ericaceae and scores for the agricultural: arable index for the locations of each archaeological site for that period. The results are displayed in the form of pollen diagrams for each taxon showing the mean and standard deviation for that taxon for each category of archaeological evidence for each period.

Chapters 7 to 9 applied the methods investigated and developed in Chapters 5 and 6 to investigate settlement and land-use in north-east Englandfrom *circa* 8000 cal. BC - cal. AD 500. Chapter 7 produced pollen maps for selected 500 year time periods for selected herb taxa used as indicators and for the agricultural: arable index. Summary maps for total trees, shrubs, herbs and Ericaceae were also produced. Chapter 8 presented the results of the combined pollen and archaeological approaches discussed in Chapter 6.

This study is the first to draw upon the vast potential information provided by the large numbers of pollen cores available for north-east England to address archaeological questions over such a long time period, from the Mesolithic to the end of the Roman period. Many reviews of the pollen evidence already exist in the archaeological literature for the later periods, from the late Bronze Age onwards, although these have focused on the area between the Tyne and Tees and rather neglected Northumberland. The results for these periods redress the balance by investigating whether trends demonstrated to have occurred south of the Tyne also occurred to the north, or whether developments in Northumberland were different. It is for the earlier periods, from the Mesolithic to the late Bronze Age, that the results in Chapters 7 and 8 make a particularly important contribution, since to the author's knowledge there is no previously existing comprehensive review and account of the pollen evidence for these periods for the whole of the north-east.

10.2 Prospects for further work

Further work that could be carried out stemming from the research in this study divides into several sections. Firstly, further work that could be carried out using the North-east England Pollen Database created for this study is outlined. Secondly, suggestions are made as to where pollen cores could be profitably be taken in future to fill in the gaps in the distribution of pollen sites. Thirdly, some suggestions are made as to how to improve the use of pollen indicators and indices by carrying out surface pollen sampling studies in order to improve our understanding of pollen rain associated with different types of land-use. A research proposal for a pollen sampling study is outlined. Fourthly, some suggestions as to how to improve combined pollen and archaeological approaches described in Chapter 6 are proposed, and some new methods for using pollen and archaeological data to shed light on past settlement and land-use are put forward.

10.2.1 Further work stemming from the construction of the North-east England Pollen Database

The pollen database for north-east England created for the purposes of this study has considerable potential to be used in a wide range of projects, other than investigating past settlement and land-use. Not only does the database contain pollen data for the indicator herb taxa used in this study, but also the full range of pollen taxa identified at all the pollen cores, including tree and shrub taxa plus pteridophytes and aquatics. The database design enables specific pollen data for certain periods, certain pollen or certain areas of the region to be retrieved and extracted easily. Since the pollen data is available in raw count form it is possible to use whatever pollen sums are necessary for the particular research project. In addition, since the database was designed along the lines of the European Pollen Database, it is hoped to be able to make the database fully compatible with other databases. It is hoped to be able to continue maintaining the pollen database, and to bring it up to date as new pollen cores are studied. The database would then form a valuable archive for pollen data from the region. The database is also of great value for individual pollen workers, since pollen data can then be kept in Tilia format on disk instead of in the form of pollen count sheets. In addition, since the pollen count sheets of various pollen workers are distributed in many different places, and are often a couple of decades old, and since several pollen workers have not stayed in the field, it is important to create a central database containing all information to which users can apply to gain access to pollen data, obviously with the permission of the relevant pollen worker.

As well as having the pollen data and site information available in the form of the database, it would be useful to develop the G.I.S. side of the database further and make it more user-friendly, so that any user wishing to retrieve data say for a particular taxon, could bring up on screen pre-created maps for that taxon for different time periods. Similarly, any combination of different pollen taxa could be combined to form a new map (for example one could combine all the maps for taxa found in particular ecological conditions, such as blanket bog, or arable land or open grassland). This could be carried out using the Grid options in Arc/Info to add or subtract grids together to form new grids, and then display the new grid as a map. In addition it could be possible to set up the G.I.S so that a user could query for the locations of all the pollen cores within a given radius of a location, say an archaeological site that the user is excavating or surveying, if he/she wishes to investigate the pollen evidence in the area of the site in more detail. This could easily be carried out using the buffering option in Arc/Info described in Chapter 6. Alternatively a pollen worker wishing to take new cores from the region could examine the distribution of existing pollen core locations, their elevations and type of locations, and the time periods covered by each core, in order to find locations where new study would be most profitable. Furthermore it would be possible to interpolate pollen values for each proposed new pollen core location using Arc/Info and create a mock pollen diagram of expected pollen values for a site, and then compare this with the resultant pollen diagram, once it had been created. This would be a useful way to test the value of interpolation as a predictive tool. A pollen worker could also use the buffering tool to locate all the known archaeological sites and findspot locations within a stated radius of their pollen site for stated periods, to aid interpretation of the pollen diagram, or alternatively choose to locate a pollen core very close to an existing archaeological site location to investigate whether this shows up in the pollen record.

The pollen database is also a valuable research tool for workers outside the fields of palynology and archaeology; for example, a worker in ecology studying the present day ecology and distribution of a particular species, genus or family may require distribution maps of that particular taxon in the past, showing its change in distribution over time.

There are a range of possible research projects that could be addressed using the North-east England Pollen Database. These include building upon the studies carried out by Turner and Hodgson (1979, 1981, 1983, 1991) for the Northern Pennines studying the distribution of different tree taxa across this area for the Boreal, Atlantic and Sub-Boreal periods. This study could be expanded by using data from the whole of north-east England, by using more, shorter time periods and producing pollen maps for these tree taxa as well as carrying out multivariate analyses as were carried out by Turner and Hodgson to summarise the trends in the data. The data could also be used to investigate the timing of events in the pollen curves across the region, such as the timing of spread of certain tree and shrub taxa into the area following the deglaciation, or the *Ulmus* decline. It would also be possible to concentrate on one taxon and investigate the soil types, geology, elevation and locations in which it occurred in the past to see how its distribution has changed through the past up to the present day.

A particularly interesting study in the light of the present study would be to examine individual indicator taxa in more detail to investigate whether it was associated with a different range of taxa in the past compared to today. This could be carried out using multivariate analyses to show changing associations and groupings of different taxa over time. Multivariate analyses such as DECORANA could be used to identify vegetation groupings in the past and show how these groupings change in distribution over time and also change in composition over time. Analyses such as CANOCO could be used to investigate how these vegetation groups relate to factors such as location, elevation, soil type and geology and how this changes over time. The resultant vegetation groupings could be mapped in the same way as individual pollen taxa, to produce maps for the north-east of England. Past vegetation groups could be compared with the range of vegetation communities known to occur across north-east England today to identify groups in the past that have no modern analogues.

It could also be possible to use pollen data to reconstruct past climatic conditions in the north-east of England, and how they vary across the region. As discussed in Chapter 2, the north-east of England has a very interesting west-east gradient in elevation which is closely related to temperature and precipitation, but also a north-south gradient in temperature and in addition the North Sea has interesting localised effects of summer temperatures. It would be very interesting to investigate whether these gradients existed in the past, and how they have changed over time. If certain pollen taxa could be found which were good indicators of particular climatic conditions, temperature ranges and precipitation levels, these could be mapped or analysed to produce climatic maps for the region.

This account of possible research that could be carried out using the North-east England Pollen Database only covers a small range of the possible research projects that could benefit from using an already existing pollen database. Since there is a large amount of pollen data already available, in an easily retrievable form, the database is a valuable research tool to address a wide range of issues that can be addressed using pollen data, whether these are ecological, archaeological or climatological issues.

10.2.2 Suggestions for further pollen coring work

The description of the distribution of pollen core site in the region in Chapter 3 has highlighted a few gaps in the pollen record of the region, which could benefit from further pollen work. In terms of the overall distribution of pollen cores, there is a noticeable lack of cores in central Northumberland, Tyne and Wear and on the coast between Lindisfarne and Hartlepool. A number of promising sites were sampled by Blackburn in the 1930s in this area, but not in any great detail, and would repay further study. Glacial deposits in the Northumberland lowlands studied by Bartley would benefit from radiocarbon dating long sequences, to match the long dated sequence from the Tees lowlands to the south. There is a need for more sites with longer sequences from Northumberland as a whole, as the majority of dated sites from the county focus upon time periods more recent than the first millennium BC. Concentrations of sites in the Northumberland uplands on the same level of density as the Northern Pennines would also be ideal to investigate local variations across this area.

The lack of pollen cores in heavily urbanised areas of the region and the surrounding intensively cultivated lowlands is largely a result of landscape destruction and modification, mineral extraction and widespread land drainage for agriculture (as discussed in Chapter 2 and shown on the map of urban development and industrial land in Chapter 4). There is a great need for cores from isolated undrained locations, if local variations in vegetation and land-use in these areas is to be understood.

In contrast to Northumberland and the Tyne and Wear, County Durham is fairly well represented for pollen cores, over the range of landscape types from the lowland coalfields and Tees lowlands, to the Magnesian limestone plateau and Northern Pennine uplands. However there is still potential for further work in these areas; although the Northern Pennines have a high concentration of pollen cores, very few of these concentrate in any detail or with any dating on post-*Ulmus*-decline periods. There is a need for more studies in the upland valleys rather than the surrounding uplands to determine the changing nature and extent of vegetation and land-use here and to complement archaeological survey work. There is also a notable gap in core distribution between the Tees upland sites and lowland sites; work is needed between Barnard Castle, where the river comes out onto the floodplain and Neasham.

Survey is required in order to find suitable sites for coring in those areas already highlighted where there is a lack of pollen cores. Outside of areas covered by blanket bog, suitable sites are restricted to sites occurring in wetland areas, lowland peat deposits, lakes, old river or stream channels, and kettle holes and other infilled glacial features.

A notable gap in understanding of the pollen rain associated with different types of land-use has already been highlighted in Chapter 5. Prospects for further work in investigating the relationship between land-use, vegetation and pollen rain are considerable, and are detailed in Appendix C, together with a detailed research proposal describing the various phases of a study into the pollen rain associated with land-use, rather than being discussed here.

10.2.3 Improving combined pollen and archaeological methods for investigating settlement and land-use

Chapter 6 investigated two methods for combining pollen data with archaeological evidence for settlement and land-use to try and shed more light upon settlement and land-use in each period. There are, however, a number of ways in which these approaches could be improved and a few new approaches that could be investigated using pollen and archaeological data.

The catchment approach used in this study compares the number of archaeological sites in a catchment with only summarised pollen data for total trees and shrubs, herbs and Ericaceae. This could be improved by widening the number of pollen taxa used to identify clearance, by including a wide range of indicator herb taxa, and also a wide range of other herb taxa so that it is possible to distinguish between open, heavily disturbed sites with lots of, say, arable indicators, from open disturbed sites with lots of taxa associated with grassland, from open sites that are open because of the spread of blanket bog. Obviously, triangular ordination plots would be of no use to display this kind of information. Instead DECORANA could be used to group together sites with similar pollen compositions, so that groups dominated by high trees could be distinguished from those with more open tree cover and more shrubs and a few herb types associated with open woodland, from those with more open grassland, from heavily disturbed waste or cultivated land, from moorland, either wooded or unwooded. The numbers of archaeological sites within each catchment could, as before, be indicated by the size of the circle at each site on the DECORANA plot.

A similar, but alternative method to the catchment approach would be, instead of counting the numbers of archaeological sites within the pollen catchment, to measure the distance from each pollen site to the nearest archaeological site and compare the distances with pollen evidence for clearance.

The interpolation approach would also benefit from pollen values for a wider range of taxa being interpolated for each archaeological site location, not just trees, shrubs, herbs, Ericaceae and the agricultural:arable index score. In this way, a whole interpolated pollen diagram could be recreated for each archaeological site type, and each archaeological site location. Another useful type of information to interpolate for each archaeological site location would be a score for the agricultural land capability of that location for each period. Agricultural land capability can be expected to have changed over time since changes in climate, vegetation and land-use are likely to have affected soils, and therefore affect suitability of the land for agriculture. By calculating the agricultural land capability for archaeological site locations, it would be possible to tell whether, for example, settlement sites had over time changed from being situated on agriculturally good land to situation on agriculturally poorer land, or vice versa. Although this approach does not use pollen to help shed light upon the land-use associated with archaeological sites, it is a useful and interesting study which could complement the interpolation approach well. The likely vegetation around each archaeological site could be reconstructed using the interpolation approach and then the likely agricultural land capability could be reconstructed for that site location also.

Agricultural land capabilities for different areas of the north-east have been calculated by Ferrell (1992). This has been carried out by allocating scores to each area of the region according to its solid geology, present day climate and elevation, based upon knowledge of the different land capabilities of different bedrock geology types, different elevation bands and different climatic zones. These scores are then modified for each period in the past depending upon changes in climate, inferred from climatic maps produced by pollen workers. Ferrell calculated for each archaeological site location individually scores for agricultural land capability for each period. This however could be facilitated by using Arc/Info to create separate grids for geology and elevation and then have a different grid for climate for each period. These grids could then be combined together to produce an agricultural land capability grid for each period, and values could then be easily and quickly extracted for any location in the region.

There is a further way in which archaeological and pollen evidence could be combined to shed more light upon past land use. Archaeological evidence could be used as a way of identifying which pollen types might be good indicators of different types of land-use in the past. This would be useful, since the use of indicators is based upon the uniformitarian assumption that taxa associated with particular types of land-use today will be useful to identify those types of land-use in the past. However this may not necessarily be the case. If archaeological evidence could be used to identify good indicators for different periods, then this would avoid the need to rely upon the traditionally used indicator types in the literature. A possible way of doing this would be to find particular types of archaeological evidence or sites that could be identified with a particular type of land-use.

An example of this is quern findspots or carbonised or waterlogged crop and weed seeds to use as an indicator for arable agriculture, or artefacts linked with dairying or wool production or faunal evidence as indicators for pastoral agriculture. Obviously this is rather simplistic, as querns and charred seeds do not in themselves necessarily indicate cereal production at a site, only consumption (although the presence of charred or waterlogged remains from different stages of crop processing may suggest that more than consumption was going on at a site), just as spindle whorls and wool combs do not necessarily imply sheep farming at a site, just the processing of the wool product. However, in the absence of more direct evidence for arable activity at a site, or pastoral activity, or both, this type of evidence suffices. Other useful evidence could include ard marks, possible droveways or animal pens, or evidence for metalwork associated with cultivation. Archaeological sites could then be categorised across the region according to whether they were associated with evidence for arable or pastoral agriculture, or both, or none.

The next stage would be to use the pollen interpolation technique to interpolate pollen values for each of these archaeological sites. Multivariate analyses could then be carried out to identify groupings in archaeological sites according to their interpolated pollen values, and also to identify those pollen taxa responsible for distinguishing between the different groups. It would also then be possible to identify whether certain pollen taxa tended to be associated with those archaeological sites classed as "arable", as opposed to those sites classed as "pastoral" , or those classed as "both" or "neither". The presence of these taxa in areas where archaeological evidence is scarce, owing to lack of research, could then be used to indicate arable or pastoral or both types of land-use from the pollen data alone.

This would be an ideal situation if it worked. However, for north-east England it may be very difficult to find enough evidence to classify sites as arable or pastoral across the region for the analysis to work, and it may not be possible to classify any site as wholly arable or wholly pastoral, and rather sites may fall within a continuum from one to the other. The nature of the available archaeological evidence for north-east England means that this type of analysis might not be possible for all periods (for example the Mesolithic is only represented by lithic artefacts, and the Neolithic has very few settlement sites, and is mostly represented by monuments, lithics and pottery) or all areas of the region.

Comparatively few sites have been excavated. Most of the large numbers of rectilinear and curvilinear settlement sites for the region for example have been revealed through survey and aerial photography and only a small proportion have been excavated. It is excavated evidence which is required to class sites as arable or pastoral, or both, and in most cases the excavated evidence is not adequate to be able to classify sites in this way. Very few sites have had studies of carbonised plant remains carried out, although the number of sites is increasing, and there are few sites with good, sizeable faunal assemblages large enough to establish relative proportions of different species at a site, and whether the animals were kept at the site, or only certain body parts brought in. There might be only a small number of areas and a small range of periods where this type of analysis could be carried out in the north-east of England. In other parts of England where there are a greater proportion of excavated sites and archaeological evidence for land-use, the pollen record will not necessarily be as rich as that found in north-east England.

To sum up, this study has investigated some possible ways in which pollen and a combination of pollen and archaeological evidence can be used to help shed light upon past settlement and land-use, particularly in areas such as north-east England where the archaeological evidence is often patchy but the pollen evidence is abundant. This study does not claim to have covered every possible method that could be implemented to use pollen or a combination of pollen and archaeological evidence to investigate past settlement and land-use, but instead to show ways in which the past use of pollen evidence has been inadequate and suggest ways in which this might be improved. Only a few of the interesting issues brought to light by the pollen maps for each period have been discussed in Chapter 9 and there is considerable potential for further, more detailed study on each period. A range of approaches have been investigated and applied to investigate past settlement and land-use in north-east England from the Mesolithic to the end of the Roman period. This is a very long time period, and involves large amounts of archaeological evidence to consider and considerable amounts of archaeological literature to cover. As a result this study does not claim to provide ground-breaking new insights into the settlement and land-use for every period, particularly for the late prehistoric, for which the pollen evidence for the north-east has already been well studied with respect to archaeological issues. Instead, this study has used the north-east of England merely as a test ground and a study area to try out different methods for using pollen and pollen and archaeological evidence together for investigating past settlement and land-use investigated in earlier periods.

Although the main emphasis of this study has been on the investigation of different methods for using pollen to investigate settlement and land-use, the application of these methods to north-east England has resulted in the production of some interesting insights into land-use for the earlier prehistoric periods, which have been far less well studied in the archaeological literature compared to the later prehistoric. However, even for the later prehistoric, previous studies have concentrated only upon the area between the Tyne and the Tees and only looked at radiocarbon-dated pollen sites. This study has attempted to redress the balance by looking at changes in Northumberland as well as south of the Tyne and by using the large amount of information available from non-dated cores. It is hoped that the maps produced in this study will encourage archaeologists studying the north-east to move away from the traditional focus on the later prehistoric in the archaeological literature and concentrate in more detail upon the earlier periods and also to shift emphasis away from the Tyne-Tees region to the whole of the north-east of England.

Appendices

Appendix A

Appendix

A | A Guide to the North-east England Pollen Database

A 1. Introduction

This guide to the North-east England Pollen Database provides a detailed, table by table, column by column description of the structure of the pollen database. This document does not include any of the data entered into the database, which is contained on computer disk. It provides guidelines for the use of the database, to aid information retrieval. Tables summarizing the nature of the pollen data from the region entered into the database are presented in Chapter 3. Chapter 3 also provides a detailed account of the construction of the database, including the criteria for collection of pollen data, the reasons behind the choice of pollen database structure, and the reasons for choosing the database software program Paradox and pollen spreadsheet package Tilia to construct the database and enter in data.

To briefly review what has already been covered in Chapter 3 concerning the construction of the database, the North-east England Pollen Database, or NEEPD, was constructed along the lines of the European Pollen Database and North American Pollen Database (EPD and NAPD). Some differences do occur between the NEEPD and these two databases in terms of database design and table structure, although these are mainly minor differences concerning the differences in the nature of pollen data available for the region. These differences are outlined below. The smaller diversity of different types of pollen site and smaller number of dating methods used, to name a couple of main differences, have resulted in a lower number of tables in the NEEPD than the two other databases.

Like the EPD and NAPD, the basic design characteristic of the NEEPD is the large number of tables, each containing only a few fields, rather than having a smaller number of tables with a large number of fields. Tables are linked together by common fields for data retrieval. Although the large number of tables may at first sight appear confusing, the tables divide into different categories, explained below, according to the type of data they contain. The table-by-table guide which comprises the bulk of this Appendix aims to clearly explain the data contained in each table, the structure of the table, and how it relates to other tables in the database.

As has already been explained in Chapter 3, the database software program Paradox for Windows has been used to construct the database, since it is a Relational Database Management System, one which organises data as a set of interrelated tables. Tables consist of columns, or "fields" that contain only one type of information, and rows (or records) that represent individual entries. For example, in the table "SITELOC", containing information about the location of each pollen site, a typical fields include "Site Name", giving the full name of pollen sites, and Grid.Ref. giving the full National Grid Reference for site locations. A typical row would contain information about a single pollen site. The pollen spreadsheet program Tilia was used to enter in pollen count data, but this was then converted into Paradox tables storing pollen sample depth information, taxon lists and pollen counts. This means that all information concerning the pollen cores and sections available for north-east England, both background information and pollen count information, is stored in one database.

The database contains data concerning individual pollen cores and sections (here both called "entities", since not all pollen is taken from cores), pollen sites (a "site" is a location which can include one or more entities), publication information referred to in the database, information on pollen workers and authors, data on dating methods used and the dates available for each pollen entity, descriptions of sediment lithology of each entity, and lastly pollen count information.

A 2. Conventions used in this guide

This guide presents each table on a separate page, and for each table lists the table name, a brief description of the type of data contained in the table, the field names and type of data contained in each field. Those fields which are also found in other tables and can be used to link tables for retrieving data (termed "querying" in Paradox-speak) are identified, as are those fields which uniquely identify each entry in the table. Such fields are called "Key Fields" and are explained below.

A 2.1 Table and field names

In this guide, table names are referred to in bold letters (e.g. **SITELOC**), and names of columns, or "fields" referred to in italics (e.g. *Site no.*.) Table and field names found in the European Pollen Database, but not in the North-east Pollen Database, are differentiated by being underlined (e.g. **<u>ESR</u>** and *<u>HasAnLam</u>*.)

A 2.2 Data types

Each table is divided into a series of fields which fall into one of the three field categories below:

S Short integer

N Floating point number

A(n) Alphanumeric string with a fixed length of "n" characters. The string can include letters, numbers and symbols.

A 2.3 Keys

Keys are fields in a table which facilitate the sorting and querying of data. There are three types of key used in the database: Primary, Alternate and Foreign. Each table has a Primary key, which uniquely identify every row in the table. For example, the table **ENTITY** has as its Primary Key the field named *Entity no.*, a short integer field type (S) which uniquely identifies every entity (i.e. pollen core/ section/ surface sample) in the table. Tables may also have other fields which could alternatively be used to uniquely identify each row, which are called Alternate Keys. With the table **ENTITY**, the fields *Codename* and *Fullname* act as Alternate Keys; the six-letter codename for each entity and also the full name of each entity are both unique identifiers for each entity in the table.

The last type of key, the Foreign key, is any field which is a Primary key in another table. Foreign keys are essential when querying tables to search for information, since they form a common element between different tables, and enable them to be linked together whilst querying. Examples of Foreign keys in the table **ENTITY** are the fields *Site no.* and *Worker no.* The field *Site no.* also occurs as the Primary key in the tables **SITELOC** and **SITEDESC**. This enables these tables to be linked with the **ENTITY** table to find out more about the site location, vegetation, geology and topography of an individual core or section. The second Foreign key, *Worker no.*, also occurs as the Primary key in the tables **WORKERS**, **ADDRESS** and **AUTHORS**, which enables information about pollen workers associated with an entity, their address and publications they have produced to be obtained. Similarly the Primary key for the **ENTITY** table, *Entity no.*, is found as the Foreign key in many other tables.

A 3. An overview of the structure of the pollen database

The pollen database described here is made up of over 120 columns or "fields" of data organised into some 27 tables. Each table contains a different type of data concerning the pollen data. The tables divide into several categories, in terms of subject matter and also in terms of type of table. In terms of subject matter, the tables divide up as follows:

A 3.1 Pollen site location and setting

SITELOC	Information about pollen site location.
SITEDESC	Further information about topography, soil, geology and vegetation of the site.

A 3.2 Individual cores or sections

(N.B. individual cores, sections etc. are here called pollen "entities", rather than "cores" since pollen can be obtained from a variety of sources other than cores. Also note that there may be more than one entity at any given pollen "site", hence the need for a separate **ENTITY** table.)

ENTITY	Information about the name, codename and exact location of each entity.
ENTSIZE	The size of each entity; length and depth of top and base from the surface.
ENTDATA	Information about the nature of the pollen data available for the entity (for example raw pollen counts, percentage data) and whether it is gained from published data or from the pollen worker.)
ENTITY&&	This table stores additional notes on an entity.
P_PREP&&	Notes on pollen sample preparation methods.

A 3.3 Pollen workers

WORKERS	Information about the identity of each pollen worker responsible for information referred to in the database (whether as pollen collectors, analysts or authors of publications.)
ADDRESS	Contact addresses of workers in the **WORKERS** table.

A 3.4 Publication information

PUBLCIT	Full bibliographic citations for each publication referred to by the database.
PUBLSITE	Publications cross-referenced by site, so that the user can query for those publications associated with a pollen site, or conversely for those sites associated with any given publication.
PUBLENT	Similar to **PUBLSITE**, but this table cross-references publications by entity.
AUTHORS	Similar to **PUBLSITE** and **PUBLENT**, this table cross-references publications by author and notes whether each author is the first, second, third etc. author of a publication.
PUBLEVNT	Similar to the above tables, but this table cross-references publications by pollen "event". (A pollen "event" is a commonly occurring phenomenon in the pollen record such as the *Ulmus* decline which can be used to date non-radiocarbon dated sites by using dates

from nearby radiocarbon dated sites.) This table links publication information with tables concerning dating (below.)

A 3.5 Pollen data tables

(N.B. These tables (with the exception of the table **SEDIMENT**) contain all the pollen count data originally entered into Tilia, but converted into Paradox tables for ease of searching and querying. Spreadsheets were exported from Tilia as Lotus 1-2-3 files and imported into Paradox, where they underwent modification to form the following data tables.)

SAMPLE	Stores pollen sample depth information for each entity.
TAXA	Stores the name and identifying code for each pollen taxon used in the database.
COUNTS	Stores all the pollen counts for an entity. Here pollen counts are given in percentage format; as a percentage of total dry land pollen ("tdlp", which is pollen of trees, shrubs, herbs and ericaceous types.) Percentages are given for each combination of sample depth and taxon.
GROUP	Notes the group to which each taxon belongs, e.g. trees, shrubs, herbs, ericaceous types.
SEDIMENT	Information about the sediment lithology of each entity.

A 3.6 Dating information

C14	Information about all the dated levels in those entities with radiocarbon dates. This includes uncalibrated radiocarbon dates plus the calibrated midpoint of each date. (Chapter 3 explains the use of the calibrated midpoint.)
SYNEVENT	Lists the radiocarbon dated entity used to date each non-radiocarbon dated entity, based on the shared occurrence of a particular "event" in the pollen curves. Typical "events" include the *Alnus* rise and the *Ulmus* decline. These are assumed to have occurred broadly synchronously between sites that are close together geographically

and similar in elevation, although over wider areas such events can vary more in timing . (Chapter 3 contains a more in-depth explanation of the dating of non-radiocarbon dated entities by using such broadly synchronous events.)

CALEVENT Stores the date (in calibrated years BC/AD) of each event dated at each radiocarbon dated entity where that event occurs and is radiocarbon dated.

EVENT A look-up table which gives more information about the pollen event used for dating, including the nature and name of each event.

AGEDEPTH Stores an age estimate in calibrated years BC/AD for every sample depth for every entity, calculated by interpolation using the Tilia program. Dates are interpolated from radiocarbon dated levels or in the case of non-radiocarbon dated entities, by assigning dates from radiocarbon dated entities on the basis of commonly occurring events, as explained above.

AGEBASIS Stores the dates used for interpolation, whether they are radiocarbon dates (converted to calibrated midpoint dates for the purposes of interpolation) or dates assigned to levels in non-radiocarbon dated entities, based on the occurrence of a pollen event.

DATING&& Stores additional information on dating methods used, whether radiocarbon, or using broadly synchronous events to date non-radiocarbon dated entities. In the latter case, reasons for choosing the specific radiocarbon-dated entity used to date the non-radiocarbon dated entity are given.

A 4. Database design differences between the North-east England Pollen Database and the European Pollen Database:

The North-east England Pollen Database design was based upon the design of the European Pollen Database. However, owing to the different aims of the construction of the databases, and differences in the nature of the data entered into the two databases, there are a number of differences in database design, table structure and field and table names. The differences in aims and nature of data between the databases is discussed in Chapter 3 in more detail. The differences in database structure between the NEEPD and EPD are described below, together with explanations for the changes.

- Since the North-east England Pollen Database is only dealing with a region containing four counties, rather than many countries, fields in tables such as **WORKERS** and **SITELOC** concerning addresses or locations of sites will be different. Similarly, there is no need for look-up tables explaining codes for different countries or regions in detail and therefore the tables **POLDIV1**, **POLDIV2** and **POLDIV3** are ommitted from the NEEPD.

- In the table **SITELOC**, since only National Grid References are used in this study rather than Latitude and Longitude or UTM designations, fields are modified accordingly. In addition, a code is not assigned to each site in the NEEPD. Instead, a code is given to each entity, and is stored in the table **ENTITY**.

- In the table **SITEDESC**, since information on the geology, soils and topography of each pollen site is needed for this study, this information is included, whereas it is absent in the EPD. Information on the vegetation formation and IGCP type code for the vegetation is not used: instead there is a brief description of the surrounding present vegetation of the site. As a result, there is no need for the EPD table **IGCTYPE** which is a look-up table storing names and codes for the IGCP type regions.

- The table **PUBLSITE** in the NEEPD cross-references sites and their associated published information. This table is called **SITEINFO** in the EPD. The change of table name was carried out to make it more consistent with other cross-referencing tables such as **PUBLENT** and **PUBLEVNT**.

- In the NEEPD, the table **ENTITY** has no field called *HasAnLam* since annual lamination data (for example, glacial varves) is not available for the north-east of England. Information about the nature of the modern entity site (e.g. basin, plateau, shelf) is not included here, but is included in the table **SITEDESC**, and there is no table called **DESCRIPTOR** in the NEEPD listing codes for different types of topography, nor a look-up table explaining these codes (**DESCR**.) This is because there are only a few types of pollen site topography in the region, and therefore no real need for a separate look-up table.

• In the NEEPD the table **ENTDATA** is used to refer to the type of pollen data available for each pollen entity, whilst in the EPD this is called **P_ENTITY**. It is felt that this table more clearly indicates the type of information in the table. Similarly, the table ENTSIZE in the NEEPD replaces the table **COREDRVS** in the EPD. This is because information on individual core "drives" (each individual coring that makes up a whole core length) is unavailable for the North-East of England. Instead information on the length of an entity and depth from the surface of the top and base, whether it is a core or a section is included in the table (hence the name **ENTSIZE** rather than "CORESIZE", which would refer just to cores rather than all entities.)

• In the NEEPD, since radiocarbon dating is the only method used for dating pollen entities so far, there is no need for the various tables concerned with different dating methods found in the EPD, such as **AAR** for Amino Acid Racemisation, or **ESR** for Electron Spin Resonance, or for a master table **GEOCHRON**, summarizing the type of dating used for each entity. Instead there is only one table, concerning radiocarbon dates, called **C14**, similar in design to the EPD table **C14.** There is also, due to the lack of large numbers of different dating methods, no need for a look-up table (**INFOTYPE**) listing full names of dating methods for all the codes used in **GEOCHRON**.

• Since calibrated dates are used in this study, the table **C14** includes an extra field *Cal. Midpoint* recording the calibrated midpoint of each radiocarbon date.

• A series of tables are needed in the NEEPD to show the use of broadly synchronous events to date non-radiocarbon dated entities. These include **EVENT, PUBLEVNT, CALEVNT** and **SYNEVENT**. In the EPD there is a table called **EVENT**, and this stores the description of any synchronous event such as the occurrence of tephra (volcanic glass) deposits, and a table called **SYNEVENT** storing infomation on ages associated with entities based on evidence for synchronous events. In the NEEPD the tables are more complex and numerous, because the NEEPD uses non-radiocarbon dated sites, and also because events used to date them are not strictly synchronous. Therefore, there is not just one single date associated with a given event, but several. As a result, there is a need to specify which date from which radiocarbon dated entity is being used to date the occurrence of an event from a non-radiocarbon dated site. The tables **AGEBASIS** and **AGEDEPTH** correspond to the EPD tables **AGEBASIS** and **P_AGEDPT**, with the exception that calibrated midpoint dates are used in interpolation, instead of uncalibrated radiocarbon dates. The notes table CHRON&&, used in the EPD to store notes on the derivation of the age-depth data is not needed here. Any notes on derivation of the age-depth curve are recorded in the notes table **DATING&&**.

• Since there is no information on annual laminations from North-East England, the EPD tables **ALSEGS** and **P_ANLDPT** are not necessary.

• Since macrofossil evidence is not used in this study, and rarely noted for entities from the study-region, no macrofossil tables are needed, such as the EPD tables **M-COUNTS** (dealing with counts of macrofossil evidence) or **M_SAMPLE** (macrofossil sample depths.)

• The table **SAMPLE** is virtually identical to the EPD table **P_SAMPLE**, ommitting the field *Thickness*, since the thickness of each sample taken is rarely specified in the pollen literature for north-east England. Similarly the table **COUNTS** is virtually the same as the table **P_COUNTS**, except that the field *Var#* is renamed *Taxon#* to be consistent with the table **TAXA**, which contains the names and codes of each pollen taxon used in the database (called **P_VARS** in the EPD.) The table **GROUP** corresponds to the EPD table **P_GROUP**, except that since there are only four main groups of taxa used in the NEEPD (trees, shrubs, herbs and ericaceous types), there is no need to have a look-up table (**GROUPS**).

• The EPD table **LITHOLGY** is renamed **SEDIMENT** in the NEEPD, but apart from this the tables are very similar, except for missing out the field *LoBoundary* (since the nature of the lower boundary of lithological units in most pollen accounts from the north-east is not described.) Since loss-on-ignition data is not available for the study-region either, the table **LOI** is ommitted.

• Since accession numbers are not recorded in this study, the separate publications table **PUBL** is not included in the NEEPD. Instead, the main publications table is **PUBLCIT**, which, like its counterpart in the EPD, contains full bibliographic citations. The cross-referencing tables **PUBLENT** and **AUTHORS** are also identical to their counterparts in the EPD.

• The system tables used in the EPD (**SYSCAT**, **SYSCOL**, **SYSIDX**, **SYSFKS** and **SYSNOS**) to record the names of all the tables, the field types and the keys used by each table are not used in the NEEPD. Instead, the diagram showing the interrelationships of the tables and fields in each table (Fig. A1) is considered adequate for this purpose.

Table: **C14** Dating information

Description:

This archival table stores information about the dated levels in pollen cores, including the age determination of each radiocarbon sample sent for dating, the standard deviation, the laboratory number of each sample, the depth of each sample in the core and the core from which each dating sample derives. Unlike with the European Pollen Database, only one table is needed to store information about dating, as only one method of dating pollen cores, radio-carbon dating, has been used so far for the north-east of England. The EPD has several tables each containing information about a specific method of dating (for example Amino Acid Racemisation or Thermoluminescence dating).

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for the entity (core/surface sample etc.) from which the dating sample comes from.)
Sample no.	**S**	Unique identifier for each dating sample.
Depth (cm)	**N**	Depth in cm. of the midpoint of the dating sample.
Age (BP)	**N**	Age determination of the sample in years BP (where BP is 1950, using the Libby half-life.)
UpperSTD	**N**	The upper standard deviation of the age
LowerSTD	**N**	The lower standard deviation of the age
Publ. no.	**S**	Number referring to the publication containing information about this dated sample.

Keys:

Primary Key	*Entity no.*	
	Sample no.	
Foreign Key	*Entity no.*	references the table **ENTITY** (basic information about each core/surface-sample etc.)
	Publ. no.	references the table **PUBL** (full citation for each publication.)

Table: **ENTSIZE** Dimensions of each entity.

Description:

This archival table stores information about the length and depth in cm of the top and base of each entity (whether this is a core, section or surface-sample) from the surface.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for the entity (core/surface sample etc.)
CoreTop (cm)	**N**	Depth in cm. of the top of the entity from the surface.
CoreBot (cm)	**N**	Depth in cm. of the base of the entity from the surface.
CoreLength	**N**	Length of the entity in cm.

Keys:

Primary Key *Entity no.*

Foreign Key *Entity no.* references the table **ENTITY** (basic information about each entity).

Table: **ENTITY** Basic information about each entity.

Description:

This archival table stores basic information about each entity. An entity can be a core, a section or a surface sample; basically, any entity from which pollen samples can be taken. There may be more than one entity at any given pollen site.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for the entity.
Site no.	**S**	Unique identifier for the site from which the entity comes.
Codename	**A(6)**	Unique six-letter code name ascribed to each entity.
Name	**A(30)**	Full name of the entity. This may be the same as the site name if there is only one entity per site.
Entity Type	**A(15)**	Identifies whether the entity is a core, section, surface sample or soil sample.
Entity Location	**A(40)**	Exact location of the core within the site (e.g. "On the south edge of the bog.)
LocalVeg.	**A(40)**	Information about the local vegetation at the collection site.
Sampling Device	**A(30)**	Type of sampling or coring device used.
Worker no.	**S**	Unique identifier of worker responsible for colection of the entity.

Keys:

Primary Key *Entity no.* Alternate Key *Codename*

Fullname

Foreign Key *Site no.* references the table **SITELOC** (containing locational information for each site.)

Worker no. references the table **WORKERS** (information about each pollen worker.)

Table: **SITELOC** Information about location of each site.

Description:

This archival table stores information about the location of each pollen site. A site is a location which may have more than one "entity" (pollen core, section or surface sample) collected from it.

Table Structure:

Field name:	Field type:	Description:
Site no.	**S**	Unique identifier for the site.
Site Name	**A(40)**	Unique name of the site referred to in publications and/or by the worker(s).
Nat.Grid.Ref	**A(8)**	National Grid Reference (e.g. NY 860 335)
Easting	**N**	Six-number National Grid Reference for Easting (The two letters referring to each 100 km square, e.g. NY, are represented here in numeric format. Hence NY 860 335 becomes Easting 3860000 Northing 533500.)
Northing	**N**	Six-number National Grid Reference for Northing (e.g. the Northing of the above example would be 533500.)
Elevation	**N**	Elevation (altitude) of the site in metres above sea level.
Area of Site	**N**	Approximate area of the present site in metres (e.g. the extent of a bog.)
Loc.1	**A(30)**	Name of the nearest habitation.
Loc.2	**A(30)**	Name of the district.
Loc.3	**A(30)**	Name of the county within north-east England.
Loc.4	**A(30)**	Geomorphological zone (e.g. upland/lowland)

Keys: Primary Key *Site no.*

Alternate Key *Site Name*

Table: **SITEDESC** Information about the nature of each site.

Description:

This archival table stores further information about the each pollen site, including a description of its surroundings, the nature of the topography, the surrounding vegetation, geology and soils.

Table Structure:

Field name:	Field type:	Description:
Site no.	**S**	Unique identifier for the site.
Site Description	**A(40)**	Brief description of the present nature of the site (e.g. "extensive blanket bog", or "infilled kettle hole").
Topography	**A(15)**	Information about the topography of the site (e.g. plateau, basin, shelf, col, stream channel, glacial hollow.)
Geology	**A(30)**	Bedrock and drift geology at the site.
Soils	**A(30)**	Type of soil occurring at the site.
Surrounding Veg.	**A(40)**	Information about the vegetation surrounding the site.

Keys:

Primary Key *Site no.*

Foreign Key *Site no.* references the table **SITELOC** (containing locational information for each site.)

Table: **WORKERS** Information about each pollen worker.

Description:

This archival table stores information about each pollen worker responsible for information included in this pollen database. A pollen worker can be a collector of pollen cores/sections/surface samples, a pollen analyst, and/or an author responsible for publications referred to in the database. Information in this table includes names, work phone number and electonic (e-mail) address (if available). Contact addresses for each worker are stored in the separate table **ADDRESS**.

Table Structure:

Field name:	Field type:	Description:
Worker no.	**S**	Unique identifier for each worker.
Title	**A(10)**	Title of worker (e.g. Mr/Mrs/Miss/Dr./Prof.)
Initials	**A(10)**	Full initials of the worker, without spacing (e.g. "J.B.")
Last Name	**A(30)**	Last name of worker.
First Name	**A(15)**	First name of worker.
Phone	**A(20)**	Telephone number (including area code.)
E-Mail Address	**A(40)**	Electronic mail address of worker (if available.)

Keys:

Primary Key *Worker no.*

Table: **ADDRESS** Addresses of workers.

Description:

This is an archival table storing addresses of workers. Addresses are stored line by line, with each line having an unique identifier, and each line being attributed to an individual worker in the **WORKERS** table.

Table Structure:

Field name:	Field type:	Description:
Worker no.	**S**	Unique identifier for each worker.
Line no.	**S**	Unique identifier for each line of the address.
Address	**A(60)**	Text of each address line.

Keys:

Primary Key	*Worker no.*	
	Line no.	
Foreign Key	*Worker no.*	references the table **WORKERS** (information about each pollen worker.)

Table: **ENTDATA** The source and type of data available for each entity.

Description:

This archival data contains information about the source of the data for each entity entered into the database (for example whether the data was gained from publications or from the pollen worker) and the form of data available (for example raw pollen counts, percentage data, data already entered into Tilia, data only available in the form of pollen diagrams.)

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Worker no.	**S**	Unique identifier for the worker responsible for the data (i.e. the contact person.)
AnalyDate	**A4**	Year the pollen analysis was carried out.
Data Source	**A(30)**	Source of the data (publication or the pollen worker.)
Data Form	**A(30)**	Form of the data, whether raw pollen counts, pollen percentages, or data already entered in Tilia format.

Keys:

Primary Key	*Entity no.*	
Foreign Key	*Entity no.*	references the table **ENTITY** (basic information about each entity.)
	Worker no.	references the table **WORKERS** (information about each pollen worker.)

Table: **SEDIMENT** Sedimentlithologyinformation.

Description:

This archival table stores information about the sediment lithology of the entity, dividing each entity into lithological units with the same type of sediment, and describing the nature of the sediment in each unit.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Sediment no.	**S**	Unique identifier for each lithological unit.
Description	**A(40)**	Description of the lithological unit.
DepthTop (cm)	**N**	Depth of the top of the lithological unit in cm.
DepthBot (cm)	**N**	Depth of the base of the lithological unit in cm.

Keys:

Primary Key	*Entity no.*	
	Sediment no.	
Foreign Key	*Entity no.*	references the table **ENTITY** (basic information about each entity.)

Table: **SAMPLE** Pollen sample depth information.

Description:

This archival table stores the sample depths in cm from the surface for each entity. Each entry has an unique sample number and is identified to the entity it comes from by the entity number.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Sample no.	**S**	Unique identifier for each sample.
Depth (cm)	**N**	Depth in cm of the sample from the surface.

Keys:

Primary Key	*Entity no.*	
	Sample no.	
Foreign Key	*Entity no.*	references the table **ENTITY** (basic information about each entity.)

Table: **COUNTS** Pollen count information.

Description:

This archival table stores the pollen counts for an entity. The table stores the counts for each combination of taxon and sample. The depths of each sample in cm from the surface are recorded in the table **SAMPLE**. Pollen counts are given here as a percentage of total dry land pollen (tdlp), i.e. excluding pollen of acquatics and spores.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Sample no.	**S**	Unique identifier for each sample.
Taxon no.	**S**	Unique identifier for each pollen taxon.
Count	**N**	Pollen count (given as a percentage of tdlp.)

Keys:

Primary Key	*Entity no.*	
	Sample no.	
	Taxon no.	
Foreign Key	*Entity no.*	references the tables **ENTITY** (basic information about each entity) and **SAMPLE** (sample depth information.)
	Sample no.	references the table **SAMPLE** (sample depth information.)
	Taxon no.	references the table **TAXA** (storing names and codes of each pollen taxon used in the database.)

Table: **TAXA** Look-up table for pollen taxa names.

Description:

This archival table stores the name and identifying code for each pollen taxon used in the pollen database. The identifying codes used for each pollen taxon are firstly the numeric code and secondly the eight letter code used in the European Pollen Database. Also included is the taxon number of the next higher taxon of which the pollen type is a member (for example the next higher taxon of *Plantago lanceolata* is *Plantago*.) If the taxon number is the same as the next higher taxon number, then it is the highest taxon recognised.

Table Structure:

Field name:	Field type:	Description:
Taxon no.	**S**	Unique identifier for each taxon.
Numeric code	**N**	Numeric code for each taxon (following the EPD numeric coding system.)
8-letter code	**A(8)**	Eight letter code for each taxon (following the EPD eight-letter coding system.)
Taxon name	**A(30)**	Name of the pollen type.
HigherTaxon	**S**	Taxon number of the next higher taxon of which the pollen type is a member.

Keys:

Primary Key *Taxon no.*

Alternate Key *Numeric code*
8-letter code
Taxon name

Table: **GROUP** Major group to which a pollen taxon is assigned.

Description:

This table stores the group to which each pollen taxon is assigned. Pollen taxa are grouped according to whether they are trees, shrubs, herbs or Ericaceae (and other dwarf shrubs.)

Table Structure:

Field name:	Field type:	Description:
Taxon no.	**S**	Unique identifier for each pollen type.
Group Name	**A(30)**	Name of the group to which the pollen type is assigned (e.g. “trees”.)

Keys:

Primary Key *Taxon no.*

Foreign Key *Taxon no.* references the table **TAXA** (names and codes for each pollen type.)

Table: **PUBLCIT** Full bibliographic citation information.

Description:

This table stores the full bibliographic citation for each publication referred to by the database. Each line (60 characters) of a bibliographic citation has its own unique identifier. Publications are entered in the style of the journal Ecology, following the practice of the EPD.

Table Structure:

Field name:	Field type:	Description:
Publ. no	**S**	Unique identifier for each publication.
Line no.	**S**	Unique identifier for each line.
Text	**A(60)**	Sixty characters of text for each line of the bibliographic citation.

Keys:

Primary Key *Publ. no.*
Line no.

Table: **PUBLENT** Publications cross-referenced by entity.

Description:

This table can be used to find those publications associated with an entity, and conversely those entities associated with a publication.

Table Structure:

Field name:	Field type:	Description:
Publ. no	**S**	Unique identifier for each publication.
Entity no.	**S**	Unique identifier for each entity.

Keys:

Primary Key	*Publ. no.*	
	Entity no.	
Foreign Key	*Publ. no.*	references the table **PUBLCIT** (full bibliographic citations for each publication.)
	Entity no.	references the table **ENTITY** (information about each core/ section/ surface sample.)

Table: **PUBLSITE** Publications cross-referenced by site.

Description:

This table can be used to find those publications associated with a site, and conversely those sites associated with a publication. This table is very similar to PUBLENT, but since there may be more than one entity at any one site location, there may be more publications associated with a site than one single entity at that site.

Table Structure:

Field name:	Field type:	Description:
Publ. no	**S**	Unique identifier for each publication.
Site no.	**S**	Unique identifier for each site.

Keys:

Primary Key	*Publ. no.*	
	Site no.	
Foreign Key	*Publ. no.*	references the table **PUBLCIT** (full bibliographic citations for each publication.)
	Site no.	references the table **SITELOC** (pollen site location.) references the table **SITEDESC** (more information about each pollen site.) references the table **ENTITY** (information about each core/section/ surface sample.)

Table: **AUTHORS** Publications cross-referenced by author(s).

Description:

This table can be used to find those publications associated with a pollen worker, and conversely those pollen worker(s) associated with a publication. This table links together the publication table **PUBLCIT** with the table **WORKERS** giving information about each pollen worker.

Table Structure:

Field name:	Field type:	Description:
Publ. no	**S**	Unique identifier for each publication.
Worker no.	**S**	Unique identifier for each worker.
Order	**S**	Ordering of authorship in a publication (e.g. 1,2,3)

Keys:

Primary Key	*Publ. no.*	
	Worker no.	
Foreign Key	*Publ. no.*	references the table **PUBLCIT** (full bibliographic citations for each publication.)
	Worker no.	references the table **WORKERS** (information about each pollen worker.)

Table: **AGEDEPTH**

Age estimates for each sample depth.

Description:

This table stores an age estimate in calibrated years BC/AD for each sample depth of each entity, calculated by interpolation using the Tilia pollen program. Ages for each sample depth are interpolated from radiocarbon dated levels or levels dated by analogy with dated cores. These dated events are converted from radiocarbon years BP to calibrated years BC/AD before interpolation to each sample depth.

Table Structure:

Field name:	Field type:	Description:
Entity. no.	**S**	Unique identifier for each entity.
Sample no.	**S**	Unique identifier for each sample depth.
Age (cal yrs. BC/AD)	**N**	Estimated age in calibrated years BC/AD derived by interpolation using Tilia.

Keys:

Primary Key	*Entity no.*	
	Sample no.	
Foreign Key	*Entity no.*	references the table **ENTITY** (information about each core/section/ surface sample.)
	Sample no.	references the table **SAMPLE** (giving sample depths for each entity.)

Table: **AGEBASIS** Dates used to establish age-depth.

Description:

This table stores the dated levels in each entity that are used to interpolate ages for each sample depth, the results of which are stored in the table **AGEDEPTH**. This table contains all dated sample levels, whether they were dated by radiocarbon dating (listed in the table **C14**), or by analogy with radiocarbon dated cores, on the basis of the occurrence of common events in the pollen curves, for example the *Ulmus* decline (samples dated by analogy are listed in the table **SYNEVENT**.)

Table Structure:

Field name:	Field type:	Description:
Entity. no.	**S**	Unique identifier for each entity.
Sample no.	**S**	Unique identifier for each sample depth.
Depth (cm)	**N**	Depth of the sample in cm. from the surface.
Age (cal.yrs BC/AD)	**N**	Calibrated midpoint of the sample (explained in Chapter 3.)

Keys:

Primary Key	*Entity no.*	
	Sample no.	
Foreign Key	*Entity no.*	references the table **ENTITY** (information about each core/section/ surface sample.)
	Sample no.	references the table **SAMPLE** (giving sample depths for each entity.)

Table: **SYNEVENT** Dates from commonly occurring events.

Description:

This table stores, for each non-dated pollen entity, the depth of each sample where an event occurs which can be dated by analogy with a nearby, suitable radiocarbon dated site. This table notes the number of each non-dated pollen entity and the sample depth where the event is noted. This is followed by a reference to the event dated at the nearest radiocarbon dated entity. This refers to the table **CALEVENT** which givest the calibrated date of each event at each radiocarbon dated site. Further information about the nature of the event e.g. the Ulmus declin is listed in the table **EVENT**. As discussed in Chapter 3, these events are not strictly synchronous across the region, although on a more local scale it is assumed that similar types of pollen site will tend to have events occurring more or less synchronously.

Table Structure:

Field name:	Field type:	Description:
Entity. no.	**S**	Unique identifier for each entity.
Sample no.	**S**	Unique identifier for the sample where the event is noted to occur (if the event occurs over several sample depths, the midpoint is taken.)
Dated Event no.	**S**	Unique identifier for the dated event from the nearest most suitable radiocarbon dated site.

Keys:

Primary Key	*Entity no., Sample no.*	
Foreign Key	*Entity no.*	references the table **ENTITY** (information about each core/section/ surface sample.)
	Sample no.	references the table **SAMPLE** (information on all the sample depths for each entity.)
	Dated Event no.	references the table **CALEVENT** (giving the calibrated midpoint date for each event radiocarbon dated.)

Table: **CALEVENT** Calibrated dates for events.

Description:

This table gives the calibrated midpoint date (in years BC/AD) (Chapter 3 explains this) of each event dated at a radiocarbon dated entity. Information about the nature of each event can be found in the look-up table **EVENT**.

Table Structure:

Field name:	Field type:	Description:
Dated Event no.	S	Unique identifier for each date available for an event.
Event no.	S	Unique identifier for each event.
Entity no.	S	Unique identifier for the radiocarbon dated entity where the event is radiocarbon dated.
Sample no.	S	Unique identifier for the sample depth where the event is noted to occur.
Age (cal.yrs. BC/AD)	N	Age in calibrated years BC/AD of the radiocarbon dated event at this entity. The age given is the calibrated midpoint.

Keys:

Primary Key *Dated Event no.*

Foreign Key *Event no.* references the table **EVENT** (name and nature of each event.)

Sample no. references the table **SAMPLE** (information on all the sample depths for each entity.)

Table: **EVENT** Name and nature of events.

Description:

This look-up table gives the name of each event referred to in **CALEVENT**, plus a brief description of the nature of the event.

Table Structure:

Field name:	Field type:	Description:
Event no.	**S**	Unique identifier for each event.
Event Name	**A(15)**	Name of the event.
Description.	**A(60)**	Description of the nature of the event and how it is identified in the pollen record.

Keys:

Primary Key *Event no.*

Event name

Table: **PUBLEVNT** Published information referring to each event.

Description:

This table cross-references events to publications referring to them.

Table Structure:

Field name:	Field type:	Description:
Event no.	**S**	Unique identifier for each event.
Publ. no.	**S**	Unique identifier for each published reference.

Keys:

Primary Key	*Event no.*	
	Publ. no.	
Foreign Key	*Event no.*	references the table **EVENT** (name and nature of each event.)
	Publ. no.	references the table **PUBLCIT** (full bibliographic citations for all published material referred to in the database.)

Table: **ENTITY&&** Additional notes on entities.

Description:

This table stores extra notes on each entity. Notes are stored as up to 60 characters per line of text.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Line no.	**S**	Unique identifier for each line of the notes.
Text	**A(60)**	Notes on the description of the entity.

Keys:

Primary Key *Entity no.*
Line no.

Foreign Key *Entity no.* references the table **ENTITY** (information about each pollen core/ section/ surface sample.)

Table: **DATING&&** Additional notes on dating.

Description:

This table stores additional information on dating methods used, whether radiocarbon, or using broadly synchronous events to date non-radiocarbon dated entities. In the latter case, reasons for choosing the specific radiocarbon-dated entity used to date the non-radiocarbon dated entity are given.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Line no.	**S**	Unique identifier for each line of the notes.
Text	**A(60)**	Additional notes on dating.

Keys:

Primary Key *Entity no.*

Line no.

Foreign Key *Entity no.* references the table **ENTITY** (information about each pollen core/ section/ surface sample.)

Table: **P_PREP&&** Notes on pollen preparation methods.

Description:

This table stores notes on pollen sample preparation methods used for each entity. Notes are stores as any number of sixty character lines of text.

Table Structure:

Field name:	Field type:	Description:
Entity no.	**S**	Unique identifier for each entity.
Line no.	**S**	Unique identifier for each line of the notes.
Text	**A(60)**	Notes on pollen sample preparation methods.

Keys:

Primary Key *Entity no.*

Line no.

Foreign Key *Entity no.* references the table **ENTITY** (information about each pollen core/ section/ surface sample.)

Appendix B

Appendix

B | Ecology of taxa used as anthropogenic indicators or as components of arable/pastoral and agricultural/arable indices

B 1. Introduction

This study examines the ecology of taxa used as indicators of arable, pastoral or general agricultural activity by different pollen workers, with the aim of determining the usefulness of each pollen type as an indicator. For each indicator type, this study looks at the species and/or genus making up each type (most indicator types are on the family level, and the rest are on the genus level), and the types of habitats in which each species and/or genus is found. For example, ideally, all members of a family used as an indicator of arable activity should be found unambiguously in cultivated habitats. Any evidence contradicting this is highlighted, for example, the existence of members occurring in pastoral situations, or naturally occurring in habitats not affected by human activity. The value of each indicator type is assessed on the basis of the numbers of species occurring in arable, or pastoral type habitats, or generally associated with disturbance, the present abundance of these species, and the numbers of species occurring in habitats not associated with human activity. The indicator types studied here are those listed in Table 5.3 in Chapter 5, with the exception of Gramineae, which would include a very large number of grass species, and *Cerealia*-type, which is obviously an arable indicator. However, it must be noted when using *Cerealia*, that its value as an indicator depends very much on the certainty to which it can be identified as definitely being *Cerealia*, as opposed to other large Gramineae pollen grains such as *Glyceria*. Edwards (1989) has discussed the various criteria used to distinguish *Cerealia* pollen from other pollen grains and this has been discussed in the text of Chapter 5.

Indicator types will be dealt with in the following account in alphabetical order.

Information about ecology and present distributions within the region of species comprising each indicator type is obtained from Graham's (1988) "The Flora and Vegetation of County Durham", Swan's (1993) "Flora of Northumberland" and Grime, Hodgson and Hunt's (1990) "Comparative Plant Ecology."

B 2. *Artemisia*

Type of indicator: *Artemisia* is used as an arable indicator by Fenton-Thomas (1992), Riezebos & Slotboom (1978) and Turner (1964), but as a pastoral indicator by Roberts *et al.* (1973).

Likely types: In Northumberland and Durham *A. vulgaris* is the only species present in any abundance, followed by the naturalised herb *A. absinthum*, the naturalised *A. verlotorium*, the very rare coastal *A. maritima* and *A. campetsris* on ballast.

Ecological account:

A vulgaris: Frequent on waste ground, road verges, railway ballast, borders of fields and hedgebanks. It is well distributed in east and central Durham, but absent from the western uplands (Graham 1988). In Northumberland, it has a scattered distribution, with little found in the uplands (Swan 1993). Grime *et al.* note it as occurring most often in disturbed, relatively fertile urban sites, especially on rubble and ballast where taller species are prevented from growing. It occurs most commonly in very disturbed habitats, soon being replaced by other species once disturbance ceases. It is absent from grazed and damp situations such as meadows and pasture. Seeds are widely distributed through human activity, and this species exploits trackways, roads and railways as corridors of dispersal.

Indicator value: There appears to be a contradiction between the use of *Artemisia* by most workers as an arable indicator, but by Roberts *et al.* (1973) as a pastoral indicator. It is rather more an indicator of considerable disturbance and open conditions where there is an absence of taller vegetation. This could be on arable land, but could equally be on trackways, around settlement, or in other similar disturbed habitats. The use of *Artemisia* as a pastoral indicator is puzzling, since it is intolerant of damp, grazed situations. However, it could be found in well trampled areas of drier pasture, such as on tracks or by gateways. In coastal areas the use of *Artemisia* as an indicator is confused by the occurrence of coastal species.

B 3. *Cannabis*

Type of indicator: *Cannabis* is used as an arable indicator by Fenton-Thomas (1992).

Likely types: *Cannabis sativa* is the only member of the genus *Cannabis* in the region.

Ecological account:

Cannabis sativa: This species today is only occasionally found on ballast hills and as a garden weed in Northumberland and Durham. Formerly grown as hemp.

Indicator value: The occurrence of *Cannabis* in the pollen record refers to *Cannabis sativa*, and indicates its use as a cultivated species. However, sometimes in the pollen record it is grouped with the genus *Humulus* (hops).

B 4. Caryophyllaceae

Type of indicator: Caryophyllaceae is used as an arable indicator by Brown (1977).

Likely types: The family Caryophyllaceae contains a large number of genera which divide into the following types. **Type A** is found on well-drained soils, usually sandy, or on igneous or whin rock, or on walls, and includes *Arenaria, Cerastium, Dianthus, Moenchia,* one species of *Sagina*, *Scleranthus*, one species of *Spergularia* and one species of *Stellaria*. **Type B** is found in damp conditions, such as damp woods, streamsides, damp pastures and meadows, marshes and fens and salt marshes, and includes *Lychnis*, *Spergularia* and *Stellaria*. **Type C** is found in well drained woods, hedgebanks and road verges, including *Moehringia* and one species of *Silene*. **Type D** is found on arable and waste ground, often on sandy, or other well-drained land, and includes *Agrostemma*, *Cerastium*, two species of *Silene*, *Spergula* and one species of *Stellaria*. **Type E** is found in well grazed pasture, or well mown meadows, and in other disturbed habitats such as paths and waste ground, and includes one member of *Cerastium* (which is also in type D) and two *Sagina* species. *Minuartia* is a metallophyte occuring on lead spoil.

Below only Type D, E, *Lychnis* and *Minuartia* will be discussed, as they are relevant to land-use.

Ecological account:

Type D

Agrostemma githago: This colonist was formerly a common weed of arable land, and is now probably extinct in the region.

Cerastium fontanum and *C. glomeratum:* These species are widespread in the region on arable land and sand dunes, *C. glomeratum* also being found on pathways and walls, and *C. fontanum* also on grassland. *C. fontanum* extends up to the highest uplands. It is typically found on disturbed, moderately fertile habitats, and is also found commonly in mown meadows, grazed grassland, lawns and on wasteland, like *Sagina procumbens* (see below). In this sense, it is also a member of type E.

Silene latifolia and *S. noctiflora*: Both species are found on arable land, especially on sandy soil. *S. latifolia* is widespread and also found in hedgerows, road verges and near the sea. *S. noctiflora* has only a localised distribution and is confined to the lowlands.

Spergula arvensis: This colonist is a widespread weed of arable ground and other fertile, disturbed habitats. It is thought to have been a common weed of flax (*Linum*) in the past (Grime *et al.* 1990). It is today classified as one of the world's worst weeds, particularly of cereals. Unlike most other weeds, it is most common on acidic sandy soils. It has been grown for fodder in the past, and has been used for human consumption. Its distribution is now decreasing due to the decrease in acidic sandy conditions on arable land.

Stellaria media: This species is a very widespread weed of arable land and gardens, favouring nitrogen rich soil, and also occurs on waste ground and other recently disturbed, fertile habitats. It responds readily to high levels of fertilisers on arable land. It has been used as a salad plant, and is also palatable to stock. Seed is widely dispersed by human activity and by crops. It, like *Spergula arvensis*, is classified as one of the world's worst weeds (Grime *et al.* 1990).

Type E:

Cerastium fontanum: See above.

Sagina procumbens and *S. apetala:* *S. procumbens* occurs in pastures and on lawns where the growth of other species is prevented by close or frequent mowing. It also occurs in other disturbed habitats, such as spoil heaps. In pasture it is little grazed by stock, and is tolerant of trampling. It is a common colonist of artificial habitats. *S. apetala* is found occasionally on paths, roadsides, bare ground and railway tracks.

Other species:

Lychnis flos-cuculi: This species is widespread in the region in damp pastures, meadows, marshes and fens, ascending high into the uplands.

Minuartia verna: A noted metallophyte, this species grows on spoil heaps of old lead mine workings and by streams and rivers downstream from workings. Formerly located on the Whin Sill.

Indicator value: The use of Caryophyllaceae as an arable indicator is poorly supported by the above evidence. The family includes a wide range of species occurring in different types of habitat, naturally occurring on both well-drained sandy or igneous soils, and on damper ground. Of those taxa associated with human activity, members of the Caryophyllaceae family are found both on fertile or sandy, well-drained, cultivated ground on the one hand, and on damp pastures and meadows on the other.

B 5. *Centaurea*

Type of indicator: *Centaurea* is used as an arable indicator by Fenton-Thomas (1992) and Riezebos and Slotboom (1978) and, more specifically, *Centaurea cyanus* is used as an arable indicator by Roberts et al. (1973).

N.B. *Centaurea* is a member of the family Compositae, which is discussed below, but since *Centaurea* is a commonly used indicator taxon, it will be dealt with here separately.

Likely types: *Centaurea* is represented by the following native species in the region: *C. scabiosa and C. nigra,* and by the casual hortal *C. cyanus*. Other hortals (*C. montana*) and casual colonists (*C. calcitrapa, C. aspera, C. solstitialis, C. jacea*) have been recorded in the region, but will not be dealt with here. They are commonly found in waste places, on ballast and as garden plants or weeds.

Ecological account:

Centaurea cyanus: This species is now a very rare weed of cultivated fields in Northumberland and Durham.

Centaurea nigra: This species is widespread and frequent in hedgebanks, road verges, meadows and rough grassland in Northumberland and Durham, ascending into upland valleys, but it is absent from heather moorland.

C. scabiosa: *C. scabiosa* is frequent in meadows and rough grassland and road verges mostly on limestone.

Indicator value:

The use of *Centaurea* as an arable indicator obviously, from the above ecological account, refers to *Centaurea cyanus*, formerly a serious cornfield weed (Swan 1993), since the other, native, species of *Centaurea* (*C. nigra* and *C. scabiosa*) occurring in the north-east are found almost exclusively in grassland situations including meadows. Roberts *et al.* (1973) are therefore justified in specifying that *Centaurea cyanus* alone be used as an arable indicator. The use of *Centaurea* undifferentiated as a general anthropogenic indicator is also unfounded, since the native species are found in a wide range of grassland situations across the region, including rough grassland, which are not always necessarily associated with human activity. Only if *Centaurea cyanus* can be distinguished from other Centaurea pollen can it be used as a good indicator of arable activity.

B 6. *Centaurium*

Type of indicator: *Centaurium* is used as an arable indicator by Roberts *et al.* (1973).

Likely types: *Centaurium* is represented by three native species in the region: *C. erythraea*, *C. littorale* and *C. pulchellum*, all occuring on sand dunes and dune slacks along the coast, but *C erythraea*, which also occurs on grassland, spreading inland in some places.

Ecological account:

Centaurium erythraea: Frequent in dry grassland and sandy places by the coast, on Magnesian Limestone in Durham, and up the river Tyne, also exploiting areas of waste ground. Favours disturbed habitats. According to Grime *et al.* (1990), it is not found on pasture owing to vulnerability of plant to grazing.

Indicator value: Outside of coastal habitats, where species of *Centaurium* occur naturally, its occurrence inland (in the form of *C. erythraea*) on dry grassland and waste ground means that it can be used as a disturbance indicator. The intolerance of *C. erythraea* to grazing means that it cannot be used as a pastoral indicator, and in this sense, outside of coastal areas, it can be used as a non-pastoral disturbance indicator.

B 7. Chenopodiaceae:

Type of indicator: Chenopodiaceae are used by Roberts *et al.* (1973), Turner (1964) and Fenton-Thomas (1992) as an arable indicator.

Likely types: The family Chenopodiaceae covers a range of genera present in the north-east, including *Atriplex*, *Beta*, *Chenopodium*, *Salicornia*, *Salsola* and *Suaeda*. Of these, *Beta*, *Salicornia*, *Salsola*, *Suaed* and all but two members of *Atriplex* occur solely along the coast, in the salt-marshes and seashores of the region. This section will, therefore, focus on members of the genus *Chenopodium* and on *Atriplex patula* which occurs inland as well as in the coastal zone. Of the genus *Atriplex*, *A. patula* is common in the region, and *A. prostrata* can be found occasionally in inland ruderal communities, although it is mainly coastal. Of the genus *Chenopodium*, the only commonly occurring species are *C. album*, *C. rubrum* and *C. bonus-henricus*, a naturalised hortal.

Ecological account and present distribution:

Atriplex patula: This species is widespread in Northumberland in weed communities of cultivated and waste ground, road verges, and rubbish dumps and manure heaps, as well as on open ground near the sea (Swan 1993). In Durham it is also widespread, but thins out on the Magnesian Limestone and on the coast. According to Grime *et al.* (1990), it commonly occurs with *Chenopodium album* (see below). It is found on severely disturbed sites, especially when they are relatively fertile, moist and unshaded. It is largely absent from trampled and grazed areas, such as meadows and pasture. It is a common impurity in crop seed.

Atriplex prostrata: This species seldom occurs inland in Northumberland, but when it does, can be found on road verges and waste ground. (Swan 1993). In Durham it is occasionally found inland in a few ruderal communities for quite a distance along the main river valleys, but occurs mainly along the coast and estuaries. According to Grime *et al.* (1990), it occurs in disturbed habitats, along the coast and sporadically inland where it established quickly on newly disturbed sites such as demolition sites and coal mine spoil heaps.

Chenopodium album: This species is widespread in the lowlands on disturbed waste and cultivated ground (Swan 1993; Graham 1988). It is a noted troublesome weed of arable crops, commonly found in nitrogen-rich habitats including manure heaps and sewage waste. It is not generally found in grazed habitats owing to an inability to recover from shoot damage (Grime *et al.* 1990). It is not found in areas of very severe disturbance.

Chenopodium rubrum: Only occasionally found in Northumberland on arable and waste land, especially in areas of low rainfall where nitrogen levels are high. More common along the coast. Also scattered in lowland Durham where it occasionally occurs on waste ground and rubbish tips, but is mainly coastal. It is mostly found on farmyard manure and sewage residues, and by nutrient rich lakes and ponds.It rarely occurs in grazed habitats. Like *C. album*, it is not found in areas of severe disturbance (Grime *et al.* 1990).

Chenopodium bonus-henricus: This species is a naturalised hortal formerly grown as a herb and now widely established on road verges and grassland where nitrogen levels are high, near human habitation and on waste ground. It is scattered in the lowlands of Durham and Northumberland, and its distribution spreads along the dales, occurring as high as 400m in Allendale (Swan 1993, Graham 1988).

Indicator value: Chenopodiaceae are used by all workers as an arable indicator, and there is no attempt to differentiate any particular genus or species. Owing to the large numbers of members of Chenopodiaceae found in coastal habitats, its use as an indicator in coastal areas is of little value. However, when found inland, it is most likely to be one of only a small number of taxa; *Chenopodium album* and *Atriplex patula* being the most common. Both species are rarely found on pasture and grassland, being intolerant of grazing, and are common in fertile, unshaded, disturbed habitats, which include cultivated land, but also on spoil heaps. *A. patula* is more common in severely disturbed habitats. This is consistent with the use of Chenopodiaceae, outside of coastal areas, as an arable indicator, although it should be more accurately depicted as a disturbance indicator. It should be noted that these species may occur in pastoral areas away from well grazed areas, such as on manure heaps, or close to habitation.

B 8. Compositae:

Type of indicator: Both Compositae Liguliflorae and Compositae Tubuliflorae, the two main divisions of the Compositae family in pollen analysis, are used as arable indicators by Brown (1977) and Fenton-Thomas (1992). Compositae undiff. is used by Turner (1964) as an arable indicator. Donaldson & Turner (1977) isolate out Compositae-*Bellis*-type as a pastoral indicator, and use Compositae-excluding-*Bellis*-type as an arable indicator.

Likely types: Compositae is a family with a large number of genera, which can occur in habitats ranging from arable land and pastures/meadows, road verges and hedge banks and also on waste ground. Despite this two main groups are apparent: **type A** which is found in damp situations such as damp pasture and meadow, wet road verges, marshes, riverbanks and ditches, and **type B** which is found on waste ground, disturbed ground, cultivated land, hedgebanks, road verges and railway tracks. **Type A** includes *Achillea*, *Bellis*, *Bidens*, two species of *Centaurea* (already discussed above), *Cirsium* (2 species), *Crepis*, *Eupatorium*, *Leontodon*, *Petasites*, *Pulicaria*, some *Taraxacum* and *Tragopogon*. **Type B** includes *Anthemis*, *Arctium*, *Artemisia* (see above), *Carduus*, one species of *Centaurea*, *Chrysanthemum*, *Cichorium*, *Cirsium* (2 species), *Lapsana*, *Leucanthemum*, *Matricaria*, *Senecio*, *Sonchus*, some *Taraxacum*, and *Tussilago*. Some of Type B can occur on both cultivated land and pasture (*Carduus*, *Cirsium*, *Leucanthemum*, *Senecio*), owing to their capacity for exploiting disturbed habitats, including overgrazed, patchy pasture and mown meadows. *Gnaphalium* is a Type A genus which is also found on damp arable fields. *Centaurea* will not be included in the ecological account below since it has already been dealt with.

Other members of Compositae are confined to the coast: native *Aster*, *Carlina* and *Tripleurospermum*.

Hortals (introduced cultivated/once cultivated types) include some *Artemisia*, most *Aster*, some *Carthamus*, *Centaruea*, *Doronicum*, *Inula*, *Lactuca*, some *Petasites*, some *Senecio*, some *Solidago* and *Tanacetum*.

In the next section, common species of Types A and B will be dealt with.

Ecological account:

Type A:

Achillea millefolium and *A. ptarmica*: Both species are found in meadows, pastures and road verges, *A. ptarmica* also being found in swamps, fens and wet heath. Both are widespread in Northumberland and ascend into the uplands, *A. millefolium* being far more common. (Swan: 1993) In Durham *A. millefolium* is found almost everywhere except the high uplands, whilst *A. ptarmica* thins out in arable and industrial areas (Graham 1988).

Bellis perennis: This species is very widespread and abundant on short grassland - lawns, parks, meadows and road verges and ascends high into the uplands in Northumberland and Durham. It is strongly associated with trampled, moist habitats.

Cirsium palustre and *C. heterophyllum*: *C. palustre* is very widespread and abundant across Northumberland and in Durham (apart from the east) on damp grassland, wet pasture, marshes and woodland glades, whilst *C. heterophyllum* is frequent in upland meadows, road verges and woodland glades.

Crepis paludosa and *C. mollis*: *C. paludosa* is found frequently in wet meadows, damp woodland, alder carr and by streams in Northumberland and Durham. *C. mollis* is scattered in upland hay meadows and road verges.

Eupatorium cannabinum: Found in wet woods, fens and along the banks of streams and rivers.

Leontodon autumnalis and *L. hispidus*: Both species are very widespread in meadows, pastures and road verges, *L. hispidus* favouring calcareous soil, in Northumberland and Durham. According to Grime *et al.* (1990), *L. autumnalis* is capable of resisting trampling, cutting or grazing.

Petasites hybridus: Abundant in wet meadows, damp road verges, woodland glades and stream banks in Northumberland and Durham.

Pulicaria dysenterica: Occasionally found on damp grassland and ditches in the Tees lowlands and coast in Northumberland.

Taraxacum Sect. *Naevosa* and Sect. *Spectabilia*: Members of the section *Naevosa* are found on road verges, damp pasture and damp grassy places. Members of Sect. *Spectabilia* are generally confined to acidic wetlands and wet grassland.

Tragopogon pratensis: This species is frequent in rough grassland, pastures, meadows, road verges and also on waste ground in central and eastern Durham and Northumberland. It is therefore intermediate between types A and B.

Type B:

Anthemis arvensis and *A. cotula:* Both species are now found only occasionally (*A. arvensis* now only rarely) in arable fields in Northumberland. Both are also found on waste ground.

Arctium minus: Frequent on road verges and waste ground in eastern and central Northumberland and Durham.

Carduus nutans and *C. acanthoides:* Both are found occasionally on waste ground and rough grassland, *C. acanthoides* in the lowlands and *C. nutans* on limestone soils.

Chrysanthemum segetum: Formerly a plentiful cornfield weed, now very rare, but occurring on ballast hills in east Durham and Northumberland.

Cichorium intybus: Formerly a weed of cultivated ground, now only sparsely distributed on waste ground and railway banks.

Cirsium vulgare and *C. arvense*: Both species are very widespread on cultivated and waste ground, but also in pastures. *C. arvense* occurs also in meadows and grassland on the lower slopes of hills. According to Grime *et al.* (1990), both are unpalatable to stock. Their reason for occurrence in both Type A and B habitats (meadows/pastures and waste and arable land) is that they primarily colonize disturbed habitats, and this includes overgrazed and patchy pasture.

Lapsana communis: Widespread on disturbed habitats such as waste ground, cultivated land, road verges and hedge banks. Absent only on high ground in Northumberland and Durham.

Leucanthemum vulgare: Frequent both on waste ground, railway banks and road verges, and on rough grassland. Also found in pastures and meadows where disturbance by cutting and grazing encourages its *spread (Grime et al 1990).*

Matricaria recutita and *M. discoidea*:*M. recutita* is a weed occasionally found on cultivated ground, waste ground and road verges, whilst *M. discoidea* is widespread today on waste ground, tracks, paths and gateways, on trampled disturbed ground. *M. discoidea* is thought to be a recently introduced colonist.

Senecio jacobaea, S. viscosus, S .vulgaris: All these species are found on waste ground, *S. vulgaris* also is very widespread on cultivated ground, *S. viscosus* is scattered on road verges and railway ballast, whilst *S. jacobaea* is very widespread on over-grazed pastures where the level of disturbance is high. *S. jacobaea* is a persistent and injurious weed of hay meadows and pastures.

Sonchus asper, S. arvensis, S. oleraceus: All species are found on cultivated and waste ground, *S. asper* is widespread, *S. oleraceus* and *S. arvensis* less so, being confined to the lowlands. *S. arvensis* is also found along rivers and streams, and salt marshes in the lowlands

Taraxacum Sect. *Hamata* and Sect. *Ruderalia*: These sections are commonly found on road verges and on waste ground, railway banks and in urban areas, but some members are also found on pasture and other grassland where disturbance is high.

Tussilago farfara: Abundant on cultivated and disturbed ground, spoil heaps, waste ground, demolition sites, railway banks and road verges. Absent only from high heather moorland. According to Grime *et al.* (1990), it is vulnerable to grazing, and mowing, so is not common on pasture or hay meadows.

Indicator value: Compositae are used by most workers as an arable indicator, whether Compositae Liguliflorae or Compositae Tubuliflorae, although *Bellis*-type is singled out by Donaldson and Turner (1977) as a pastoral indicator. Compositae include a vast number of different taxa occurring in a wide range of habitats, which reduces the value of this large family as an arable indicator. Many taxa, those in the Type A group, are found in damp or wet conditions, some of which occur in damp meadows and pastures, the most common of which include *Bellis, Leontodon, Achillea* and *Centaurea nigra*. The latter is interesting, since *Centaurea* is used by many workers as an arable indicator (on the basis of the occurrence of *Centaurea cyanus* in arable situations.) Donaldson and Turner's (1977) decision to separate out *Bellis*-type pollen as a pastoral indicator is therefore supported. It is the Type B taxa that include types occurring on arable land, although they occur on disturbed and waste ground in general. These include *Anthemis cotula* and *Centaurea cyanus*. A further complicating factor is that species belonging to genera such as *Cirsium, Centaurea, Taraxacum* and *Senecio* occur both on pasture and grassland on the one hand, and in disturbed habitats such as cultivated land, on the other. Compositae is therefore by no means an unambiguous indicator of arable, occurring in both pastoral and arable situations. The common element is that many taxa occur in disturbed habitats, whether this is due to grazing and trampling, or to cultivation.

B 9. **Cruciferae:**

Type of indicator: Cruciferae are used as an arable indicator by Brown (1977), Donaldson & Turner (1977), Roberts *et al.* (1973), Turner (1964) and Fenton-Thomas (1992).

Likely types: The family Cruciferae is represented by a large number of genera. Of these, *Barbarea*, *Cochlearia*, *Coronopus* and *Rorippa* are confined to the coast and/or river banks, and will not be discussed in more detail. One species of *Thlaspi*, *T caerulescens*, is found on lead mine spoil heaps as well as on river banks.

The other types divide into two groups: plants of **type A**, which are found on dry waste ground, walls, paths, railway tracks and cultivated ground (*Arabis*, *Capsella*, one species of *Cardamine*, *Erophila*, *Lepidium*), and **type B**, found in damp meadows and woodland (*Cardamine*).

Other members of Cruciferae are naturalised hortals and introduced species, such as *Brassica*, *Camelina*, *Diplotaxis*, *Hesperis*, *Raphanus*, *Sinapsis*, *Sisymbrium* and one species of *Thlaspi* - most of which, like the majority of other Cruciferae, are type A: found on waste ground, rubbish tips, roadsides, railways and cultivated fields.

Only the major native species of type A and B will be discussed below.

Ecological account:

Type A:

Arabis hirsuta: This is occasionally found on rock outcrops in limestone areas of Northumberland and on walls (Swan 1993), and in Durham is restricted to the limestone dales and Magnesian limestone.According to Grime *et al.* (1990) it is a plant of disturbed, calcareous habitats, restricted to rocky sites and shallow soils. Its narrow ecological niche has probably prevented its spread into artificial habitats. This species is therefore unlikely to be useful as an anthropogenic indicator.

Capsella bursa-pastoris: This species is very widespread in all areas of Northumberland and Durham except at the highest elevations, on cultivated and waste ground (Swan 1993; Graham 1988). It is a very common arable weed, particularly in broad leaved crops (Grime *et al.* 1990).

Cardamine hirsuta: Frequent in Northumberland and occasionally found in Durham on dry sandy or calcareous soils, on waste ground, railway ballast, paths and walls, but only rarely as an arable weed. Sparse in east Durham (Swan 1993; Graham 1988).

Erophila verna: This species is virtually absent from the lowlands of Northumberland and Durham, but is occasionally found in the western uplands on walls, scree and on roadsides (Swan 1993; Graham 1988).

Lepidium heterophyllum: Sparsely scattered in Northumberland on dry grassy banks, waste ground, cultivated fields and railway tracks. Only recorded in central Durham (Swan 1993; Graham 1988).

Type B:

Cardamine pratensis: Very widespread across Northumberland and Durham in damp meadows and pastures by streams, in woodland and on ditch sides, ascending into the highest uplands. Sparse on Magnesian Limestone and in urban areas (Swan 1993; Graham 1988). Not as common today as formerly in lowland pastures, but common in upland damp grassland (Grime *et al.* 1990).

Cardamine flexuosa: Frequent in Northumberland in damp shaded woods and on stream banks, and sparse in damp meadows. (Swan 1993) Widespread in the west of Durham, absent from the Magnesian Limestone (Graham 1988).

Cardamine amara: Constantly occuring in woodland flushes and alder and willow carr, in shaded, semi-aquatic conditions, this species is concentrated along river courses.

Indicator value: Cruciferae are used by all workers as an arable indicator. However, along rivers and the coast its use as an indicator is diminished by the occurrence of riverine and coastal species and genera of Cruciferae. When occurring inland, on dry, sandy, calcareous or rocky habitats, it may be any of the Type A taxa characteristic of disturbed habitats, of which *Capsella bursa-pastoris* is the most common arable weed. However, several types in this group are restricted to rocky, scree-like habitats. When occurring in moister habitats, it may be any one of the Type B taxa found in damp woodland, some of which can occur on damp grassland, particularly *Cardamine pratensis*. The use of Cruciferae as an arable indicator is complicated by the large number of taxa occurring in natural habitats, either in damp situations or in dry, rocky habitats. Only a small number of taxa are found in arable situations, but in some cases, in damper situations, it may even be an indicator of wet pasture.

B 10. *Fagopyrum*

Type of indicator: *Fagopyrum* is used as an arable indicator by Riezebos & Slotboom (1978).

Likely types: The only species recorded for *Fagopyrum* in the region is the casual hortal *F. esculentum*.

Ecological account:

Fagopyrum esculentum: This species, formerly grown as food for game, poultry and cattle, is found rarely on ballast hills in the region.

Indicator value: Where *Fagopyrum* occurs in the pollen record, it can be assumed that this refers to its cultivation, and indicates the presence of *Fagopyrum esculentum*, since it is a hortal.

B 11. *Knautia*

Type of indicator: *Knautia* is used as an arable indicator by Roberts *et al.* (1973).

Likely types: *Knautia arvensis* is the only recorded species for the region.

Ecological account:

Knautia arvensis: This species has a scattered distribution in rough grassland and road verges in the lowlands of Northumberland and Durham, mostly on calcareous and sandy soils.

Indicator value: The use of *Knautia* as an arable indicator is confusing, since the only known recorded species for the region is found on rough grassland on calcareous and sandy soils. Its occurrence in these conditions is most probably explained by an intolerance to grazing which restricts its growth elsewhere.

B 12. **Leguminosae**

Type of indicator: Leguminosae undifferentiated is used as an arable indicator by Riezebos & Slotboom (1978), *Trifolium* is used by Donaldson & Turner (1977) and Roberts *et al.* (1973) as an arable indicator, and *Vicia* is used as an arable indicator by Roberts *et al.* (1973).

Likely types: The family Leguminosae includes types which fall into three main groups. The first, **type A**, occurs on well drained short turf on igneous, whin, limestone or sandy soils, on heath, or along the coast, and includes *Anthyllis*, *Astragalus*, *Cytisus*, one species of *Genista*, *Medicago*, *Ononis*, six species of *Trifolium*, *Ulex*, and two species of *Vicia*. **Type B**, occuring in rough grassland, pastures, meadows and road verges includes one species of *Genista*, *Lotus*, two species of *Lathyrus*, two species of *Trifolium* and two species of *Vicia*. **Type C** only includes two species of *Vicia* which occur in cultivated land as well as occuring in Type B habitats.

Cultivated or once-cultivated hortals include *Lathyrus*, *Medicago*, *Onobrychis*, *Pisum*, *Securigera*, *Trifolium* (*T. repens* has been cultivated for fodder, and *T. hybridum*) and *Vicia*.

Only those species occuring commonly in Type B or C habitats (relevant to land-use and agriculture) will be discussed below.

Ecological account:

Type B

Genista tinctoria: Occurs occasionally in rough pastures and on grassy banks in the lowlands, particularly on old grassland. Most common in SE Northumberland.

Lotus corniculatus and *L. pedunculatus: L. corniculatus* is very widespread in Northumberland and Durham in meadows, pastures and on road verges. *L. pedunculatus* is widespread in damp meadows and pastures and at the edge of lakes and ponds, streams or rivers.

Lathyrus pratensis and *L. linifolius*: *L. pratensis* is very widespread in Northumberland and Durham in pastures, on rough grassland, road verges and hedgebanks. *L. linifolius* is widespread on grassland and moors, but also in hedgebanks and woods.

Trifolium repens and *T. pratense*: Both species are very widespread in meadows, pastures and also on moorland grassland.

Vicia cracca and *V. sepium*: These species are very widespread on rough grassland, hedgebanks and road verges in the region.

Type C:

Vicia hirsuta and *V. tetrasperma*: Both species are found as weeds of cultivated ground, as well as occuring on rough grassland, road verges and waste ground. *V. tetrasperma* only occurs rarely. It is worth noting that the hortal *V. sativa* subsp *sativa* is often cultivated for forage and sometimes escapes onto adjoining land.

Indicator value: *Trifolium* and *Vicia* are both singled out as arable indicators by Roberts *et al.* (1973) and Donaldson and Turner (1977). However, several species of both are found in natural habitats occurring on well-drained sandy or igneous soils, or along the coast. In addition two species each of *Trifolium* and *Vicia* occur in grassland situations, the *Trifolium* species in question being commonly found in pastures and meadows. There are no occurrences noted above of *Trifolium* in arable habitats, and only two species of *Vicia* found as weeds of cultivated ground, although even these can occur also on rough grassland. Leguminosae, on the whole, cannot be used as indicators of arable activity, and neither can *Vicia* or *Trifolium*, although they can be used as indicators of well-drained soils.

B 13. *Linum*

Type of indicator: *Linum* is used as an arable indicator by Riezebos & Slotboom (1978).

Likely types: The genus *Linum* is represented in the region by the native *L. catharticum*, the once cultivated hortal *L. usitatissimum,* the very rare but locally profuse (on the Magnesian Limestone plateau of East Durham) native species *Linum perenne* subsp. *anglicum* (Graham 1988) and the rare casual colonist *L. bienne,* found on ballast, which will not be covered here any further.

Ecological account:

Linum catharticum: Very widespread on short grazed calcareous grassland and heaths.

Linum perenne subsp. *anglicum:* This native species is only recorded by Graham (1988) since it occurs very rarely in the region, but where it does occur, it occurs profusely. It is particularly abundant on Magnesian Limestone grassland. This is its northern limit in the British Isles. Apart from occurring on limestone grassland it is occasionally found on railway embankments and dry road verges.

Linum usitatissimum: This once cultivated but now rare casual hortal is occasionally found in cultivated fields, road verges and ballast hills.

Indicator value: The use of *Linum* as an arable indicator refers to the cultivation of *Linum usitatissimum*. However, the occurrence of *Linum catharticum,* which commonly occurs on grazed calcareous grassland, and the local abundance of Linum perenne subsp. anglicum on Magnesian Limestone grassland limits the usefulness of *Linum* as an arable indicator on limestone soils in the region.

B 14. *Plantago*

Type of indicator: *Plantago* undifferentiated is used as an indicator of pastoral activity by Turner (1964), *Plantago lanceolata* is used by all workers except Turner. *P. major/media* is used as a pastoral indicator by Brown (1977), but *P. major* is used as an arable indicator by Fenton-Thomas (1992).

Likely types: Swan (1993) notes the present-day presence in Northumberland of the following members of the genus *Plantago*: *P. lanceolata, P. major, P. media, P. coronopus* and *P. maritima,* of which the first two are the most widespread and common, the last two are confined to coastal areas and *P. media* to calcareous grassland. Only those species relevant to land use will be discussed below.

Ecological account:

Plantago lanceolata: This species is very widespread and common in meadows, pastures, road verges and coastal grassland. According to Grime *et al.* (1990) its commonest habitats are in meadows and on rocky outcrops, waste and spoil heaps. It is a very successful colonising species and is found in a wide range of habitats except woodlands and wetlands. It resists trampling and grazing. It is common on poor, exhausted soils.

Plantago major: This species is very widespread and common on disturbed ground, on road verges, waste and cultivated ground, farmyards and tracks. It is tolerant of trampling. According to Grime *et al.* (1990) it is widespread on paths, soil heaps and rubble and arable land. It is found in a wide range of disturbed habitats, especially well trampled grassland and compacted soil or bare areas resulting from trampling, ploughing and overgrazing.

Plantago media: This species is a good indicator of limestone: frequent on calcareous grassland. It has a scattered or localized distribution over Northumberland.

Indicator value: *Plantago lanceolata* does tend to occur most commonly in pastoral locations, being able to resist trampling and grazing, and would therefore appear to be a fairly reliable indicator of meadow or pasture. However, its occurrence on waste heaps and its status as a good coloniser implies that it can be found in a wide range of other habitats. There is a contradiction between Brown's use of *P. major/media* as a pastoral indicator and Fenton-Thomas' use of *P.major* as an arable indicator. The occurrence of *P.major* on disturbed ground is consistent with arable agriculture, and it is the only *Plantago* species found consistently on arable land, but could equally occur on overgrazed or overtrampled pasture, or by trackways and gateways. It is rather more a general indicator of disturbance and cannot be used on its own to differentiate between intensive pastoral activity or arable activity. Where pollen of *P. media* can be identified, this is a better indicator of pasture on limestone. The use of *Plantago* undifferentiated as a pastoral indicator is ambiguous; where this is made up mostly of *P. lanceolata*, it is more likely to indicate grazed or trampled grassland, but where this is mostly *P. major*, it could indicate either well trampled or grazed grassland or arable, or other well disturbed land. In coastal areas the use of *Plantago* is complicated by the occurrence of coastal types *P. maritima* and *P. coronopus*.

B 15. *Polygonum:*

Type of indicator: *Polygonum* is used as an arable indicator by Donaldson & Turner (1977) and Roberts *et al.* (1973).

Likely types: The genus *Polygonum* has ten noted species occurring in the region, which divide into four groups according to habitat. Type A has species found by ponds, lakes, marshes, rivers, streams and ditches, which can also occur on cultivated ground where water stands in winter. This includes *P. amphibium*, *P. hydropiper* and *P. laxifolium*. Type B is found on waste ground, arable fields, tracks, trampled places and disturbed habitats. This includes *P. aviculare*, and *P . arenastrum*. Type C is intermediate between A and B and is found both on waste ground and cultivated ground, and also by ponds, streams and rivers, and includes *P. maculosum* and *P. lapathifolium*. Type D occurs in meadows, road verges and on grassy riverbanks, particularly in upland areas, and includes P. *bistorta* and *P. viviparum*. Below only those common species occuring with cultivation, disturbance and meadows will be discussed.

Ecological account:

Type A

P. amphibium: This can occur both floating on water bodies, as well as occurring in marshes, on banks by water and on agricultural land, especially when that land has been drained. Scattered in Northumberland and Durham.

P. hydropiper: This species has a localised distribution in the lowlands by lakes, ponds, rivers, streams and ditches, and where standing water occurs over winter, such as arable fields.

Type B

P. aviculare: Very widespread in arable fields and on waste ground. Absent only from high moorland.

P. arenastrum: Widespread on road verges, waste and cultivated ground and on tracks and well trampled places.

Type C

P. maculosum: This species is widespread both on waste ground, road verges and arable ground, and by rivers, streams, ponds and lakes.

P. lapathifolium: This is found occasionally in the lowlands on waste and cultivated land as well as on river gravels and by ponds.

Type D:

P. bistorta: This species has a scattered distribution in meadows, road verges and by rivers and streams.

P. viviparum: This species has a localised distribution in upland hay meadows and on grassy river banks, especially on calcareous grassland. In Durham it is confined to Upper Teesdale and Weardale.

Indicator value: *Polygonum* is used by two workers as an arable indicator, but its use as an indicator of human activity in wet situations such as along rivers, is diminished owing to the natural occurrence of Type A taxa in these conditions. Some taxa, however, can be found in both riverside situations and on wet cultivated land, which complicates the picture. Away from wet conditions *Polygonum* is more likely to be represented by Type B taxa occurring in disturbed conditions including cultivated land, but also including waste ground and other disturbed habitats. In these conditions, *Polygonum* can be used as an arable indicator. However, occasionally, in upland situations, taxa such as *P. viviparum* are found in pastoral situations.

B 16. **Ranunculaceae:**

Type of indicator: Ranunculaceae is used as a pastoral indicator by Donaldson & Turner (1977) and Roberts *et al.* (1973), and as a general agricultural indicator by Fenton-Thomas (1992).

Likely types: The family Ranunculaceae includes six common native genera found in the region, which divide into four main groups. **Type A** is found along river banks, in rivers, ponds, ditches and streams (of varying speed of flow), including eleven species of *Ranunculus* and *Thalictrum*. **Type B** is found in damp meadows and pastures, and often in woodland also, including *Anemone*, *Ranunculus* (four species) and *Trollius*. **Type C** is found only in woodland and hedgerows (one species of *Ranunculus* and *Aquilegia*). **Type D** is found on arable and waste ground (two species of *Ranunculus*).

Only types B and D will be discussed below, since they are relevant to land-use.

Ecological account:

Type B

Anemone nemorosa: This species is widespread in meadows, deciduous woods and in hedgerows, also extending onto moorland. *A. nemorosa* is, like many other members of the Ranunculaceae, unpalatable to stock, and is found in lightly grazed pasture, particularly on not very fertile land (Grime *et al.* 1990).

Ranunculus acris and *R. repens:* Both species are very widespread across the region, occurring in damp meadows, pastures and woods. *R. acris* is particularly unpalatable to stock. *R. repens* is found more often in poorly drained conditions than *R. acris* including mires. *R. repens* can survive occasional digging or ploughing, and it occurs in a wider range of habitats, including disturbed habitats, than *R. acris*. *R. acris* is absent from blanket peat.

Ranunculus bulbosus: This species is the main buttercup on limestone in the region, occuring frequently in pastures on light, shallow soil. On ridge and furrow, it tends to occur on the better drained ridge tops, whereas *R. acris* will occur on the wetter ridge sides, and *R. repens* occurs in the furrows (Harper and Sagar 1953; Harper 1977). It is particularly common in older, species-rich, permanent pastures on freely-drained soils, where heavy grazing and/or low soil fertility prevent it from being dominated by taller species. Absent from heather moor and arable land, thinning out in hill/rough pasture.

Ranunculus ficaria: Very widespread on road verges, pastures, deciduous woods, hedgerows and streamsides and near the coast. It often grows in mown or grazed habitats, such as pathsides, verges and hay meadows. Toxic to stock, they escape grazing. Subspecies *ficaria* is more common in woodland, whereas subsp. *bulbifer* is found in more disturbed habitats. Absent only in upland moorland.

Trollius europaeus: This species has a very localised distribution, formerly much more frequent, in damp, species-rich, meadows, pastures, woodlands and river banks in the uplands. In Durham distributed thinly on the Magnesian limestone, but mostly in the Upper Teesdale pastures.

Type D

Ranunculus arvensis and *R. sardous*: Both species are now very scarce in the region, but are noted to have occured on arable and waste ground. In the last century, *R. arvensis* was noted as a common weed of cultivated ground.

Indicator value: The value of Ranunculaceae as an indicator of human activity is diminished by the natural occurrence of many species in wet conditions such as along riverbanks and streams, and in woodland situations. Apart from this, several species are found in meadows and pastures, although many of these are also found in woodland, and so are not unambigous indicators of pastoral activity. A couple of species of *Ranunculus* are even found on arable and waste ground. On the whole, Ranunculaceae, when not associated with woodland or waterways, is a reasonably good indicator of grassland, although this could be naturally occurring grassland as well as meadow and pasture.

B 17. *Rumex*

Type of indicator: *Rumex* undifferentiated is used as a pastoral indicator by Roberts *et al.* (1973), Riezebos & Slotboom (1978) and Fenton-Thomas (1992). *R. acetosa*, *R. acetosella* and *Rumex/Oxyria*-type are used by Brown (1977) as pastoral indicators, whilst Donaldson & Turner (1977) use *R. acetosa/acetosella*-type as a pastoral indicator.

Likely types: The most common species of *Rumex* noted by Swan (1993) in Northumberland are *R. acetosa* and *R. acetosella*. *R. obtusifolius* and *R. crispus* are also widespread, but not found on acidic peat. Of the less widespread species, *R. longifolius* is localised on road verges in the Northumberland uplands and on sea cliffs, whilst *R. conglomeratus* and *R. sanguineus* are confined to the lowlands, the former in wet grassy areas, the latter in woods, road verges and waste ground. Other species are scarce, casual colonists or naturalised hortals.

Only those types relevant to land use will be discussed below.

Ecological account:

R. acetosa: Very widespread in meadows, pastures and woodland glades. Extends into Cheviot corries and ravines. According to Grime *et al.* (1990) it is particularly characteristic of meadows and pastures. Early seed production facilitates the exploitation of hay meadows. Can also tolerate grazing. Can also be found on calcareous soils, including lead mine spoil, but most common on mildly acidic soils. Probably mainly dispersed as an impurity in hay and seed crops.

R. acetosella: Very widespread on bare areas of acidic grassland. Grime *et al.* (1990) state it is very common on acidic wasteland, acidic pastures, coal mine waste. Characteristic of infertile sandy or peaty acidic soils. Restricted to open vegetation due to disturbance, fire or rocky terrain. Little grazed as it is toxic to stock. Calcifuge. Can occur on dry soils.

R. crispus: This species is widespread on grassland, verges, waste and cultivated ground. It is not found on acidic peat. According to Grime *et al.* (1990) it is associated with relatively disturbed ground. A noted troublesome weed exploiting agricultural land and other artificial habitats. Now more uncommon on arable land. This may be due to its increasing perenniality.

R. obtusifolius: This is very widespread on waste and disturbed ground, road verges, field borders and river banks. Not found on acidic peat. Grime *et al.* (1990) state it is common on spoil heaps, rubble, river banks, and arable land. It behaves very similarly to *R.crispus*, but is somewhat less ruderal. A noted troublesome weed of pastures, field edges and in trampled gateways. Unpalatable to livestock and resistant to mowing.

Indicator value: All workers agree in using *R. acetosa* and *R. acetosella* as pastoral indicators. These taxa are most common on grazed grassland, especially on more acidic soils. The occurrence of both taxa on wasteland and bare ground, however, suggests that occurrence in arable situations is not ruled out entirely. Using *Rumex* undifferentiated as an indicator allows for the possibility that *R.obtusifolius* or *R.crispus* is present. These taxa are more likely to occur on the less acidic, more calcareous soils, and can be found in a wide range of disturbed habitats, including both pasture and cultivated land. The use of *Rumex*, particularly in calcarous areas, is therefore not an unambiguous indicator of pasture. However, where *R.acetosa* or *R.acetosella* are specified, or where the soils are more acidic, a pastoral interpretation is more likely.

B 18. Summary

• *Artemisia* should be seen, rather than as a specific indicator of arable activity, as a general indicator of considerable disturbance and open conditions where there is an absence of taller vegetation. This could be on arable land, but could equally be on trackways, around settlement, or in or other similar disturbed habitats.

• The occurrence of *Cannabis* in the pollen record refers to *Cannabis sativa,* and indicates its use as a cultivated species.

• Caryophyllaceae cannot be used with any value as an arable indicator. The family includes a wide range of species occurring naturally in both well-drained habitats, and on damp ground, and includes species occurring in disturbed habitats, including cultivated ground, on well-drained ground, and meadow and pasture in damper situations.

• *Centaurea* only has value as an arable indicator if Centaurea cyanus can be distinguished from other types of Centaurea, since its the only type which occurs in arable situations. *Centaurea nigra* and *Centaurea scabiosa* occur in meadows, pasture and on road verges, hedgerows and rough grassland. As a result, the use of *Centaurea* undifferentiated as an arable indicator is inadvisable.

• Outside of coastal areas, *Centaurium* has some value as an indicator of disturbed ground, but this does not include grazed land. It is, however, not particularly associated with cultivation.

• Members of the genus Chenopodiaceae, where they occur inland, can be used as a reliable indicator of disturbed, fertile ground, which includes (but is not restricted to) arable land. However, disturbed, fertile situations may occur in predominantly pastoral areas, around settlement or barns.

• The large number of members of the family Compositae, and their occurrence in both pasture and grassland habitats on the one hand, and waste and cultivated ground on the other hand, make it difficult to accept the use of Compositae as a purely arable indicator.

The choice of genera to single out as pastoral or arable is further complicated by the occurrence of several genus in both arable and pastoral habitats.

- The use of Cruciferae as an arable indicator is complicated by the large number of taxa occurring in natural habitats, either in damp situations or in dry, rocky habitats. Only a small number of taxa are found in arable situations, but in some cases, in damper situations, it may even be an indicator of wet pasture.

- Where *Fagopyrum* occurs in the pollen record, it can be assumed that this refers to its cultivation, and indicates the presence of *Fagopyrum esculentum*, since it is a hortal.

- The use of *Knautia* as an arable indicator is confusing, since the only known recorded species for the region is found on rough grassland on calcareous and sandy soils.

- The use of members of the family Leguminosae as arable indicators is of little value. Only two species of *Vicia* occur on waste and cultivated ground, and even these can be found in rough grassland. No species of *Trifolium* are found to occur commonly on arable land, and most occur on dry grassland or pasture. On the whole, Leguminosae can at best only be used as indicators of well-drained land, whether this is used for grazing or agriculture.

- The use of *Linum* as an arable indicator probably refers to the cultivation of *Linum usitatissimum*. However, the occurrence of *Linum catharticum*, which commonly occurs on grazed calcareous grassland and the localised occurrence of *Linum perenne* subsp. *anglicum* on the East Durham Plateau on limestone grassland, limits the usefulness of *Linum* as an arable indicator on limestone soils.

- The use of *Plantago* undifferentiated as a pastoral indicator is ambiguous; where this is made up mostly of *P. lanceolata*, it is more likely to indicate grazed or trampled grassland, but where this is mostly *P. major*, it could indicate either well trampled or grazed grassland or arable, or other well disturbed land. In coastal areas the use of *Plantago* is complicated by the occurrence of coastal types *P. maritima* and *P. coronopus*.

• The use of *Polygonum* as an arable indicator is complicated by the natural occurrence of many species in riverside and wet conditions, and the occurrence of one species in the uplands which is more of a pastoral indicator. However, away from these areas, *Polygonum* is an useful indicator of disturbed conditions, which can include cultivated land.

• Although a couple of species of *Ranunculus* are found associated with waste and cultivated ground, on the whole, away from rivers and streams and woodland, Ranunculaceae can be used as an indicator of grassland.

• The use of *Rumex* as a pastoral indicator is complicated by its occurrence on disturbed and waste ground on calcarous soils. However, where *R. acetosa* or *R. acetosella* are specified, or where the soils is more acidic, a pastoral interpretation is more likely.

B 19. Conclusions

The above examination of indicator species proposed by workers to identify the presence of arable or pastoral activity has revealed that many taxa are highly problematic. The choice of a taxon as an arable or pastoral indicator is often based on a very limited research into the ecological tolerances of species making up each taxon. Decisions to use a taxon as an arable or pastoral indicator are often based on only one or two species in that taxon which occur in arable or pastoral situations. Often large numbers of other species in the same taxon which are not arable or pastoral are totally overlooked.

In most cases the problem is because the pollen taxa used are at the family level, and include a large number of genera and species occurring in a wide range of different habitats. Many species naturally occur in certain habitats, and therefore complicate the use of their families even as general anthropogenic indicators, let alone indicators of arable or pastoral activity. In some cases, members of a genus occur in both arable and pastoral situations, or even (in the case of Caryophyllaceae) in arable, pastoral and natural habitats. When using taxa as indicators, care must be taken to consider the location of a pollen site, since this will determine which species of an indicator type are likely to be present, and therefore affect whether that taxa can be used as an arable, or pastoral indicator, or is useless for that type of location.

A further point to note is that this study has only looked at the present day ecology and distributions of indicator taxa in north-east England and that these distribution patterns and ecological associations may have changed. When using these indicator species to study the past, it must be noted that many more species than covered in the above account might have been present in the region in the past. In addition, species that are today associated with arable fields or meadows and pastures may have occurred in different situations in the past, associated with different plant communities, or found in a wider or narrower range of situations than today. For example plant taxa now typically found in arable situations most probably occurred originally in areas of natural disturbance, whilst taxa now found in meadows or pastures most likely occurred in natural grassland or areas of open woodland. When interpreting the presence of indicator types for the past, care must therefore be taken to avoid jumping to the conclusion that the presence of an arable indicator automatically indicates arable activity at any time in the past, and instead the general characteristics of that indicator type should be considered. For example, a plant taxon commonly found in arable conditions is likely to be successful because it can withstand disturbance, possibly also trampling, bare soil and open conditions, or happens to seed at the same time as a crop plant, or entwines itself around the stems of a crop plant, so that its seeds become included with the crop plants seeds and therefore it spreads in subsequent fields. A plant taxon successful in meadow and pasture is likely to be abundant in these conditions because it can withstand grazing, or is unpalateable to animals (whether wild or domesticated), and because it favourably occurs in areas of open grassland.

Appendix C

Appendix C | Prospects for research into the relationship between pollen rain and land-use

C 1. Introduction

Although a range of different pollen methods for investigating land-use from pollen data has been studied in Chapter 5, there are a number of ways in which further work can improve our understanding of the relationship between pollen and land-use. The most important area where further work needs to be done is on the comparative approach, investigating using modern pollen surface sampling and vegetation survey the pollen rain associated with different types of land use in different environments, and studying the fall-off in pollen rain associated with settlement or land-use with increasing distance away from sites or fields. It has already been stated that most traditionally used indicator taxa and indices are based on surprisingly little actual modern research into the pollen rain associated with different types of land-use. The choice of indicators to use to identify arable or pastoral activity has tended to be based on limited observation of the modern occurrence of these taxa in arable or pastoral situations. Indicator taxa and indices have tended to traditionally be applied uncritically to a wide range of environmental conditions where they might not actually be very suitable indicators. An obvious example is the use of *Plantago* and Chenopodiaceae as indicators of pastoral and arable agriculture respectively in coastal areas, where members of both taxa occur in natural coastal environments.

The scarcity of studies in the modern pollen rain associated with different types of land-use and settlement has already been highlighted in Chapter 5. The majority of studies of modern pollen rain and human activity have focused on the reconstruction of the extent of woodland clearance, rather than reconstructing the nature of settlement and land-use, i.e. how far away from a pollen core settlement was located, what crops were grown, what was the species diversity in arable fields, what was the proportion of arable to grazed land. If the use of pollen data to reconstruct human activity is to improve any further, it is my opinion that the comparative approach is the most promising avenue for further research, and the need for such research is all the more pressing since so little has already been done in this area. So far, too few sites in too small a range of environments, and too narrow a range of types of land-use have been studied.

For the purpose of redressing this lack of work into understanding the pollen rain associated with settlement and land-use, a surface sampling study has already been formulated. Two main approaches will be used. Firstly surface pollen samples will be taken from a range of types of traditional land-use and compared with the actual vegetation, to help characterize the pollen rain associated with these types. Statistical analyses will be used to clarify the relationship between vegetation communities and pollen assemblages. Secondly transects of surface samples will be taken across sites with a clear transition between agricultural land and rough ground (e.g. moorland), or enclosed and unenclosed land, to understand how pollen rain associated with land-use falls off with increasing distance. Results will be compared with theoretical models of pollen transfer. This modern work will be supplemented with closely spaced fine resolution pollen diagrams , the interpretation of which will be aided by the above findings. The study divides into several phases, described below.

C 2. Phase I: Planning and initial survey

Much of the initial stages of planning and survey, including design of the sampling sheets for pollen sampling and vegetation survey, have already been carried out for a test study area in the Northern Pennines. Initial reconnaissance has already been carried out for possible sites to sample. A number of sites were chosen where there was a sharp transition between different types of land-use, with no roads or habitation nearby to complicate the picture. It is planned to follow the same procedure for this larger study:

a) Choice of study area

Although the final choice of study area will largely depend on where the research is to be based, there are a number of criteria which will be used to determine suitable locations for research. The area should preferably have:

- a good range of different types of agriculture and land-use as opposed to uniform land-use, over a fairly small region.

- varied topography and situation of fields, so that the effects of factors such as altitude, aspect, slope and proximity of woodland on pollen-rain can be assessed.

- plenty of isolated fields not surrounded by habitation, roads or other farmland, or fields with clear transitions onto moorland/ contrasting vegetation, as opposed to a continuously agricultural landscape. This is to ensure that the pollen rain is minimally contaminated by agricultural and other human activity other than the field being studied.

- an agricultural regime which favours "traditional" methods which encourage species diversity (for example "traditional" species-rich hay meadows as opposed to seeded pasture which are virtually monocultures.) If possible, carry out studies at locations where historic and prehistoric agriculture is being replicated (e.g. at Lejre in Denmark and at the Butser Iron Age village) This would be of more use for trying to reconstruct past agriculture and land-use that focusing entirely on modern, highly mechanised forms of farming which tend towards low species diversity.

- abundant moorland, peat and mosses to facilitate pollen sampling, both of surface-samples (using moss polsters) and for taking pollen cores.

An example of a suitable area is in upper Teesdale or upper Weardale in the Northern Pennines, where there is plenty of opportunity to take transects out from agricultural fields onto unenclosed moorland to examine the fall-off in pollen associated with those fields with increasing distance. This area is ideal since it is possible to find isolated fields or farms surrounded by moorland or rough grassland, rather than in areas in the lowlands of the region where it could be difficult to isolate out the pollen associated with a particular field from pollen associated with roads, buildings and other nearby fields.

b) Survey of suitable sites

Within the chosen region, initial reconnaissance will be carried out to find suitable sites for study, based on the above criteria. For each site chosen, note the location, size of field to be sampled, altitude, aspect, slope, drainage, and describe the situation of the field with respect to woodland, habitation and other agricultural land. Produce base-maps for each site using 1:10,000 maps or greater, to note the location of sampling sites and vegetation survey quadrats. Produce a questionnaire for the land-owner to help discern the type of land-use at the site. Note what the field is currently used for, how long it has been used in this way. Any record of former land-use. Type of ploughing, if present. Presence of manuring/fertilizers/use of weedkillers/sowing. Grazing, and if so, how intensively and by what species of animal.

C 3. Phase II: Sampling - vegetation survey and pollen sampling

a) Vegetation survey

Each site will be initially divided into areas of different vegetation type and random quadrats taken from each to characterize the vegetation in the field. One metre square quadrats will be used for this purpose, and the species composition of each will be noted. Survey may also be carried out outside the field to characterize the nature of surrounding vegetation. The species composition of any woodland will also be noted.

b) Pollen surface sampling

Moss polsters will be used wherever possible, or failing that, air traps. A vegetation survey quadrat will be taken at the site of each pollen sample to determine the very local pollen input of the pollen sample. Where there is a good clear transition from the field onto another type of vegetation, transects of pollen samples will be taken out from the field. The location of each pollen sample will be noted.

C 4. Phase III: Analysis

a) Analysis of vegetation survey data

Statistical analyses of the results of the vegetation surveys will be carried out to characterize the vegetation in each field and to investigate whether there is any relationship between type of land use and vegetation composition.

Numerical classification of the data will be carried out using TWINSPAN (Two Way Indicator Species Analysis). Ordination, using DECORANA (Detrended Correspondence Analysis) and correspondence analysis using CANOCO (Canonical Correspondence Analysis) will be used to help understand the environmental and land-use factors affecting species composition of the samples, for example crop type, degree of disturbance, manuring, grazing, ploughing, as well as environmental factors such as altitude, slope, soil type, moisture, underlying geology. The results will be used to determine whether it is possible to characterize different types of land-use by their vegetation.

b) Analysis of surface pollen samples

Pollen samples will be prepared and counted in the same way as standard pollen procedures. Several pollen slides will be counted per sample to ensure that rarer taxa are represented. Wherever possible, identification of pollen will be carried out to the species level. Pollen diagrams will be drawn showing the species composition of each sample, and transect diagrams drawn to show the pattern of fall-off of different taxa.

c) Comparison of vegetation, pollen and land-use data

Various different statistical analyses will be used to compare the vegetation, pollen and land-use data. Firstly, each sampling point will be characterized by its vegetation, pollen and its land-use information. Tabulations can be drawn to compare directly summary data about land-use and vegetation type, pollen and vegetation type and land-use and pollen type. Ordination can be carried out on both the vegetation and pollen data, and the land-use types indicated on the diagrams. From these diagrams it should be possible to tell whether, for example, grazed samples differ from mowed, or from manured, in their vegetation composition and their pollen composition. Species richness analysis will be undertaken to compare the number of pollen types in each sample with the species richness in the associated vegetation (following Berglund and Persson 1986). Comparison of the pollen and vegetation can be used to gain an idea of the pollen-rain associated with different types of vegetation, by comparing % cover of a species in the vegetation at different distances from the pollen sample, and % of pollen that species takes up in the pollen sample.

C 5 Phase IV: Application of results to interpretation of pollen diagrams

In suitable areas near to where surface sampling studies have been carried out, a number of closely spaced fine resolution pollen diagrams will be studied. Closely spaced cores have been used by a number of workers to help pinpoint the location of woodland, clearance activity or agricultural activity based on differences in pollen counts between the different cores. This type of work is known as a 3-dimensional approach. (Turner 1964, 1975; Turner, Innes & Simmons 1993) The modern work into pollen-rain should be directly applicable to the interpretation of these cores, since they will be taken in similar environments to the modern samples.

A further related line of research would be to take pollen cores along a transect away from an archaeological site and investigate how the pollen rain associated with that site falls off with increasing distance. Studies like this could be used to predict how far away from an archaeological site a pollen core has to be located in order for the site to be registered in the pollen record. Pollen sites of different catchment areas could also be investigated to see how catchment area affects the registration of human activity in the pollen record. A particularly good example of an archaeological monument from the north-east where this could be studied is Hadrian's Wall. A few sites do already exist in the area, and studies by Dumayne (1992) have been carried out to determine whether there is a fall off in types associated with disturbance with increasing distance from the Wall. However, this could be valuably supplemented with further work on pollen cores situated closer together than Dumayne's core sites, perhaps along a transect across the Wall. This could be supplemented by modern surface sampling work in the area to understand the pollen dispersal characteristics of that environment, in both wooded and open areas, close to settlement, and in a range of different types of land-use.

It is hoped that such work will provide more secure guidelines for pollen analysts and archaeologists using pollen cores to reconstruct past land-use. Such work can only provide a starting point, since it cannot cover the entire range of types of land-use ever carried out, or all types of environment that could affect the pollen rain. However, instead of providing hard and fast indicators of land-use that will be of universal application, the aim of this study is to investigate factors likely to vary the species associated with a given type of land-use in different conditions. Since so little work has already been done on this, it is felt that this study will provide a valuable contribution to any study aiming to use pollen data to reconstruct past land-use.

By drawing upon modern work into the pollen rain associated with settlement and land-use, one hopes it will be possible to suggest more relevant indicator types and indices for identifying arable activity for different environments and conditions than those traditionally relied upon in the pollen literature.

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