

ENVIRONMENTAL ARCHAEOLOGY IN MERSEYSIDE

J. B. Innes and P. R. Tomlinson.

Introduction

This paper is intended to provide an environmental setting for the archaeology of Merseyside. It is divided into three sections. The first describes, in some detail, the natural development of the landscape since the end of the last glaciation. Using results from several areas of research, it looks at evidence from the natural stratigraphy of Flandrian sediments, both coastal and inland, in order to understand changes in landforms, coastline, climate and vegetation. More detailed analyses of the environmental factors which influenced the evolution of the landscape may be found elsewhere (Johnson 1985a, Innes and Tomlinson unpub.).

Section two summarizes the results of a recent programme of palynological research on the peat deposits in the area which show the developing impact of prehistoric people on the natural vegetation (Innes and Tomlinson 1980, 1983a, 1983b).

The third section discusses the variety of environmental evidence which has come from some of the archaeological excavations in the region. This has provided details of local vegetation and land use as well as human health, diet and living conditions.

The area covered in this paper is not confined to the county of Merseyside, but includes the lower Mersey valley, the Lancashire plain as far north as the lower Ribble valley and the peripheral parts of northern Cheshire. Where relevant, analogous evidence has also been used from beyond this region.

The chronology and terminology used here follow the accepted British scheme (eg West 1970):

Devensian glaciation	up to 10,000 BP
Flandrian postglacial	after 10,000 BP

The Flandrian is subdivided as follows:

Flandrian I	10,000-7,000 BP
Flandrian II	7,000-5,000 BP
Flandrian III	5,000 BP to present

All dates are given as 'BP', meaning number of uncalibrated radiocarbon years before AD 1950. Other classifications are explained in the text. Plant taxonomy follows Clapham *et al.* 1962.

SECTION 1: THE NATURAL ENVIRONMENTAL BACKGROUND

Relief and Drainage

The main geographical features of the Merseyside region are shown in figure 1. It is an area of mainly low and subdued relief, part of the Lancashire and Cheshire plain, having been subjected to heavy glacial action during the Ice Age which smoothed the relief features of the pre-glacial landscape by processes of glacial erosion and deposition. This homogeneity is relieved only by occasional outcrops of bedrock which protrude through the drift cover. While on Wirral such solid rock exposures at sea level form headlands, in general the Merseyside coastline is of the soft-shore type, composed of a variety of unconsolidated sediments. Merseyside's three large river estuaries, the Ribble, Mersey and Dee, are features typical of this kind of shore.

The Dee, mid Wirral Fender, lower Mersey, Gow, Weaver, Alt, Sankey, Ditton and Douglas river systems all fill valleys which are aligned northwest/southeast. This modern drainage pattern is largely the result of the erosive effects of glacial action, allied to the creation of meltwater channels and meltwater streams. As the ice sheet retreated to the northwest, these almost parallel river systems evolved. Troughs were gouged into the sandstone bedrock by ice action or meltwater along this axis, then filled with glacial sands and gravels into which streams were then incised. Meltwater erosion seems to have been the main factor in forming these troughs, some of which are greatly over-deepened (Johnson 1985b). Changes in rates of flow in the region's rivers, particularly during the early postglacial, have formed terraces in several river valleys most notably that of the Mersey itself.

Geology

The solid geology of the region is comprised mainly of Bunter and Keuper sandstones of Triassic age. The former outcrops mainly in the higher land of Liverpool and the two main ridges on Wirral. Older, Carboniferous sandstones also occur, particularly to the east of the area, for example around St Helens. In most of the region the bedrock is masked by glacial and recent deposits. Solid rock only outcrops at the surface infrequently, where it forms sandstone ridges, the

summits of which reach between 150m and 200m O.D. Although such outcrops are most numerous in the south of the region, on Wirral, around Liverpool and south of the Mersey near Runcorn, isolated hills also occur in the north (Fig. 2).

Over most of the rest of the region the surface geology is formed of glacial deposits laid down by the main ice sheet of the most recent (Devensian) glaciation and by periglacial processes in the subsequent late glacial period. The glacial depositional history of the region has been described by Wray and Cope (1948) and Evans and Arthurton (1973), and recently reviewed by Longworth (1985) and Worsley (1985). The glacial sediments comprise alternating sequences of tills and

sands or gravels. There is much variation in the number of sedimentary units, where for example, there are between one and four till units of differing fabric character in the north Merseyside area alone (Longworth 1985). Intercalated tills, sands and morainic material have been attributed by Worsley (1985) to late subglacial and supraglacial origin. The various till units around Merseyside, termed the Northern Drift by Kear (1985), are not considered to be the result of separate glacial events, but reflect variable depositional conditions during the advance and retreat of the main Devensian ice sheet. The composite glacial succession, clearly exposed near Thurstaston on Wirral (Brenchley 1968), has, however, been classified as a single drift sheet, the 'Stockport Formation' (Worsley 1985).

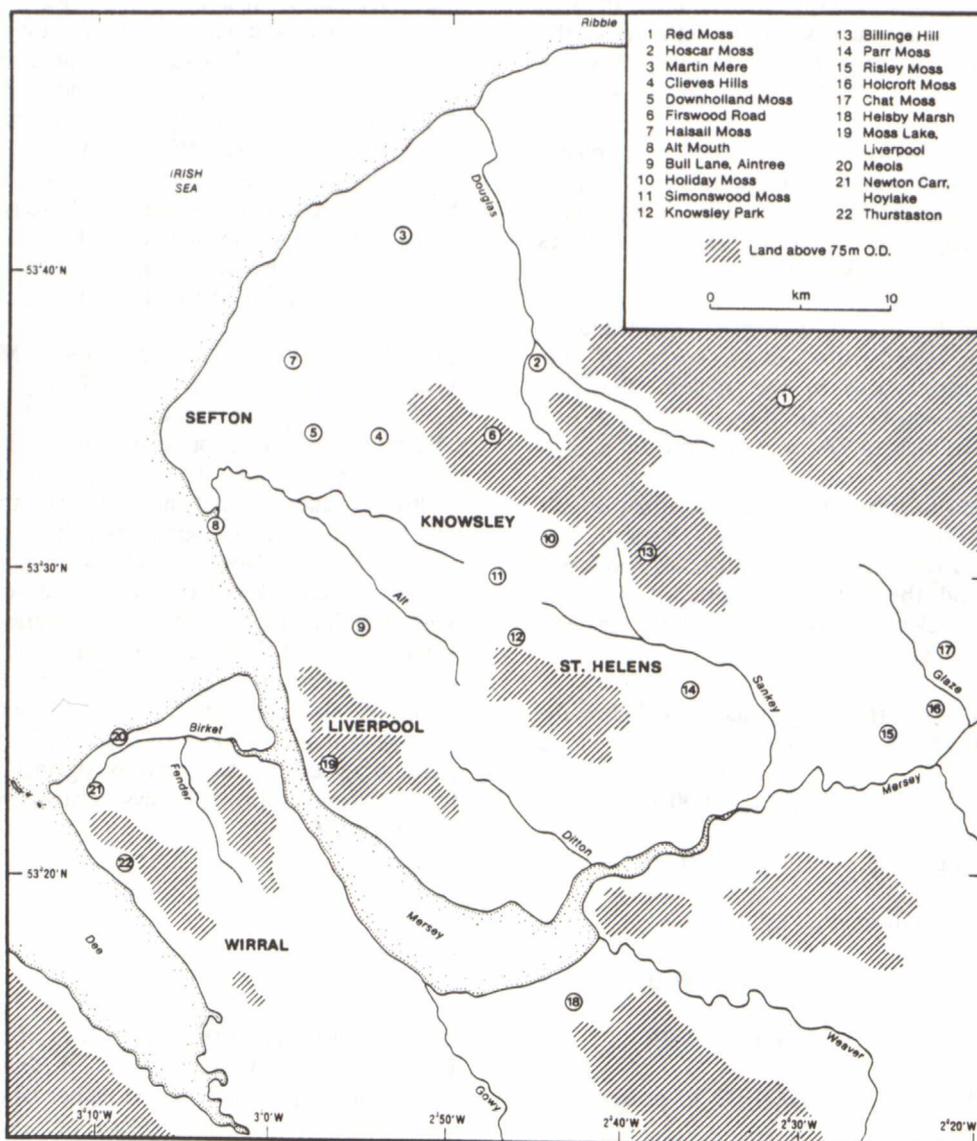


Figure 1: Sketch map showing the main relief and drainage features of the Merseyside region and the location of pollen sites mentioned in the text.

Radiocarbon dating of organic deposits above and below the till places the age of the Devensian glacial maximum at between 30,000 and 14,000 BP, with the major extent of ice cover around 18,000 BP. Ice movement was in a south easterly direction from the Irish Sea, eroding the Triassic sandstone bedrock and depositing a red coloured, stony till.

In the north of Merseyside the glacial tills are covered by the Shirdley Hill Sand. This sand is derived from fluvio-glacial material, which was redistributed by aeolian action (Tooley and Kear 1977; Wilson *et al.* 1981). Although it is only a superficial deposit, a few metres in thickness, it covers a large area between sea level and about 125m OD. Small, isolated areas of Shirdley Hill Sand also occur in the south of the region around Speke and South Liverpool. Godwin suggested the fluvio-glacial origin of this coversand and recognised that it overlay mud deposits dating to the late glacial (pollen zone II - Windermere Interstadial) at Moss Lake, Liverpool (Godwin 1959). The sand was itself overlain by muds and peats of the earliest postglacial (Flandrian Ia) age onwards. Subsequent pollen analysis and radiocarbon dating of peat lenses subjacent to Shirdley Hill Sand at Clieves Hills (10,455 ± 110 BP, Hv-4710, Tooley 1978) has confirmed its Late Devensian stadial (LDe III) origin. Tooley (1985b) considers that some of the sand deposit may have formed coastal dunes if a late glacial high sea level stand took place in this area, but this is not yet proven. The sand body was destabilised and redistributed by wind action at various times during the ensuing postglacial period (Innes 1986, Innes *et al.* 1989), so that its present distribution may not correspond to that of its initial deposition.

The glacial sediments are also masked in many places by later, superficial, deposits of postglacial age. These include peats, blown sand and both freshwater and estuarine alluvium (Fig. 2). These are the products of more recent processes of landscape evolution, described in more detail below.

Coastal Change

The position and character of Merseyside's coastline have been subject to considerable changes during the period since the height of the Devensian glaciation about 18,000 years ago. There is some evidence that during the process of deglaciation, which appears to have occurred quite rapidly after the time of maximum ice cover (Thomas 1985), parts of the Irish Sea basin experienced a high relative sea level stand. Sediments of marine origin have been reported from altitudes of between +14 and +18m O.D. on Wirral and the Isle of Man by Brenchley (1968), Syge (1977) and Thomas (1977). These have been interpreted by Thomas (1985) and Tooley (1985a) as having been deposited under the cold water environment of a proglacial sea, as marine conditions accompanied ice margin retreat. Although the level of this Ice Age sea might be assumed to have been eustatically low, it would appear that isostatic

depression of the region at this time was sufficient to allow inundation of the present day coastal areas. This Devensian transgression was not, it seems, of long duration, because isostatic uplift following the removal of the ice load next caused a relative fall of sea level. By perhaps 13,000 BP (Thomas 1985) the sea level was relatively very much lower, causing much of the current floor of the eastern Irish Sea to be, temporarily, dry land.

By the Flandrian I/II transition, isostatic readjustment was nearing completion. The early postglacial is characterised by very rapid rates of sea level rise causing further inundation of the low lying plain of the eastern Irish Sea floor, as the eustatic rise of sea level was increasing. Tooley (1978) has recorded complex lithologies in the Merseyside coastal area comprising intercalated clays, silts and peats. These he has been able to ascribe to marine, estuarine, freshwater or terrestrial origin using detailed pollen and diatom analyses. The lithological changes reflect radical alteration in local depositional conditions which are interpreted as the result of the introduction or withdrawal of marine conditions. It has been possible, with the use of radiocarbon dating and altitudinal correlations, to use the lithostratigraphic boundaries as index points to the creation of transgressive and regressive overlap sequences. From these index points, regional tendencies of sea level movement can be induced (Shennan 1983). Tooley (1982, 1985b) has identified twelve such periods of transgressive and regressive sea level tendencies from the Merseyside region, between 9000 BP and the present day. The temporal limits of these are shown on figure 3. Between 9000 and 5000 BP sea level rise was rapid and sustained so that by the later date a mean sea level height about equal to that of the present day had been achieved. After this time sea level movement was much slower and fluctuating, with periods of relative sea level fall. The prolonged early Flandrian transgressive tendency culminated in late Flandrian II, shortly before 5000 BP, with the extreme extension of marine conditions across the Merseyside lowlands as far as the eastern edge of Downholland Moss. Extensive marine sediments, known as the Downholland Silts, were laid down. Later in Flandrian II, between 6500 and 5000 BP, two further transgressive episodes deposited further marine clays. During the intervening periods of lowered sea level peat deposits were formed. A major retraction of marine conditions occurred around the Flandrian II-III transition, causing further widespread peat deposition upon the exposed marine clay surface, identifiable as regressive overlap 7 on Tooley's scheme (Fig. 3). These mid-Flandrian peat/clay intercalations are fully described from the Downholland Moss area of Sefton (Tooley 1978). They have also been recognised elsewhere, for example, south of the Mersey at Helsby Marsh (Tooley 1978), on the north Wirral coast (Kenna 1979, 1986) and at Newton Carr, Hoyle (Innes *et al.* 1990).

A brief renewed rise in sea level affected Merseyside in

early Flandrian III, about 4500 BP, and forms Tooley's overlap sequence 8. This has been recognised at the Alt Mouth, Sefton (Tooley 1978) and near Meols, Wirral (Innes 1984). Due to the rapid growth of coastal peat deposits and other barrier sediments, this rise was insufficient to inundate the coastline except in these small exposed embayments. Although, from this time onwards, sea level continued to rise slowly and remained a little higher than today's level, significant transgression of the coastline in this area did not occur. Instead, the effects of sea level rise have been shown in indirect ways through its influence on coastal landforms such as dune systems (Tooley 1980, 1985b).

A major indirect effect of rising sea level has been the elevation of ground water tables in landward areas beyond the reach of marine incursion. Tooley, using the terminology of Dutch workers, called these areas the

'perimarine zone'. In this zone, waterlogging caused the creation of swamps, fens and lakes. In the early postglacial, rapid sea level rise prevented major peat formation. Since mid-Flandrian times, however, the slow rise of sea level has allowed the extensive freshwater wetlands to develop. These, in turn, provided the conditions for the inception of the accumulation of the lowland mosslands, a major landscape feature in the region (see below). Several lakes, the largest of which was Martin Mere (Tooley 1985b), existed within these mosslands, until filled in by sedimentation, or drained in modern times.

A second major coastal development (Pye 1990; Tooley 1990) has been the creation of sand dune belts on the Wirral and Sefton shores as a result of the early Flandrian III lowering of sea level. Intertidal sand deposits, exposed to wind redistribution and over-

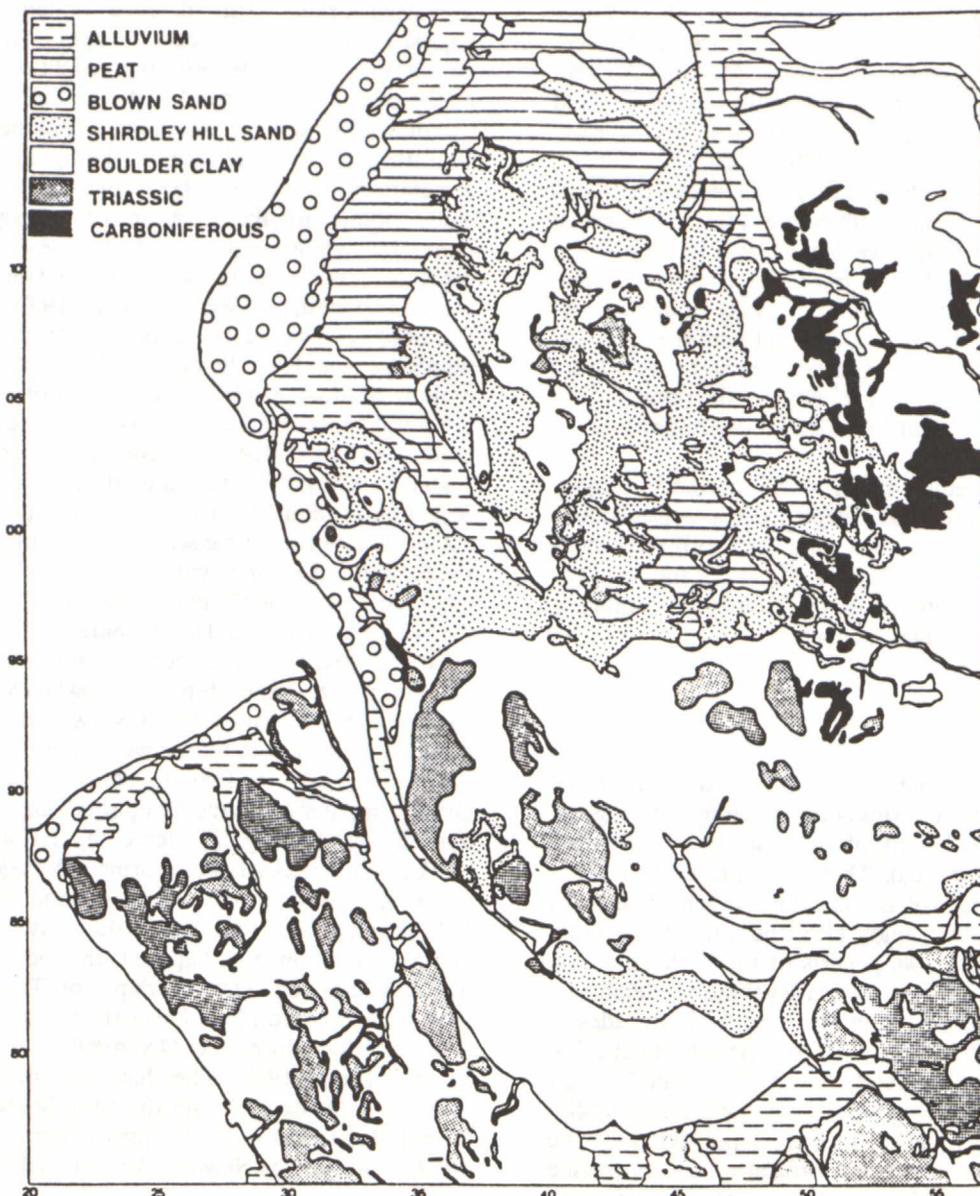


Figure 2: Surface geology of the Merseyside region.

blowing, buried the western fringes of the mossland, forming a barrier to further marine inundation. This process began before 4000 BP ($4,090 \pm 175$ BP, Hv-4705) at Downholland Moss (Tooley 1978) and has continued subsequently. The effects of two later periods of high sea level (Tooley's overlap sequences 10 and 12) can be recognised in periods of dune stability about 2300 BP and 800 BP, when high dune slack water tables caused peats to form (Tooley 1985b). At other times since 4000 BP, sea level has been little higher than that of today.

Climate

The changes in the British climate which took place during the Devensian glaciation and the subsequent postglacial period have been reviewed by Lamb (1977) and, with particular reference to northwest England, by Musk (1985). Generally cold conditions prevailed during the Devensian glacial age, with two 'stadial' periods of extreme low temperatures and maximum ice sheet development, around 55,000 BP and, in particular, about 18,000 BP. Two main warm, 'interstadial' episodes can be recognised within the Devensian: the 'Chelford' interstadial about 60,000 BP, when summer temperatures were similar to those of today, and the short 'Upton Warren' interstadial about 42,000 BP when summer temperatures may have been a little higher than today's. In both cases winter temperatures remained very cold and the climate was of continental type.

A further period of higher temperatures occurred between c. 12,000 and 11,000 BP during the Late Devensian, and this has been termed the 'Windermere' interstadial (Coope and Pennington 1977). After 11,000 BP a return to cold conditions occurred, with mean temperatures falling at least 4 °C from the Windermere maximum. This late glacial stadial cold phase came to an end c. 10,000 BP when a prolonged rise in temperature began and full interglacial climatic amelioration ensued. The early Flandrian was characterised by warm and mild winters and a relatively dry continental climate, which persisted up to about 7500 years ago. In contrast, the mid Flandrian period between c. 7500 and 5000 BP experienced a more oceanic climate; warm, with mean temperatures at least 3 °C higher than at present and with high rainfall. Since c. 5000 BP, however, climatic conditions have declined from this postglacial optimum. Although the period from c. 5000 BP to c. 3000 BP was drier, it was cooler, and from 3000 BP to 2000 BP the climate deteriorated to become much colder, wetter and of maritime type (Musk 1985). This stimulated rapid peat growth and the formation of 'recurrence surfaces' in bogs (Barber 1982). Many Merseyside mosses, such as Simonswood Moss and Parr Moss, show such features very clearly and the major recurrence surface at Chat Moss (Birks 1964) has been dated to 2645 ± 100 BP (Q-683, Godwin and Switsur 1966). This period of cold, wet climate was accompanied by a greatly increased

incidence of storminess (Lamb 1977).

A return to a warm, dry climatic regime occurred at about 2000 BP and lasted until about 800 BP, with particularly congenial conditions (in human terms) in the last few centuries of that period (Musk 1985). There were long, hot summers averaging at least 2 °C higher than today's. After 800 BP a phase of climatic decline ensued, with increasingly cool, wet conditions accompanied by very high sea level, frequent storms and storm-surge floods in coastal regions. This phase of deterioration culminated in a period, between c. 600 and c. 150 BP, of widespread cold climate, sufficiently severe to be termed the 'Little Ice Age', although there were some warmer decades within this period. Since the latter date, however, climate has again become milder.

Soils

The irregular surface distribution of geological deposits in the Merseyside region has provided a complex mosaic of parent strata which has fostered the development of a wide range of soil types. This variability has been compounded as external factors such as climate and local topography have further modified soil properties, while changes in sea level tendency have altered soil drainage characteristics in coastal areas. In addition, changes in texture, acidity and organic matter content will have taken place as a consequence of the natural processes of maturation within soil profiles (Taylor and Smith 1980). The retraction of Devensian ice cover around 14,000 BP gives a maximal date for the beginning of soil development in the region, but extreme periglacial conditions associated with the Late Devensian stadial phase between 11,000 and 10,000 BP would effectively have disrupted soil profiles. Extant soil types began to evolve broadly at the same time, shortly after the beginning of the Flandrian period at 10,000 BP, although continued ground instability in some areas, such as on the Shirdley Hill Sands, postponed pedogenesis a little longer.

Once stable ground conditions had allowed soil genesis, increasing postglacial temperatures would have encouraged subsequent development, although this would have occurred at different rates. Much of the glacially-derived material available for soil formation in the early Flandrian would have been relatively base-rich, so that soils would have tended to develop rapidly. Upon siliceous strata of glacial outwash or sandstone, however, formation may have proceeded more slowly. It seems likely that even in this early Flandrian period of young, transitional soil profiles, a degree of diversity in soil properties had been established. Although direct palaeosol evidence is lacking from Merseyside, some indirect support for this, in the form of pollen evidence, showing variations in early Flandrian I vegetation patterns, is discussed below.

During the mid Flandrian 'climatic optimum' between c. 7,500 and c. 5,000 BP, it is probable that most soil

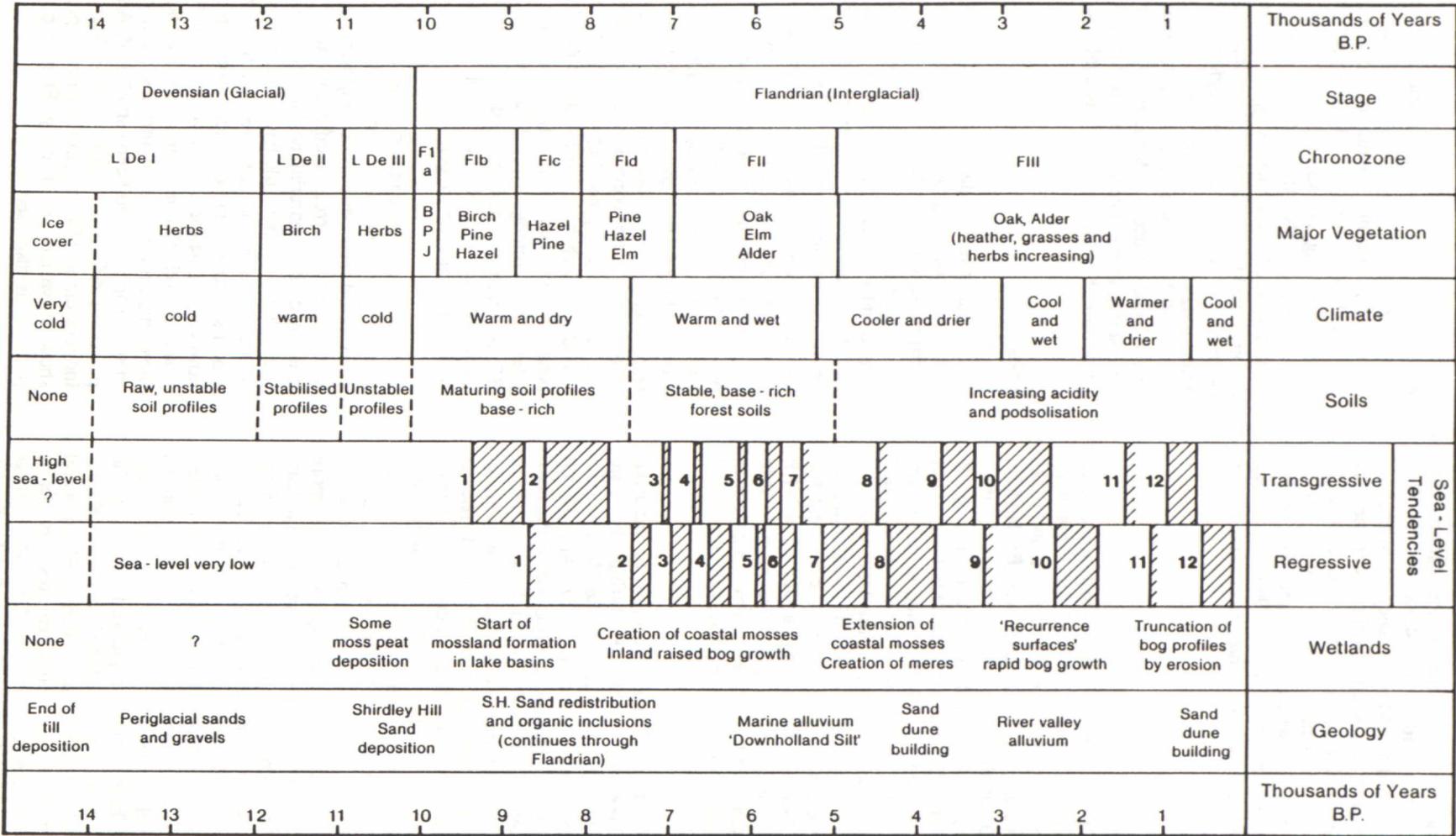


Figure 3: Correlation of the main natural factors influencing environmental history in the Merseyside region. Data derived from Johnson (1985a). B=Birch, P=Pine, J=Juniper.

profiles would have reached, or been close to, maturity (Simmons and Tooley 1981). In many cases, particularly upon till, this would comprise brown earth forest soils. In areas of acid substrate, or where leaching had been heavy, formation of forest podsoils may have occurred. Locally, drainage impedance by topographic or other factors may have encouraged soil gleying to occur, perhaps leading to organic soil formation. The leaching process was intensified in the later Flandrian period, from c. 5000 BP to the present, as climatic deterioration resulted in lower temperatures and increased precipitation. Although the effects of this natural acidification and podsolisation were general soil degeneration and the spread of peat, man's influence has obscured these natural processes since 5000 BP.

The soil patterns which developed on the surface geologies of the Merseyside region have been studied in detail by Hall and Folland (1970), Gagen (1982) and Kear (1985). In summary, the Northern Drift till plain of southern Merseyside has developed fertile clay-loam topsoils over clay subsoils (Kear 1985). This soil type is prone to waterlogging and shows gley features where gradients are low, producing surface water gleys, brown soils or, exceptionally, impermeable clays. In contrast, fluvioglacial sands and gravels which occur in the river valleys of the Douglas, Mersey and Sankey provide coarse textured, siliceous soils which are free draining and prone to leaching. Loamy brown sands typify this association, with features of gleying where drainage is restricted. Alluvial silt also occurs in these three river valleys, as well as those of the Alt, Birket and Fender. High water tables and flooding have led to the formation of ground water gleys in this situation, as upon the marine Downholland Silts along the Sefton coast.

The Shirdley Hill Sand of northern Merseyside, although permeable, is underlain by till. Its soils are characterised by their degree of gleying and their profile drainage impedance, which occur to a greater or lesser extent, depending on local topography. Acid gley podsoils are most common, while in depressions, peaty gleys lead to the formation of true peat. Other sand deposits in Merseyside which are sufficiently stable to permit pedogenesis, are characterised by acid podsoils. The blown sand areas of the Wirral coast and between Crosby and Southport sustain such soils, as do those minor inland formations, such as the Mere Sands (Wilson 1985), which are believed to derive from beach sediments. In contrast, the outcrops of Triassic sandstone, which form ridges on the Wirral and in the Liverpool area, have produced free draining sandy brown earths, with some degree of local podsolisation and the formation of sandy gleys on their lower slopes. Brown earths also occur on the outcrops of Carboniferous sandstone, in the Billinge and St Helens areas.

Mosslands

A characteristic feature of Merseyside's landscape, even

more so in the past than today, has been the great variety and quantity of peat deposits developed upon the inorganic sediments and mineral soils of the region (Innes and Tomlinson 1980). The tendency towards profile saturation and surface water gleying in Shirdley Hill Sand areas, for example, was sufficient at sites of impaired drainage to allow organic matter to accumulate at the surface, forming peaty gleys, which then developed into true peats. True peat, defined as organic matter of a depth greater than 20cm, accumulated in this way over much of north Merseyside. These peats come within the Altcar series as classified by Hall and Folland (1970).

The thin peat bed resting upon till, but beneath Shirdley Hill Sand, at Clieves Hills yielding a radiocarbon date of $10,455 \pm 100$ BP (Hv-4710, Tooley 1978) shows that suitable conditions for this kind of peat inception and growth must have existed as early as the Late Devensian. Analogous sub-Shirdley Hill Sand peat beds which have been investigated by Baxter (1983) at several sites in the region, have also yielded Late Devensian pollen assemblages. At Simonswood Moss 3 the pollen evidence was supported by radiocarbon dating which showed that the basal peat formed between c. 11,600 and 10,500 years ago, within the Late Devensian interstadial and final stadial phases. Peat beds have also formed within the Shirdley Hill Sand at some sites. These formed at intervals throughout the Flandrian period, reflecting periods of waterlogging and sand stability. A Flandrian II peat lens in sand at Firwood Road, for example, yielded a radiocarbon date of 6195 ± 80 BP (Hv-4711) (Tooley 1978). Another peat layer, within the Sand at Bull Lane, Aintree, is shown, by its pollen assemblage, to be of Flandrian III age (Innes 1984), and is dated to 4600 ± 50 BP (SRR-2932).

A major area of lowland peat moss occurs between Crosby and Southport running along the coast and separated from the sea by blown sand. This peat complex has been classified as being of 'low moor' type by Hall (1968) and more recently described by Shimwell (1985). Peat profiles in this area comprise sediments which represent the early and middle stages of hydrosere succession (Walker 1970). These include *gyttjas* (detrital lake muds), reedswamp peats, fen and fen-carr peats of up to three or four metres depth, as at Downholland Moss. Raised bog peats, several metres in depth, may overlie these deposits as, for example, at Halsall Moss, although most now have been truncated by cultivation. The reedswamp and fen peats are composed mainly of grasses and sedges, with *Phragmites communis* and *Carex* spp. prominent. Alder (*Alnus glutinosa*) is the main tree represented in the woody fen-carr peats, although birch (*Betula* spp.) and willow (*Salix* spp.) also occur. This lowland moss type is also found behind the north Wirral coast (Kenna 1979). In both these areas it extends beneath the blown sand overburden, appearing in places upon the foreshore as intertidal 'submerged forests'. In such locations, as at the Alt Mouth (Tooley 1977) or near Meols (Innes

1983, Kenna 1985), marine erosion has reduced it to less than a metre in thickness.

Other deep peat sections have developed in inland areas of the region, particularly between Ormskirk and Knowsley, at altitudes of between 30 and 60 metres above sea level. Several large raised mosses exist in this area either as individual bogs, as at Holiday Moss, Rainford, or as larger 'complexes', as at Simonswood Moss, Knowsley. Using Hulme's topographical classification (1980), the nuclei of peat formation in these mosslands were of 'confined' type, where the infilling of lakes began at an early stage of the postglacial in enclosed topographic basins. The upper peats of these deposits represent a 'partly confined' stage of development, when peat has spread from the initiation foci to coalesce and cover the intervening land surface. This expansion seems to have taken place mainly in later Flandrian II and Flandrian III. While most of the large inland mosses in Merseyside are developed over Shirdley Hill Sand (Innes 1986), some do occur over glacial till, as at Parr Moss, St Helens (Innes and Tomlinson 1981). Several deep mosses have developed over the tills and fluvioglacial gravels of the lower Mersey valley on the borders of Merseyside, of which Chat Moss, Risley Moss and Holcroft Moss are the largest.

Fully 'unconfined' blanket peats are absent from the region except perhaps for a small area near Thurstaston, on Wirral.

Vegetation History

The following chronological summary is based on the pollen analytical research of many workers in the region. A considerable body of data now exists which has been used to reconstruct the vegetation history. For periods which lack data, parallels are drawn from adjacent parts of northwest England.

Pre-Late Devensian. Before c. 14,000 BP.

Although no Merseyside data exist for this period, early botanical records are available from elsewhere which may provide relevant parallels (Worsley 1985). Interglacial sediments, possibly of Hoxnian age (about 240,000 BP), are present at Trysull, Staffordshire, while pollen representing temperate woodland, including oak, alder, hazel and yew, has been recovered from Four Ashes, Staffordshire which appears to be of Ipswichian interglacial age (about 120,000 BP). Another warm temperate woodland flora of probable Ipswichian age has been reported from Scandal Beck, Cumbria (Thomas 1985). The earlier stages of the last (Devensian) glaciation may be represented by a pollen assemblage from Oakwood Quarry, Cheshire which, dominated by herbs, reflects a cold, open, treeless landscape. Organic silts from Chelford, Cheshire record a brief interstadial expansion of temperate woodland

which is dated as having occurred about 60,000 BP, in mid-Devensian times (Worsley 1985). It may be assumed that vegetation communities of broadly similar type existed in Merseyside during each of these remote time periods.

Late Devensian. c. 14,000 - c. 10,000 BP

The early part of this period, shortly after retraction of ice cover, would have seen only pioneer vegetation, as turf and short herb communities colonised bare ground surfaces. Grasses, sedges, mosses and *Lycopodium* sp. (clubmoss) would have dominated, with *Rumex* spp. (docks/sorrel), *Artemisia* sp. (mugwort) and cold-tolerant herbs like *Helianthemum* sp. (rock rose) joining them (Pennington 1977). Between c. 13,000 and c. 12,000 BP a taller flora would have developed, including *Empetrum* sp. (crowberry), *Juniperus* sp. (juniper) and *Salix* spp. (willows), but herb taxa would still have been abundant. It is this phase which is represented in the earliest Merseyside pollen records, such as at Moss Lake, Liverpool (Godwin 1959) and Chat Moss (Birks 1965a).

Between c. 12,000 and c. 11,000 BP the warmer conditions of the 'Windermere Interstadial' (Coope and Pennington 1977) permitted the establishment of mature *Betula* (birch) woodland and a rich tall herb field layer. Between c. 11,000 and c. 10,000 BP, however, this woodland was replaced by a tundra type herbaceous pollen flora including grasses, sedges, *Artemisia*, *Rumex* spp. and Ranunculaceae family as well as *Empetrum*, although some birch remained. Aquatic herbs were also abundant. Several Merseyside sites, such as those associated with Shirdley Hill Sand, like Clieves Hills (Tooley 1978), or the basal sediments of the larger raised mosses, like Knowsley Park Moss (Innes unpublished), contain pollen records of this age. Much of our knowledge of Late Devensian plant communities in the Shirdley Hill Sand areas of the Merseyside region comes from the work of Baxter (1983).

Early Flandrian. c. 10,000 - c. 7000 BP.

The presence of Flandrian I sediments in the pollen record of many of the deeper raised moss profiles allows the recognition of some spatial differentiation in the pattern of vegetation which took place as the period progressed. In addition, the radiocarbon dated pollen diagram from Red Moss to the east of Merseyside (Hibbert *et al.* 1971), which serves as a standard diagram for northwest England, becomes relevant. At Red Moss the earliest postglacial, Flandrian Ia, is dated as ending at 9798 ± 200 BP (Q-924). Birch woodland dominated the vegetation, but it was at first very open, containing many of the late glacial herb communities which in some cases even increase in pollen frequency. *Filipendula* sp. (meadowsweet) in particular seems to have been encouraged by increasing temperatures. *Pinus* sp. (pine) and *Populus tremula* (aspen) are other trees

present in this phase and *Juniperus* sp., *Salix* sp. and some *Empetrum* sp. formed shrub woodland before tree birches shaded them out. High grass and sedge values are typical of the initial part of this period. At Red Moss, which rests upon till, the herb and shrub pollen types are steadily reduced in abundance as closed birch woodland developed. The high non-tree pollen values which persisted at Knowsley Park Moss and Simonswood Moss suggest that this succession to woodland progressed more slowly on Shirdley Hill Sand (Innes unpublished).

At Red Moss during Flandrian Ib, dated as ending at $8,990 \pm 170$ BP (Q-921), birch remained the most important tree, while pine became better represented. *Corylus avellana* (hazel) entered the assemblage replacing the more pioneer willow and juniper. By contrast, Flandrian Ic, ending at Red Moss at 8196 ± 150 BP (Q-918), is marked by the expansion of hazel to very high pollen values, pine becoming more important and birch declining in frequency. Analogous pollen changes occur in the other profiles of this age in the Merseyside region, as at Moss Lake, Liverpool (Godwin 1959) and Chat Moss (Birks 1964).

Flandrian Id ending at 7107 ± 120 BP (Q-916) at Red Moss, is notable for the increased rate of immigration of deciduous trees into the boreal woodland. *Ulmus* sp. (elm) and *Quercus* sp. (oak) become major forest constituents, and near the end of the period *Tilia* sp. (lime) and *Alnus glutinosa* (alder) increase. Tooley (1978) has recorded horizons of this age at Downholland Moss 11, but with less deciduous tree pollen and with pine and hazel still dominant. Again, vegetation patterns seem to have differed between the sand and till areas. Pine/hazel dominance was retained in this period at Hoscarr Moss (Cundill 1981), also upon sand.

Mid Flandrian. c. 7000 - c. 5000 BP

This period is characterised by the establishment and dominance of the mixed oak forest trees. Its beginning is defined by an increase in alder pollen to very high frequencies. The reduction in value of all non-tree pollen types at Red Moss suggests that this forest was very dense. On the Shirdley Hill Sand sites mentioned above, however, a more open, mixed woodland existed. These edaphic differences were perhaps compounded by the effects of early human activity.

Although many 'alder-rise' dates are of the 7000 BP mark, Smith and Pilcher (1973) have shown that it was not a synchronous event, some variation occurring in this part of Britain. Although dates at upland sites in the Pennines are rather later than this, Chambers and Price (1985) have recorded a very early rise of alder at a site in north Wales dated to 8595 ± 95 BP (CAR-643). Local, mainly edaphic, conditions may have been the controlling factors in the timing of the alder

rise at each site. Until such variation is proved within Merseyside, however, a general date of 7000 BP may be assumed for this feature. Oak and alder are the most important trees, followed by elm, lime and hazel. *Fraxinus excelsior* (ash) and *Fagus sylvatica* (beech) occur late in the period. Although some vegetation records come to an end during this period, such as Moss Lake, Liverpool, several peat centres expanded or began to form, so that the actual quantity of data available increases. The main evidence comes from the Knowsley and Sefton areas, with the Mersey valley mosses and sites on the north Wirral coast providing comparative data (Birks 1964, 1965b, Innes 1984). Later Flandrian. c. 5000 BP onwards.

The beginning of this period is defined by a fall in elm pollen frequencies to low values, which do not recover. At Red Moss this is dated to 5010 ± 80 BP (Q-912). This accords well with the timing, around 5000 BP, of this event in other parts of northern Europe. Research is showing that the elm decline is less synchronous than previously believed, with dates available which lie several centuries either side of the mean. Whilst local factors are clearly important as a source of variation, a recent elm decline date, from Park Road, Meols, of 5120 ± 50 BP (SRR-2929) (Innes unpublished) suggests that the Red Moss date remains a reliable guide for the area.

Although the pollen evidence shows that the region was still well wooded in the early part of the later Flandrian (Flandrian III), the primary forest trees of elm and lime had largely been replaced by secondary woodland types such as ash and birch. Alder and oak were most common in the damper lowland areas, as around Martin Mere (Tooley 1985b) or in south Sefton (Innes 1982), and formed fen woodland around wetland areas. Upon drier areas a more open oak woodland existed with differences in its lesser constituents. Hazel, for example, was dominant in this role on sand areas (Innes and Tomlinson unpub.) while ash and *Ilex aquifolium* (holly) were also locally important (Innes 1984). *Carpinus betulus* (hornbeam) entered the woodland late in the period at several sites. Some pine and *Calluna vulgaris* (heather) associations seem to have existed in the sand dune areas.

Although the Later Flandrian forest appears to have been increasingly opened up by human activity, edaphic factors also caused local differences to occur. For whatever reason, over a wide area of the region regeneration of woodland was decreasing. Vegetation was instead changing either to mire in many places or to a heath or scrub, dominated by heather, bracken, birch or hazel. The Later Flandrian III vegetation changes are, however, so closely connected with man's activities - agriculture, plantation and the introduction of new taxa - that their discussion is more appropriate in the following section.

SECTION 2: POLLEN EVIDENCE OF HUMAN ACTIVITY FROM PEAT DEPOSITS

Changes in the vegetation, soils and drainage of past landscapes may often be interpreted as the results of human activity, which became increasingly intensive during the prehistoric period, as agricultural systems developed. Although the scale of this landscape alteration caused by man has been greatest in the most recent past, there is much evidence that man was responsible for initiating environmental change from the time of the earliest postglacial settlement of the region (Howard-Davis *et al.* 1988)

The influence of early man on the vegetation can be recognised on pollen diagrams from Merseyside in the form of changes in the type and proportion of trees, shrubs and herbs contributing to the pollen record. These may be interpreted as reflecting actual changes in the vegetation cover due to disturbance of the environment, such as replacement of woodland by grassland or heath. In some cases the recognition of diagnostic pollen types, such as cereals, demonstrates that woodland was cleared for cultivation.

Where pollen grains of cultivated plants are absent, it is not possible to demonstrate a causal link between human activity and vegetation disturbance. Natural disturbance could have been the cause of some of the forest opening noted on Merseyside pollen diagrams. The scale and character of the evidence are, however, such that a human origin is thought to be the cause for most of the disturbance events recognised on the pollen diagrams, except, perhaps, in the earliest periods.

There are several reasons why pollen evidence in isolation cannot be interpreted reliably in cultural terms (Edwards 1979). These are mainly the absence of a comprehensive radiocarbon dating programme, although there are a few dates and some more to come, and a secure stratification of cultural material with most of the pollen phases. In this paper, therefore, we review the pollen evidence from Merseyside using the chronological Flandrian subdivisions of West (1970) and Hibbert *et al.* (1971), thus avoiding direct cultural inferences, except where possible. Figure 1 shows the location of all the pollen sites sampled for the survey and other sites mentioned in the text. The radiocarbon dates are shown although the detailed interpretation of these dates will be dealt with elsewhere (Innes and Tomlinson in prep.).

Late Devensian and Early Flandrian
c. 14,000 - c. 7000 BP.

There is no evidence from the late glacial (Devensian) or early postglacial (Flandrian) that man was involved in the disturbance of the herb/shrub tundra or successional boreal woodland communities which characterise these two early periods respectively. Since both vegetation types were relatively open and

productive, it may be that deliberate disturbance of the vegetation would not have been particularly necessary for the hunter-gatherer bands, presumably few in number, who may have been exploiting the region's resources at that time.

Evidence that the lowlands of northwest England were occupied during the Late Devensian comes from Poulton-le-Fylde (Hallam *et al.* 1973) to the north of Merseyside, where the activities of early hunters at the beginning of the Windermere Interstadial, or in a preceding, short 'late glacial interstadial' (Jacobi *et al.* 1986), are shown by barbed points and an elk skeleton. A radiocarbon date of $12,200 \pm 160$ BP (ST-3832) was given for the skeleton, but this date has subsequently been questioned (Jacobi *et al.* 1986). It is very likely that similar hunting activity occurred within the Merseyside region itself, but the impact, if any, of such people upon the environment remains to be demonstrated.

An example of the type of evidence of the environmental impact caused by these early hunters using fire comes from Holland. Layers of charcoal associated with flint artefacts were found from an Allerod (*cf.* Windermere Interstadial) context (Van der Hammen 1953). Such evidence has not been found in Merseyside in the earliest Flandrian (c. 10,000-8500 BP). It may be that sites are buried by later sediments or now lie beneath the Irish sea, having been inundated by the sea level rise.

In the latter half of Flandrian I (c. 8500 - c. 7000 BP), there is some evidence from areas adjacent to Merseyside of the effect of fire in disrupting woodland communities. In the south Pennines, at Broomhead Moor V, pollen fluctuations consistent with the removal of hazel dominated woodland and its replacement by heathland after a phase of ruderal herb expansion were reported by Radley *et al.* (1974). Mesolithic flints were present, as well as a layer of charcoal which suggests fire was the cause of the vegetation change. This disturbance is dated to 8570 ± 110 BP (Q-800). In a situation closer to Merseyside, Tooley (1978) has recorded at the Starr Hills, Lytham, a phase in which birch and pine were replaced by regeneration herb and shrub species. Again a great deal of charcoal was present. The phase is dated to 8390 ± 105 BP (Hv 4343). Whether or not it was used by human communities, it seems likely that fire was present as an ecological force within the early postglacial woodlands of Merseyside and that sites analogous to the two cited above remain to be discovered. Pollen fluctuation in late Flandrian I at Holiday Moss reported by Baxter and Taylor (unpub.) may represent such activity.

Mid Flandrian c. 7000 - c. 5000 BP.

During the mixed deciduous woodland phase of the mid Flandrian, evidence of vegetation disturbance becomes available from within Merseyside. It may be that the

establishment of dense, close canopied forest during the period itself prompted the foraging communities of the later Mesolithic, which are generally correlated with this period, to create clearings as an aid to hunting, using fire as the mechanism for change (Mellars 1976). Many phases of fire-induced clearance are recorded from the Pennine uplands to the east of the study area during this period (Simmons and Innes 1985).

In Merseyside, a number of examples occur at, or just after, the transition between Flandrian I and II (c. 7000 BP) as though the increase in alder and denser forest had been a stimulus to clearance. Cundill (1981, 1984) has recorded a charcoal layer of this date associated with pollen evidence of clearance from Hoscar Moss. Similar charcoal and pollen evidence have been described from Simonswood Moss (Innes and Tomlinson 1983a), while at Blackmoor, near Mawdesley, a large early Flandrian II charcoal layer is stratified in a bog adjacent to a Mesolithic flint site (Barnes pers. comm.).

Pollen evidence of disturbed habitats within the mid Flandrian II forest is present at Sniggery Wood and Flea Moss Wood, Sefton (Innes 1982), from Squibb's, Moreton (Kenna 1978) and from Knowsley Park Moss (Innes unpub.). Tooley (1985a) has reported charcoal from several Flandrian II levels at Downholland Moss 16, one of which is radiocarbon dated to 6210 ± 100 BP (Hv 8650). later Flandrian II pollen fluctuations reported by Baxter and Taylor (unpub.) may also represent disturbance. If such activity were as widespread in Merseyside as it appears to have been, then the evidence of unstable soil environments reported by Godwin (1959) at Moss Lake, Liverpool and by Tooley (1978) at Firwood Road may also be attributable to a similar cause; that is to disturbance by late Mesolithic hunting groups. The weight of evidence described above points to disturbance of woodland, often by fire, being a significant factor in mid Flandrian vegetation history. Natural ignition of very humid, moist deciduous woodland seems unlikely, especially since many examples are associated with wetland fringe environments, where fire would not easily be carried naturally. A human agency for the disturbance seems very likely.

An intriguing recent development of this theme has been the identification of pollen of cereal type by Tooley (1985b) at Martin Mere and by Innes (unpub.) at Flea Moss Wood and Bidston Moss, both in contexts now shown to be Flandrian II. It appears that very early cultivation was being practiced in Merseyside before c. 5000 BP, presumably by early Neolithic settlers or, less likely, as a development of advanced Mesolithic foragers (Simmons and Innes 1987). In effect, cultural labels of this kind may well be inappropriate in this context. It may be enough to say that the environmental evidence hints at the Merseyside region having supported populations practising an economy with a food production element at a very early stage of prehistory. Although in the nearby southern Pennines, Williams (1985) has dated a similar early cereal phase to $5820 \pm$

95 BP (Q-2394), any temporal or social correlations between the two areas must remain conjectural.

Late Flandrian after 5000 BP.

Although the fall in elm pollen values which defines the beginning of the later Flandrian (Flandrian III) is long thought to have been a consequence of the activities of early farmers (Iversen 1941), climate, soils and disease may also have been responsible. In Merseyside the elm decline has been recognised at several sites and in most cases it is accompanied by weed pollen and other pollen fluctuations which point to forest clearance having taken place. At Red Moss (Hibbert *et al.* 1971) this event is dated to 5010 ± 80 BP (Q-912) and is coincident with the first record of *Plantago lanceolata* (ribwort plantain) held to be a secure indicator of forest clearance. Similar features may be seen on pollen diagrams from Downholland Moss (Tooley 1978), Knowsley Park Moss and Simonswood Moss (Innes unpub.), while at Hoscar Moss (Cundill 1984) the elm decline is accompanied by a thick charcoal layer. Pollen diagrams from the Mersey valley at Chat Moss (Birks 1964) and Holcroft Moss (Birks 1965b) also display evidence of forest clearance at the elm decline. Although low overall elm pollen values on Shirdley Hill Sand sites such as Flea Moss Wood and Sniggery Wood (Innes 1982) make recognition of the elm decline difficult, levels which must be of that date or only slightly later do show evidence of quite intensive forest clearance.

Forest opening seems to have had a greater impact upon the Shirdley Hill Sand area than upon the till plain. A naturally more open woodland may have existed upon the Sand on soils of a type more attractive for exploitation. This conforms with the evidence of the previous Flandrian II period, where clearance activity seems to have been concentrated in the sandy areas. While weed pollen evidence of woodland opening is present at several sites, cereal evidence is lacking. The reason for this may be simply that a solely pastoralist way of life, perhaps involving the free herding of animals in the woodland, had been adopted. The more likely explanation is that the large raised moss pollen sampling sites are unsuitable for registering pollen evidence of small scale cultivation. In any event, it may be assumed that cereals were still grown in suitable locations and these will appear in future pollen evidence. The sandstone outcrop areas of the region may have been attractive in this respect. It would appear that human activity was widespread at this time which can, with reasonable security, be attributed to early farming by Neolithic societies.

At the sites where an elm decline is registered, clearance activity only a little way above this marker horizon in the pollen diagram, may be assumed still to be within the Neolithic period. Flandrian III clearances well above the elm decline, or in diagrams which begin in Flandrian III itself, may not, however, be assigned

any particular cultural group. The relationship of such pollen data to Bronze Age or later cultures cannot be attempted unless radiocarbon dating is available or the data are associated with archaeological remains. Unfortunately no clear pollen horizon exists later than the elm decline which may be used as a relative dating benchmark on a regional basis.

At many sites in the Merseyside region, particularly those with long raised moss profiles, a sequence of several clearance phases may be recognised in mid and late Flandrian III. This successive application and withdrawal of human pressure upon the environment may be illustrated by the data from Parr Moss, a raised bog which lies on the till plain east of St Helens (Innes and Tomlinson 1981, 1983b). Early Flandrian III woodland was cleared twice. Not only oak and alder, but also elm and lime, pollen frequencies were reduced. Although *Pteridium aquilinum* (bracken) and several other weed types increase their pollen representation, as substantial areas of open ground were created, presumably for mixed farming, conclusive evidence of cultivation is absent.

This pattern of clearance, followed by regeneration, is extended into later Flandrian III, with clearance becoming increasingly more intensive and regeneration correspondingly less successful. These phases near the top of the profile contain evidence of more explicit cultivation plants, such as *Cannabis* type (hemp or hops) and weeds like *Artemisia*.

Finally, the top of the diagram records a most intensive period of human activity, as cereals are recorded, together with *Cannabis* type and the cornfield weeds *Matricaria* (mayweed) and *Centaurea cyanus* (cornflower).

Similar evidence of increasingly severe clearances with indications of arable agriculture, is available from most Merseyside pollen sites. Considerable clearance for cereal cultivation is recorded at Birks' sites at Chat Moss and Holcroft Moss (Birks 1964, 1965b), as well as Holland Moss and Hoscarr Moss (Cundill 1981), Downholland Moss 15 (Tooley 1978) and Simonswood Moss (Innes and Tomlinson unpub.), which are upon Shirdley Hill Sand. Chat Moss has radiocarbon dates for a major clearance phase; these are 3070 ± 150 BP and 2645 ± 100 BP, which puts this phase in the Bronze Age (Godwin and Switsur 1966).

A similar, although truncated, sequence occurs at Bidston Moss, on Wirral (Innes and Tomlinson unpub.). Most instructive in this respect, however, may be a long pollen diagram from Knowsley Park Moss (Innes unpub.) for which provisional radiocarbon datings have been received. This suggests that the period between c. 4,000 and c. 2500 BP was one of intensive land use in the region. The period from c. 1,700 BP onwards also seems to have been one of agricultural activity, this time including the cultivation of cereals and widespread deforestation of the landscape. Further radiocarbon

dating of this key pollen site is awaited before these early conclusions may be confirmed.

While the interpretation of the variety of Flandrian III clearance evidence must remain tentative at present, it may be said that quite clearly humans were engaged in manipulating the vegetation to their own advantage with increasing severity from Neolithic times onwards. Acidification and erosion of the soils may well have been a further effect of the prehistoric clearance. The pollen evidence, therefore, suggests considerable human activity in Merseyside in prehistoric times.

The majority of the peat deposits in Merseyside appear to have been truncated so that later periods of prehistory and the historic periods are not represented. Recent results from the radiocarbon dates have confirmed this (Innes in prep.). Evidently this is the result of erosion and peat cutting for fuel and other purposes. Pollen evidence from archaeological excavations may help towards filling this gap as well as providing environmental evidence directly related to cultural periods, where pollen results from natural deposits cannot. Examples of pollen studies of this type are described in the next section.

SECTION 3: ENVIRONMENTAL EVIDENCE FROM EXCAVATIONS

Where deposits from archaeological sites contain suitably preserved organic material, much information may be gained, both on the kinds of vegetation growing on and around the site, as well as the nature of the deposits themselves. There may also be details of plant materials which have been used or processed on site and human, or animal, foods which have been consumed. Deposits which have revealed such a range of evidence in this region in recent years have mainly been buried soils and waterlogged material in moats, ditches and cesspits.

Environmental research has not been confined to botanical, macrofossil and pollen, material. Evidence of land use, environmental conditions and human health and diet comes from beetles, freshwater and marine molluscs, ostracods and human parasite eggs as well as the more usual bird, fish and mammal bones.

Pollen analysis from buried soils and sediments.

There are a few examples from the Merseyside region where pollen analyses of buried soils or turves have provided information on the land use and vegetation around the sites. At Winwick Bronze Age barrow, for example, pollen analysis of the turves which had been used to construct the barrow suggested that an open,

grazed landscape surrounded the site (Tomlinson 1990). At Bromborough Court House, examination of a sequence of buried organic soils underlying a metre thick layer of dumped soil, gave evidence of the vegetation of the area in the past (Innes and Tomlinson 1978). This was mainly a woodland succession which, as it was not possible to date this deposit, is difficult to interpret and impossible to integrate with the archaeology. This is often a problem with Merseyside pollen evidence as there is a lack of well dated deposits to use as a basis for the vegetation history.

Layers of natural peat are often found in Merseyside underlying very recent urban development. At Warrington Road, Prescott, for example, the peat had been severely truncated by levelling for the construction of the stables and outbuildings of a 19th century inn and possibly by earlier post-medieval ploughing (Tomlinson and Innes 1989). The profile nevertheless showed a series of phases of clearance for agriculture, the latest of which has proved to be Neolithic in date. Given the proximity of the profile to medieval Prescott, this is one of the few instances from the region which might have provided an association between pollen data and later human occupation. As at Prescott, such buried peats do not necessarily provide information which is directly relevant to specific excavations, but their study, together with other unconsolidated natural deposits, such as the Shirdley Hill Sand, is important as it allows broad, environmental developments to be compared with a known cultural sequence. As with most of the peat deposits in this area, although the profile at Prescott showed part of the postglacial vegetation history, this was greatly truncated by the construction mentioned above and probably also by earlier peat digging for fuel.

The few occasions on which pollen data have been derived from archaeological sites, or from very close to them, contrast strongly with the richness of Merseyside in terms of potential sites. The large areas of mossland and buried peats on the north Wirral shore and beneath the coastal dunes from Altmouth to Southport, as described in Section 1, above, are outstanding examples. Clearly there is a need for an archaeological excavation and fieldwork policy directed towards the recovery of artefactual material in association with one or other of these rich natural deposits. The site at Meols, where both Romano-British and medieval occupation horizons of some complexity (Hume 1863) appear to be associated with submerged, waterlogged land surfaces, is archaeologically highly enigmatic and should be ideal for environmental investigation. Other possible sites might be the margins of late glacial lakes, such as may underlie King's Moss Rainford, which may well have been attractive to prehistoric peoples and are now surrounded by extensive peat deposits.

In addition to providing information about the general wider environment, pollen evidence may give specific information about the use or cultivation of particular plants on a site. Analysis of an organic layer within the

cloister at Norton Priory, for example, showed a very high number of *Artemisia* sp. grains (Macphail and Keeley 1978). It was suggested that these might be wormwood (*Artemisia absinthium*) which could, perhaps, have been grown in the cloister for its medicinal properties. This type of result is potentially very interesting, especially if it can be related to documentary records of species used medicinally or to lists of species planted, for example, in monastic gardens. Once again, for this type of information to be forthcoming, policy decisions about the types of sites selected for excavation must be made with these questions in mind. The results of pollen analysis from archaeological sites need very careful interpretation. It is important to strive for integrated dating and phasing with the pollen profiles. A sampling strategy is necessary and care needs to be taken in choosing samples which will provide useful archaeological information as well as the general development of the vegetation. A palynologist is, therefore, needed both in the selection and planning stages of excavations.

Cesspits

One of the earliest detailed botanical analyses of a cesspit was carried out on material from Goldsmith House, Goss Street, Chester (Wilson 1975). A very large number of crushed corncockle (*Agrostemma githago*) seeds were found which were thought to have been consumed, either for their medicinal properties or as an accidental contaminant in the food. Since then many medieval cesspits have been found to contain faecal material with fragments of corncockle seeds and, although there is plenty of documentary evidence for its use in medicine, as there is for many other species, it is not now thought likely to be anything other than contamination of the food, probably bread, made from cereal grain. Corncockle was a serious cornfield weed because it has large seeds which are not easily removed from the grain crop and when a contaminant in flour it could have hallucinogenic and other poisoning effects.

The wooden-lined Roman 'plank tank' from St Anne's Lane, Nantwich was initially thought to be related to salt working (McNeil and Roberts 1987). Analysis of the organic material at its base, however, showed it to contain a high proportion of cereal 'bran' fragments, from the part of the grain known as the periderm, and a variety of seeds and fruitstones including fig (*Ficus carica*), opium poppy (*Papaver somniferum*), coriander (*Coriandrum sativum*) and dill (*Anethum graveolens*) (Tomlinson 1987). All of these plant remains are typical of Roman cesspits in Britain. In addition, it proved possible to identify tiny fragments of plant epidermis (the outer 'skin') which were contained in the organic material, as belonging to the onion family, probably including leek (*Allium porrum*) (Tomlinson 1991). There were also very high numbers of human intestinal parasite eggs (ova) which confirms the botanical evidence indicating this to be faecal material (see below). The result of all this environmental data in this

case was the interpretation of the archaeological deposit as faecal material. It was not possible to prove, although it seems very likely, that the original function of this wooden lined pit was as a latrine.

Rubbish pits and cesspits are not always easy to interpret. There may be some indications of faecal material, but if the preservation is poor, only the resistant seeds, fruitstones and fish bones will have survived. Sometimes the plant remains are preserved by mineralisation rather than waterlogging and only certain types survive. Seeds like blackberry (*Rubus fruticosus* agg.) and elderberry (*Sambucus nigra*) are sometimes the only ones which are preserved. The Saxon pit from Bridge Street, Chester, for example, contained bran fragments, intestinal parasite ova and many small fish bones, including vertebrae, some of which were obviously chewed, and doubtless constituted the remains of poorly preserved faecal material (Tomlinson unpub.). Only a few plant taxa were found including blackberries (*Rubus fruticosus*), fathen (*Chenopodium album*) and nipplewort (*Lapsana communis*). Blackberries are likely to have been consumed and there is some evidence that fathen was eaten, but not necessarily the seeds. Nipplewort seeds would more certainly have come from weeds growing nearby rather than being an element of the faecal material. The interpretation of this pit as showing that the diet was only fish, cereals, blackberries, and possibly, fathen might be misleading, as the majority of the seeds may have disappeared.

Intestinal parasites

The Lindow Bog Man provided a great deal of excitement and valuable information on a variety of environmental aspects (Stead and Turner 1985, Stead *et al.* 1986), only one of which will be mentioned here. His gut contained the eggs of two species of human intestinal parasite, as well as the remnants of his last meal, which mainly consisted of cereal fragments, some of which were charred. The two parasite species are whipworm (*Trichuris trichiura*) and maw worm (*Ascaris* sp.). Both species are frequently found in ancient faecal material and were found, for example, in two of the cesspits mentioned above. The sample from the gut of Lindow Man was particularly useful for comparing the eggs found inside a human gut with those found in medieval cesspits and floors. It has been suggested (Jones 1985) that most people would have had a few of these worms in their intestines during most of their lives but would not have been affected by them noticeably unless the infection became severe, in which case the symptoms would have been extremely unpleasant. The presence of these worms, whose life cycle requires transmission by faecal contamination, indicates the living conditions of the people concerned. Their presence, in pits and other deposits, provides a useful identification tool for faecal material, especially if other faecal indicators have not been preserved.

Charred grain

There is potential information to be obtained on crop species and cereal cultivation from plant materials which may have been preserved by charring on dry, as well as waterlogged, sites. Studies of the weeds associated with the cereal grains often provide information on crop processing, agricultural practices and perhaps the origin of imported crops. Some work has been done in the northwest of England but there are still many unanswered questions. For example, which crop species were grown and what husbandry practices were used at different times in the past? Charred deposits, from Roman excavations in London, York and elsewhere, show that spelt wheat (*Triticum spelta*), a 'glume' wheat, was the main wheat species at that time. This has implications as to the agricultural practices, both in terms of cultivation and preparation of the wheat. Spelt is not a free-threshing wheat like bread wheat (*Triticum aestivum*), and therefore, in order to release the grain, it requires special processing. Semi-charring or 'parching' the grain is one of the techniques thought to have been used.

A single sample of carbonised material from the 3rd century excavation at Wilderspool contained a large quantity of chaff fragments, 'tail' grain and weed seeds (Hillman unpub.). The 'tail' grains are the very small cereals from the tip and base of the ear which will pass through a fine mesh when the grain is sieved to remove the fine chaff. This material would have been the by-product from the final fine sieving stage in the traditional processing of glume wheats which can still be found in use today in a few parts of the world (see Hillman 1984, Fig. 3, p 5). The cereal grains were a minority component consisting of a mixture of spelt wheat and rye (*Secale cereale*). This mixture may represent the crops growing together in the same field or the processing debris of two crops being mixed, or, more likely, shows that the rye was present as a weed in the wheat crop.

No general conclusions about the plant economy in Roman Wilderspool can be drawn from this single sample. In order to gain such information it will be necessary to obtain charred assemblages from a wide range of sites and periods. This can only be done by carrying out routine sampling and site sieving programmes.

Moats and ditches

Bewsey Old Hall and Speke Hall have both been analysed for environmental information from waterlogged deposits in moats and related ditches. These have provided a variety of types of biological material for study, including seeds, vegetative plant remains (such as leaves and stems), freshwater molluscs, diatoms, pollen and beetles and have shown the potential of these well preserved contexts. At Speke

Hall the sequence of insect remains showed the aquatic nature of the lower fills and the gradual infilling of the moat (Kenward and Tomlinson forthcoming). The upper samples contained terrestrial beetles and indications of human disturbance. At the top there were suggestions of a substantial environmental change, perhaps burial by dumped material or flooding. There were many dung beetles, indicating that the area may have been grazed after its terrestrialization. The presence of caddis fly larval cases and certain species of diatom in the lower levels suggested open, relatively clean water while the plant remains in the higher levels of the profile showed that the moat was surrounded by fairly open, disturbed ground.

At Bewsey the infilling deposits provided information on the variety of trees, shrubs and other plants growing around the moat, although there was very little directly archaeological data (Tomlinson and Innes forthcoming). The pollen analysis gave some indications of the land use in a wider area around the site as well as high peaks of pollen of, for example, ash trees (*Fraxinus excelsior*) and nettles (*Urtica* sp.), no doubt growing beside the moat.

This kind of information only gives a broad environmental view and perhaps is not always directly relevant to the archaeology. A fairly swift survey of these deposits is recommended in order to assess the potential before spending time on more detailed analyses (Greig 1986). Further problems, making interpretation of the deposits difficult, are that they would probably have been regularly cleaned out and the rate of the infilling would be unknown. The fills are probably mostly from the phase of disuse and abandonment.

Wooden artefacts and dendrochronology

A large variety of wooden structures has been recovered or observed from the region. Some examples of these include the wooden 'boats' found in Martin Mere and at Warrington; part of a wooden bridge observed in Wallasey docks thought to be Roman but undated, although obviously of some antiquity; waterfront revetting timbers excavated in 1977 at South Castle Street Liverpool; part of a timber bridge over the moat at Twiss Green, Warrington excavated in 1980; the bases of timber posts for a large 12th century hall at Norton Priory excavated in 1975 and awaiting dendrochronological study; and most of a c. 12th century timber bridge from excavations at West Derby Castle, the constructional details of which have been republished recently (Droop and Larkin 1928, Rigold 1975).

One of the main local excavations which has provided a large quantity of waterlogged wood is the salt working site at Wood Street, Nantwich (McNeil 1983). Although none of the wooden artefacts is identified to species, which would have been of interest to researchers of

woodland history, management and use, the timbers recovered did provide useful sequences of annual rings which helped to consolidate the established north western chronologies. The Crown car park excavations in Castle Street, Nantwich provided timbers for the Nantwich master chronology which now runs from AD 901 to 1170 (McNeil unpub. interim report).

The Roman dating of the plank tank at St Anne's Lane, Nantwich (McNeil and Roberts 1987), on the basis of pottery evidence, was clearly confirmed by the dendrochronological analyses carried out by Nottingham University Tree Ring Dating Laboratory which gave a date of AD 112. The precision of this date, which is actually that for the felling of the tree rather than for the construction of the tank, was made possible by the presence of the sapwood on the timbers and by the reasonably long sequence of rings to match with existing chronologies. The tree had been felled when it was at the end of its maximum growth period (ie in the spring when larger water conducting vessels grow).

Research into the tree ring chronology of the north west has been carried out at Liverpool Polytechnic (Hughes and Leggett 1983, Leggett *et al.* 1978, Leggett 1980) using standard dendrochronological techniques. This entailed the collection of tree ring data from many bog oaks and large timbers from dated buildings in the region. There is a need for continuation of the dendrochronology work which started in Liverpool Polytechnic as there is no one working there at present. It is possible to send material to one of the other laboratories in the country but surveying for potential timbers and their sampling needs a local specialist.

Archaeozoology

Archaeozoology covers not only the study of bones from archaeological sites but also such groups as molluscs, insects, parasites, diatoms, fly puparia, marine and freshwater animals some of which have already been mentioned. Most of the recent work in Merseyside has concentrated on animal and bird bone studies because most archaeological sites produce bone assemblages even if no other environmental material is preserved.

A skeleton of a young sheep was found in the 12th century foundations of Birkenhead Priory which was thought to be a foundation sacrifice burial (Irwin and McMillan 1969). It is on display at the Priory.

The excavations at Castle Street, Liverpool, gave an example of the huge variety of material that can be found on urban excavations. Information on human diet came from the domestic cattle and sheep bones and edible sea shells (McMillan 1985). Details of butchery practices and the pathology of the animals, such as abnormalities of growth and congenital defects, were found. A variety of scavenging animals and birds which lived around the town, feeding on refuse were also discovered (Fisher 1985).

At Bewsey Old Hall the kitchen midden material provided information on the variety of the diet in the period, which included red deer, goose, chicken, woodcock, mallard, teal and cod as well as the usual cattle, sheep and pig. Domestic animals such as dog and horse also occurred. Two inventories relating to Bewsey Old Hall of 16th and 17th century date provide useful, additional, contemporaneous information including lists and prices of all the livestock (Roberts 1986).

Other reports on assemblages from excavations in the region have not yet been published and are often not much more than a list of species with notes on butchery and pathology (*viz.* Tanners Farm moated site; Prescott excavations; Speke Hall and Lower Bridge Street, Chester). It is important that this type of detailed information is collected from many sites so that overall results can be produced on changes in husbandry practices, animal breeds, diet and butchery techniques through time. The recovery of bones of smaller and rarer species, which are unlikely to be recovered by hand collection, can be greatly improved if bulk sieving is carried out on site. By processing large quantities of soil, and by sampling in a clearly defined way, more accurate and statistically useful results can be produced.

Conclusions

Merseyside has the potential for a wide range of environmental archaeology. There is a variety of types of site, some have good waterlogged preservation. An integrated strategy for environmental archaeology is, however, lacking. Excavation sites need to be selected not just for their archaeology but also for their environmental potential. It is becoming increasingly necessary to correlate the large amount of pollen data collected over the last ten years with the archaeological record. One way of doing this would be to find an archaeological site closely associated to, or within, a peat deposit, such as the site at Storrs Moss (Powell *et al.* 1971) so that environmental dating techniques could be directly correlated with the cultural layers. Detailed field survey is required in order to locate any such potential sites, which could well be threatened by drainage, agriculture or urban development.

Sampling strategies for environmental analysis are required from the early planning stages of excavations. Features such as pits, moats, wells and assemblages such as waterlogged wood or charred cereals need careful sampling preferably with the advice of the relevant specialist. With all of these aspects it is always best to take samples if in doubt, so that a decision can be made at a later date on whether, and how, to analyse the material. In some cases on-site sieving may be useful in order to process large quantities of material for environmental data collection and also for finds recovery (Jones 1983).

Adequate reference collections are essential for the

analysis of each type of biological material. It is not always possible for individual archaeology units to carry out this specialist work themselves. A broad knowledge of the potential of the excavated material is necessary, however, so that the relevant specialist can be contacted.

Publication of environmental work needs to be well integrated with the archaeological report, rather than published separately on its own in an environmental journal, or just attached as an appendix to the archaeology. This requires an effort from the environmentalist as well as the archaeologist, particularly because the report should not be written in a too obscure scientific way. This also means that the aims of the environmental research need to be clearly sorted out by liaison between all parties, preferably from the planning stages of the excavation.

Acknowledgements

We are very grateful to Miss C. Cowan, Miss K. Lancaster and Mr D. Cowton for drawing the figures, and to Mrs V. Innes for preparation of the typescript. PRT would like to thank Terry O'Connor for commenting on Section 3 and Gordon Hillman for allowing a mention of his unpublished results from Wilderspool. This paper would not have been completed without practical help and encouragement from Peter Davey, to whom many thanks.

Bibliography

- Barber K.E. 1982. 'Peat-bog stratigraphy as a proxy climatic record' in: A.F. Harding (ed.) *Climatic change in later Prehistory*. Edinburgh: University Press. 103-113.
- Baxter J. 1983. 'Vegetation history of the Shirdley Hill Sand in south-west Lancashire' Unpublished Ph.D. thesis. U.C.W. Aberystwyth.
- Baxter J. and Taylor J.A. (unpub.) 'Some preliminary notes on the vegetation history of the south-west Lancashire plain' in: Innes and Tomlinson *Studies in the Environmental History of Merseyside*.
- Birks H.J.B. 1964. 'Chat Moss, Lancashire' *Mem Proc Manchester Lit Phil Soc* 106, 22-45.
- Birks H.J.B. 1965a. 'Late Glacial deposits at Bagmere, Cheshire and Chat Moss, Lancashire' *New Phytol* 64, 270-285.
- Birks H.J.B. 1965b 'Pollen analytical investigations at Holcroft Moss, Lancashire and Lindow Moss, Cheshire'. *J Ecology* 53, 299-314.
- Brenchley P. 1968 'An investigation into the glacial deposits at Thurstaston, Wirral' *Amateur Geologist* 3, 27-40.

- Chambers F.M. and Price S-M. 1985 'Palaeoecology of *Alnus* (Alder): early postglacial rise in a valley mire, north-west Wales' *New Phytol* **101**, 333-344.
- Clapham A.R., Tutin T.G. and Warburg E.F. 1962 *Flora of the British Isles*. 2nd Edition, Cambridge: Cambridge University Press.
- Coope G.R. and Pennington W. 1977. 'The Windermere Interstadial of the Late Devensian' *Phil Trans Roy Soc London B*. **280**, 337-339.
- Cundill P.R. 1981 'The history of vegetation and land-use of two peat mosses in south-west Lancashire' *The Manchester Geographer* **NS 2(2)**, 35-44.
- Cundill P.R. 1984 'Palaeobotany and archaeology on Merseyside: additional evidence' *Circaea* **2**, 129-131.
- Droop J.P. and Larkin F.C. 1928 'West Derby Castle' *University of Liverpool Annals of Archaeol and Anthropol* **15**, 47-55.
- Edwards K.J. 1979 'Palynological and temporal inferences in the context of prehistory, with special reference to the evidence from lake and peat deposits' *J Archaeol Sci* **6**, 255-270.
- Evans W.B. and Arthurton R.S. 1973 'Northwest England' in: G.F. Mitchell, L.F. Penny, F.W. Shotton and R.G. West (eds.) *A correlation of the Quaternary deposits of the British Isles*. Geological Society of London Special Report **4**, 28-36.
- Fisher C. 1985 'Analysis of the Osteological Material' in: Davey P.J. and McNeil R. 'Excavations in South Castle Street, Liverpool 1976 and 1977' *J Merseyside Archaeol Soc* **4**, 141-146.
- Fisher C. 1986 'Bird bones from the excavation at Crown car park, Nantwich, Cheshire (with an Appendix on pathology by John Baker)' *Circaea* **4(1)**, 55-64.
- Gagen P.J. 1982 'The soil landscape history of Little Crosby township in Sefton District, Merseyside, Liverpool' Archaeological Survey of Merseyside.
- Godwin H. 1959 'Studies of the postglacial history of British vegetation. XIV. Late Glacial deposits at Moss Lake, Liverpool' *Phil Trans Roy Soc London B*. **242**, 127-149.
- Godwin H. and Switsur V.R. 1966 'Cambridge University Natural Radiocarbon Measurements VIII' *Radiocarbon* **8**, 390-400.
- Greig J. 1986 'The archaeobotany of the Cowick medieval moat and some thoughts on moat studies' *Circaea* **4 (1)**, 43-50.
- Hall A.R., Jones A.K.G. and Kenward H.K. 1983 'Cereal bran and human faecal remains from archaeological deposits - some preliminary observations' in: B.P. Proudfoot (ed.) *Site, Environment and Economy*. Oxford: British Archaeological Reports International Series **173**, 85-104.
- Hall B.R. 1968 'The lowland peats of Lancashire' *Proc North England Soils Discussion Group* **4**, 5-12.
- Hall B.R. and Folland C.J. 1970 *Soils of Lancashire*. Memoirs of the Soil Survey of Great Britain **5**. Harpenden.
- Hallam J.S., Edwards B.J.N., Barnes B. and Stuart A.J. 1973 'The remains of a late-glacial elk associated with barbed points from High Furlong near Blackpool, Lancashire' *Proc Prehist Soc* **39**, 100-128.
- Hammen, van der T. 1953 'Late-glacial flora and periglacial phenomena in the Netherlands' *Leid geol Meded* **17**, 71-183.
- Hibbert F.A., Switsur V.R. and West R.G. 1971 'Radiocarbon dating of Flandrian pollen zones at Red Moss, Lancashire' *Proc R Soc London B* **177**, 161-176.
- Hillman G. (unpublished) Grain processing at 3rd century Wilderspool In: Hinchliffe J. and Williams G.H. *Excavations at Wilderspool, 1966-1968*. Cheshire County Council Monograph.
- Hillman G. 1984 'Interpretation of archaeological plant remains: The application of ethnographic models from Turkey' 1-41 In: *Plants and Ancient Man, Studies in palaeoethnobotany* W. van Zeist and W.A. Casparie (eds). Rotterdam: A A Balkema.
- Howard-Davis C., Stocks C. and Innes J.B. 1988 *Peat and the Past. A Survey and Assessment of the prehistory of the Lowland Wetlands of North-West England*. Lancaster: English Heritage and Lancaster University.
- Hughes M.K. and Leggett P.A. 1983 'Tree-ring dating of the timbers. in: R McNeil Two 12th-century wick houses in Nantwich' *Medieval Archaeol* **27**, 69-70.
- Hulme P.D. 1980 The classification of Scottish peatlands. *Scottish Geographical Magazine* **96**, 46-50.
- Hume A. 1863 *Ancient Meols: some account of the antiquities near Dove Point on the sea coast of Cheshire*.
- Innes J.B. 1982 'Notes on the vegetation history of Sefton, Merseyside' in: Lewis J. *Sefton Rural Fringes Survey Report*. Liverpool, Merseyside County Museums.
- Innes J.B. 1983 'Woodlands beneath the sea' *Wirral Journal* **1 (6)**, 30-32.
- Innes J.B. 1984 'Late Quaternary palaeoenvironmental history of the Merseyside region' Unpublished ms.
- Innes J.B. 1986 'The history of the Shirdley Hill Sand revealed by examination of associated organic deposits' *Proc North England Soils Discussion Group* **21**, 31-43.
- Innes J.B. and Tomlinson P.R. 1981 'Stratigraphy and pollen analysis at Bromborough Court House, Wirral' in: Freke D. 'Bromborough Court House Moated Site Excavations, 1979' *J Merseyside Archaeol Soc* **2 (for 1978)**, 48-52.
- Innes J.B. and Tomlinson P.R. 1980 'The postglacial peat deposits of Merseyside - a programme for future research' *Amateur Geologist* **8**, 51-56.

- Innes J.B. and Tomlinson P.R. 1981 'Stratigraphy and pollen analysis from Parr Moss, St Helens' in: Chitty G. *St Helens Rural Fringes Survey Report* Liverpool: Merseyside County Museum.
- Innes J.B. and Tomlinson P.R. 1983a 'Cultural implications of Holocene landscape evolution in the Merseyside region' *Amateur Geologist* 10, 2-17.
- Innes J.B. and Tomlinson P.R. 1983b 'An approach to palaeobotany and survey archaeology in Merseyside' *Circaea* 1, 83-93.
- Innes J.B., Tooley M.J. and Tomlinson P.R. 1989 'A comparison of the age and palaeoecology of some sub-Shirdley Hill Sand peat deposits from Merseyside and south-west Lancashire' *Naturalist* 114, 65-69.
- Innes J.B. and Tomlinson P.R. (unpub.) *Studies in the Environmental History of Merseyside*. Merseyside County Museums.
- Innes J.B., Bedlington D.J., Kenna R.J.B. and Cowell R. W. 1990 'A preliminary investigation of coastal deposits at Newton Carr, Wirral, Merseyside. *Quaternary Newsletter* 62, 5-12.
- Irwin W.F. and McMillan N.F. 1969 'A foundation sacrifice at Birkenhead Priory' *Antiquity* 43, 56-7.
- Iversen J. 1941 'Land occupation in Denmark's stone age' *Damm Geol Unders* Serial ii, 66, 1-68.
- Jacobi R.M., Gowlett J.A.J., Hedges R.E.M. and Gillespie R. 1986 'Accelerator mass spectrometry dating of Upper Palaeolithic finds, with the Poulton elk as an example' in: D.A. Roe (ed.) *Studies in the Upper Palaeolithic of Britain and North-West Europe*. British Archaeological Reports, International Series 296, 121-128.
- Johnson R.H. (ed) 1985a *The Geomorphology of North-west England*. Manchester: Manchester University Press.
- Johnson R.H. 1985b 'The imprint of glaciation on the West Pennine uplands' in: Johnson 1985a, 237-262.
- Jones A.K.G. 1983 'A comparison of two on-site methods of wet-sieving large archaeological soil samples' *Science and Archaeology*. 25, 9-12.
- Jones A.K.G. 1985 'Trichurid ova in archaeological deposits: their value as indicators of ancient faeces' in: N.R.J. Fieller, D.D. Gilbertson and N.G.A. Ralph (eds.) *Palaeobotanical Investigations. Research design, methods and data analysis*. Oxford: British Archaeological Reports International Series 266, 105-119.
- Kear B.S. 1985 'Soil development and soil patterns in North-west England' in: Johnson 1985a, 80-93.
- Kenna R.J.B. 1978 'Coastal change and early settlement on the north Wirral' *J Merseyside Archaeol Soc* 2, 27-34.
- Kenna R.J.B. 1979 'Coastal change and early settlement on the north Wirral - 2' *J Merseyside Archaeol Soc* 3, 41-51.
- Kenna R.J.B. 1985 'An old woodland floor beneath the sea' *Wirral Journal* 2(8) 26-30.
- Kenna R.J.B. 1986 'The Flandrian sequence of north Wirral (N.W. England)' *Geological Journal* 21, 1-27.
- Kenward H.K. and Tomlinson P.R. (forthcoming) 'Environmental analyses from deposits in the Billiard room' in: 'Excavations at Speke Hall' *J Merseyside Archaeol Soc* 8.
- Lamb H.H. 1977 'The Late Quaternary history of the climate of the British Isles' in: F.W. Shotton (ed.) *British Quaternary Studies: Recent Advances*. Oxford: Clarendon Press. 283-298.
- Leggett P.A. 1980 *The use of tree-ring analyses in the absolute dating of historic sites and their use in the interpretation of past climatic trends*. PhD Thesis, Liverpool Polytechnic.
- Leggett P.A., Hughes M.K. and Hibbert F.A. 1978 'A modern oak chronology from North Wales and its interpretation' in: Fletcher (ed.) *Dendrochronology in Europe*. Oxford: British Archaeological Reports International Series 51, 187-194.
- Longworth D. 1985 'The Quaternary history of the Lancashire plain' in: Johnson 1985a, 178-200.
- Macphail R. and Keeley H.C.M. 1978 *The soils and pollen of Norton Priory, Runcorn, Cheshire*. Ancient Monuments Laboratory Report 92/78, Historic Buildings and Monuments Commission.
- McMillan N.F. 1985 'Mollusca' in: Davey P.J. and McNeil R. 'Excavations in South Castle Street, Liverpool. *J Merseyside Archaeol Soc* 4, 148-52.
- McNeil R. 1983 'Two 12th-century wick houses in Nantwich' *Medieval Archaeol* 27, 40-88.
- McNeil R. and Roberts A.F. 1987 'A plank tank from Nantwich' *Britannia*, 18, 286-95.
- Mellars P.A. 1976 'Fire ecology, animal populations and man: a study of some ecological relationships in prehistory' *Proc Prehist Soc* 42, 15-45.
- Musk L.F. 1985 'Glacial and postglacial climatic conditions in north-west England' in: Johnson 1985a, 59-79.
- Pennington W. 1977 'The Late Devensian flora and vegetation of Britain' *Phil Trans Roy Soc London B*. 280, 247-271.
- Powell T.G.E., Oldfield F. and Corcoran J.X.W.P. 1971 'Excavations in Zone VII Peat at Storrs Moss, Lancashire, England, 1965-67' *Proc Prehist Soc* 37, 112-137.
- Pye K. 1990 'Physical and human influences on coastal dune development between the Ribble and Mersey estuaries, north west England' 339-359 in: Nordstrom K.F., Psuty N.P. and Carter R.W.G (eds) *Coastal Dunes: Form and Process* London: John Wiley and Sons.
- Radley J., Tallis J.H. and Mellars P.A. 1974 'The excavation of three 'narrow blade' Mesolithic sites in the southern Pennines,

- England' *Proc Prehist Soc* 40, 1-19.
- Rigold S.E. 1975 'Structural aspects of medieval timber bridges' *Medieval Archaeol* 19, 48-91.
- Roberts A.F. 1986 'Faunal remains from Bewsey Old Hall, Warrington' in: 'Summaries of papers delivered at Association of Environmental Archaeology spring meeting, Oxford, 21st March 1986' *Circaea* 4(1), 26-27.
- Shennan I. 1983 'A problem of definition in sea-level research methods' *Quaternary Newsletter* 39, 17-19.
- Shimwell D.W. 1985 'The distribution and origins of the lowland mosslands' in: Johnson 1985a, 299-312.
- Simmons I.G. and Innes J.B. 1985 'Late Mesolithic land-use and its impact in the English uplands' *Biogeographical Monographs* 2, 7-17.
- Simmons I.G. and Innes J.B. 1987 'Mid-Holocene adaptations and Later Mesolithic forest disturbance in Northern England' *J Archaeol Sci* 14, 385-403.
- Simmons I.G. and Tooley M.J. (eds) 1981 *The Environment in British Prehistory*. London: Duckworth.
- Smith A.G. and Pilcher J.R. 1973 'Radiocarbon dates and vegetational history of the British Isles' *New Phytol* 72, 903-914.
- Stead I.M. and Turner R.C. 1985 'Lindow Man' *Antiquity* 11, 25-29 and plates.
- Stead I.M., Bourke J.B. and Brothwell D. 1986 *Lindow Man. The body in the bog*. London: British Museum Publications.
- Syngé F.M. 1977 'Records of sea-levels during the late Devensian' *Phil Trans Roy Soc London B*, 280, 211-228.
- Taylor J.A. and Smith R.T. 1980 'The role of pedogenic factors in the initiation of peat formation and in the classification of mires' *Proc 6th International Peat Congress*. Duluth, 109-118.
- Thomas G.S.P. 1977 'The Quaternary stratigraphy of the Isle of Man' in: C. Kidson and M.J. Tooley (eds) *The Quaternary History of the Irish Sea*. Geol. J. Special Issue 7. Chichester: Wiley. 155-178.
- Thomas G.S.P. 1985 'The Quaternary of the northern Irish Sea basin' in: Johnson 1985a, 143-158.
- Tomlinson P.R. 1984 'Tested, rapid techniques for clearing botanical specimens for the study of waterlogged archaeological plant remains' *Circaea* 2 (2), 97-101.
- Tomlinson P.R. 1987 'Plant remains', 291-5, in: McNeil and Roberts 1987.
- Tomlinson P.R. and Innes J.B. 1989 'Pollen analysis from a peat sample from Warrington Road, Prescott' in: 'Excavations in Prescott, Merseyside' *J Merseyside Archaeol Soc* 5, 7-10.
- Tomlinson P.R. 1990 'Pollen analysis' 23-5, in: Freke D.J., Holgate R. and Thacker A.T. 'Excavations at Winwick, Cheshire in 1980' *J Chester Archaeol Soc* 70, 9-38.
- Tomlinson P.R. 1991 'Vegetative plant remains from waterlogged deposits identified at York' in: J. Renfrew (ed.) *New Light on Early Farming*. Proceedings of the 7th Symposium of the International Work Group for Palaeoethnobotany, Cambridge, 1986. Edinburgh: Edinburgh University Press.
- Tomlinson P.R. (unpub). 'Investigation of organic material from Lower Bridge Street, Chester', report to Liverpool Museum.
- Tomlinson P.R. and Innes J.B. (forthcoming) 'Macro-botanical and pollen analysis from waterlogged deposits at Bewsey Old Hall'.
- Tooley M.J. 1977 'Altmouth' 32. in: Tooley M. J. (ed.) *The Isle of Man, Lancashire Coast and Lake District*. 10th INQUA Congress Excursion Guide. Norwich. Geoabstracts. 8.
- Tooley M.J. 1978 *Sea-level changes: north-west England during the Flandrian stage*. Oxford: Clarendon Press.
- Tooley M.J. 1980 'Theories of coastal change in north-west England' in: F. H. Thompson (ed.) *Archaeology and Coastal Change*. Society of Antiquaries of London Occ. Papers (NS) 1, 74-86.
- Tooley M.J. 1982 'Sea-level changes in northern England' *Proc Geol Assoc* 93, 43-51.
- Tooley M.J. 1985a 'Climate, sea-level and coastal changes' in: Tooley M.J. and Sheail C.M. (eds) *The Climatic Scene*. London: George Allen and Unwin. 206-234.
- Tooley M.J. 1985b 'Sea-level changes and coastal morphology in north-west England' in: Johnson 1985a, 94-121.
- Tooley M.J. 1990 'The chronology of coastal dune development in the United Kingdom' *Catena Supplement* 18, 81-88.
- Tooley M.J. and Kear B.S. 1977 'Mere Sands Wood (Shirdley Hill Sand)' in: Tooley 1977, 9-10.
- Walker D. 1970 'Direction and rate in some British postglacial hydroseres' in: D. Walker and R.G. West (eds.) *Studies in the Vegetational History of the British Isles*. Cambridge: University Press. 117-139.
- West R.G. 1970 'Pollen zones in the Pleistocene of Great Britain and their correlation' *New Phytol* 69, 1179-1183.
- Williams C.T. 1985 *Mesolithic exploitation patterns in the central Pennines. A palynological study of Soyland Moor*. British Archaeological Reports, British Series 139, Oxford.
- Wilson D.G. 1975 'Plant foods and poisons from Medieval Chester' in: Ward T. 'Goldsmith House site, Goss Street, Chester, 1972' *J Chester Archaeol Soc* 58, 55-67.

Wilson P. 1985 'The Mere Sands of Lancashire - a forgotten Flandrian deposit' *Quaternary Newsletter* **45**, 23-26.

Wilson P., Bateman R.M. and Catt J.A. 1981 'Petrography, origin and environment of deposition of the Shirdley Hill Sand of southwest Lancashire England' *Proc Geol Assoc* **92**, 211-229.

Worsley P. 1985 'Pleistocene history of the Cheshire-Shropshire plain' in: Johnson 1985a, 201-221.

Wray D.A. and Cope F.W. 1948 'Geology of Southport and Formby' *Memoirs of the Geological Survey of Great Britain*. London: H.M.S.O.