Covanta Energy Ltd.

Ince Park

Environmental Analysis

(Pollen and Plant Macrofossil Analysis of Peat Deposits)

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1 INTRODUCTION

1.1 Ince Marshes are located in the Mersey Estuary; a low-lying wetland area with islands of drier ground that have produced evidence of human activity dating back to the Bronze Age. A Roman Fortlet and Medieval manorial remains attest to the strategic importance of the area in the past. The deep peat deposits that have accumulated in the estuary since the last Ice Age were thought likely to contain records of changes to the surrounding environment brought about by human activities over the centuries.

1.2 In advance of proposed development across the entire site, field evaluation carried out in 2005 and 2006 was followed by agreement of a mitigation package (RSK 2010) for the site including a metal detecting survey and archaeological excavation in 2011. According to the agreed strategy, in 2010 RSK collected cores and bulk samples from c.3 metre deep peat deposits present on the site. The cores were taken from boreholes excavated by geotechnical engineers as part of ground investigation works for the development.

1.3 Three sets of samples were taken from three adjacent boreholes:

- Borehole BH405 – continuous core in three sections, through the upper clay and upper peat (UP).
- Borehole BH406 – a series of bulk samples (c.3 litres) from the top of the lower peat to the bottom of the peat 10.5m below ground level. Dark grey silty clay lies below the bottom sample, bulk 6 (LP).
- Borehole BH407 – a reserve continuous core from a borehole close to BH405 and BH406. The core contains upper peat deposits. This core has been retained in reserve untouched in case additional environmental analyses are required at some time in the future.

1.4 The borehole samples were all located in the vicinity of NGR 346730, 376610.

1.5 Assessments of pollen and plant macrofossils from a series of samples through the upper and lower peats, BH405 and BH406, were undertaken in April 2011 (Peglar and Carruthers, 2011, RSK unpublished assessment report). Following recommendations in the assessment report, full analysis was undertaken on the samples in order to retrieve the maximum amount of information from the samples. The results are discussed in this report.

2 ANALYSIS OF PALYNOLOGICAL SAMPLES

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Palynologist

Introduction

2.1 Pollen and spores may be transported from great distances although most will probably be derived from close to the deposition site and arrive either from inwash or be airborne. Thus the pollen assemblages may provide evidence of the nature of the vegetation (and hence environment) around the site but also the regional vegetation and environment. The taxonomic level to which pollen and spores may be identified is usually only to family, type or genus and rarely to species, whereas macrofossils may often be assigned to specific species. The analysis of macrofossils provides a much more local picture as, in general, macrofossils do not travel far. Thus the two analyses are complimentary to one another.

Methods

2.2 Standard volumes (1cc) of the sediment samples were prepared for pollen analysis using a standard chemical procedure, using HCl, NaOH, sieving, HF, and Erdtman's acetolysis to remove carbonates, humic acids, particles >170 microns, silicates, and cellulose, respectively. The samples were then stained with safranin, dehydrated in tertiary butyl alcohol, and the residues mounted in 2000 cs silicone oil. (method B of Berglund & Ralska-Jasiewiczowa (1986). Tablets containing a known number of *Lycopodium* spores were added to the known volume of sediment at the beginning of the preparation so that pollen and spore concentrations could be calculated (Stockmarr, 1972). Slides were examined at a magnification of 400x (1000x for critical examination) by equally-spaced traverses across two slides to reduce the possible effects of differential dispersal on the slides (Brooks & Thomas, 1967) until a land pollen & spore sum (TLP) of at least 400 had been counted. Pollen identification, where necessary, was aided using the keys of Moore et al. (1991) and a small modern pollen reference collection. Andersen, S.Th. (1979) was followed for identification of cereal-type pollen. Indeterminable and unknown grains were recorded as an indication of the state of the pollen preservation. Plant nomenclature follows Stace (2010).

Results

2.3 The results are presented as a pollen diagram (Figure 1). Tree, shrub, dwarf shrub, herb and fern taxa are expressed as percentages of the total land pollen and spore sum (sumP). Aquatics, bog moss, algae, indeterminable and unknown pollen & spores are expressed as percentages of sumP + the sum of the group to which they belong. Taxa with values of <1% are represented by a +. Charcoal was not counted as the small (<170 microns) particles remaining on the pollen slides may be derived from great distances. The larger charcoal particles found during the macrofossil analyses are likely to have been derived locally and are therefore much more informative.

Lower Peat

2.4 Six samples LP6 – LP1 were analysed from the lower peat layer (borehole BH406).. Macrofossils were analysed from sediment below the six bulk samples from the borehole (sample 22). They showed that wet peaty soils including bog moss (*Sphagnum*) were accumulating at the site with fen carr- type woodland with birch (*Betula*), willow (*Salix*), common reed (*Phragmites australis*) and a variety of aquatic and marsh plants (Carruthers below). This level was dated to the early post-glacial period (cal BC 10050 to 11610 and cal BC 9570 to 9550 (Beta-297299).

Sample 21 (LP6)

2.5 This was the lowermost sample analysed for pollen. The pollen assemblage is dominated by about 45% herb pollen, predominantly grasses (*Poaceae*), probably common reed and with about 30% tree and shrub pollen, mainly birch and willow with some poplar (*Populus*) and juniper (*Juniperus*). A few grains of pine (*Pinus sylvestris*) are present but represent pine growing at some distance from the site. Pine produces vast quantities of pollen and would have a much higher value if growing close by. The pollen assemblage suggests that at the time of deposition, freshwater reed swamp with the telmatic taxa common reed, bulrush (*Typha latifolia*), lesser bulrush and/or bur-reed (*Typha angustifolia/Sparganium*) and sedges (*Cyperaceae*) was growing at the site. Other taxa of wet soils present include meadowsweet (*Filipendula*) and carrot family (*Apiaceae*). Willow and birch were growing on the wetter soils with juniper on the drier soils perhaps at some distance. There is evidence of ferns, particularly marsh fern (*Thelypteris palustris*), growing locally and spores of horsetails (Equisetum) are also present. The pollen of pondweed (*Potamogeton*), spines of hornwort (*Ceratophyllum*) and the remains of the green algae *Pediastrum* and *Botryococcus* are all characteristic of fresh water. There is no evidence of any marine influence at this time.

Sample 20 (LP5)

2.6 The pollen assemblage from sample 20 is very similar to that from sample 21. The first grains of hazel (*Corylus*) and oak (*Quercus*) are found marking their migration into the region but there are less fern spores, particularly marsh fern. The aquatic taxa present include water milfoil (*Myriophyllum spicatum/verticillatum*) and marsh pennywort (*Hydrocotyle vulgaris*), both freshwater taxa.

Sample 19 (LP4)

2.7 There is a change in the pollen assemblage of sample 19 compared with those of samples 20 and 21. Total tree and shrub pollen increases to nearly 50% with rises in the pollen of pine (*Pinus sylvestris*), hazel, and to some extent oak. There is a concomitant decrease in the pollen of birch, willow and poplar. This marks the beginning of the spread of pine and hazel into the area and the migration of oak into the region. The first grain of elm (*Ulmus*) is found. The total herb value drops to 20%, mainly due to a decrease in grass pollen (reed?) but with an increase in sedges. This may register a slow change from reed swamp to sedge fen development. Fern taxa also increase perhaps growing in the marsh/fen (marsh fern) or in the drier deciduous woodland that was approaching the site. A few grains of polypody (*Polypodium*), a fern of woodland and tree trunks, are present. The spines of the freshwater taxon hornwort and the algae *Pediastrum* and *Botryococcus* are no longer found but there is no evidence of any marine influence.

2.8 This level has been dated to cal BC 8730 to 8460 (Beta=297298), the Mesolithic period, but there is no indication in the pollen of any human presence. However, it is interesting to note that the first grains of goosefoots (*Chenopodiaceae*) and cabbage family (*Brassicaceae*) appear, taxa associated with drier soils and often disturbed ground. Together with the decrease in aquatic taxa this suggests that the area was becoming less wet from the lowering of sea level and/or the increase in height with the accumulation of soil.

Sample 18 (LP3)

2.9 Birch and willow pollen continue to decline, while sedges increase suggesting the continued development of sedge fen and regional woodland. Fern values remain high. Large fragments of charcoal were found during the macrofossil analysis of this sample and have been identified as willow or poplar (Challinor in Carruthers below). These genera are unlikely to burn by natural fires and it is therefore possible that human impact was being made on the local vegetation at this time (Carruthers below).

Sample 17 (LP2)

2.10 Pine pollen is at its highest value in this sample marking its spread in the region but, as suggested above, it was probably not growing nearby. Sedge pollen is at its maximum in this sample indicating the occurrence of sedge fen at the site with a little hazel/oak woodland on the drier ground.

Sample 16 (LP1)

2.11 This is the upper sample from the Lower Peat. It has been dated to cal BC 7520 to 7300 (Beta-297297). It is marked by a very high value of hazel (34% TLP), slightly less pine and oak, but with slight rises in birch and willow. Sedge pollen is greatly decreased from sample 17. Unidentifiable pollen is high and several spores of *Glomus* are present, a fungus found in soil, indicating erosion of sediment. This, together with the change from organic to silty clay lying above the Lower Peat suggests this may represent increased waterlogging due to a rise in sea level at this time.

2.12 The six samples from the Lower Peat, dated to > 10140 to 8340 years BP, therefore provide evidence for the development of the vegetation during approximately the first two thousand years of the Holocene period following the Late Glacial. Reed swamp with birch, willow and poplar was growing locally during the time the two basal samples (21 and 20) were being laid down. The upper four samples (19 to 16) show the development of sedge fen with a succession of different tree types migrating into the region and then spreading as the climate ameliorated and soils became favourable for their growth: pine and hazel, oak and elm. Analyses from Knowsley Park, Merseyside (Innes, 1994) show a similar succession and spread of trees. There is no pollen evidence for any marine influence on the vegetation during this time, nor is there any evidence of human impact on the vegetation.

Upper Peat

2.13 Fourteen samples throughout the upper peat layer (borehole BH405) were analysed, (samples 14 to 1).

<u>Sample 14 (UP 190cm)</u>

2.14 This is the basal sample of the Upper peat. It has been dated to cal BC 4840 to 4690 (Beta-297296). There is thus a gap of approximately two thousand five hundred years between the two peat layers. The pollen assemblage is dominated by tree and shrub pollen especially oak, hazel and alder (*Alnus*) with elm, lime (*Tilia*) and ash (*Fraxinus*). Oak, hazel and elm were already in the region during the Lower Peat phase, but alder, lime and ash must have arrived during the time of silt deposition. Alder is known to have entered the region about 7500 years BP, lime about 7000 and ash about 6000 (Birks, 1989: Innes, 1994). The abundance of alder pollen in the assemblage together with grasses (reed?) and other wetland herbs such as meadowsweet and meadow rue (*Thalictrum*) suggest the occurrence of alder fen carr on the site at this time. Within the region mixed deciduous woodland has developed on the drier ground with oak, hazel, elm, lime, ash and birch. Spines of the freshwater hornwort are present and suggest there is no sign of any marine influence at this time.

<u>Sample 13 (UP 178 cm)</u>

2.15 The pollen assemblage from this sample is similar to that from sample 14 with the addition of bog myrtle (*Myrica gale*) and heather (*Calluna vulgaris*) both taxa which may grow on wet moorland, bogs and wet open woodland. Some Sphagnum spores are also present suggesting the occurrence of a mosaic of wetland - bogs, fen and wet woodland (alder carr), with mixed deciduous woodland on drier ground in the region. There is also some evidence for wet grassland with the occurrence of herbs such as carrot family, daisy-type, ribwort plantain (*Plantago lanceolata*), thistle-type (*Cirsium*-type) and buttercup (*Ranunculus*-type). There is also one grain which could be a cereal but its could also be from several wild grasses including sweet grass (*Glyceria*) which grows in mud or shallow water.

<u>Sample 12 (UP 166 cm)</u>

2.16 Pollen from this sample is similar to that from sample 13 but values are all suppressed by the very high value of ferns including marsh fern. This may be due to the incorporation of a sporangium into the sediment processed for pollen. Grains of the great fen sedge (*Cladium mariscus*) are present. There is further evidence of grassland being present with a variety of herb pollen including ribwort plantain, dandelion-type (Taraxacum-type), ragged robin (*Lychnis flos-cuculi*), bird's foot trefoil-type (*Lotus*-type) and sorrel-type (*Rumex acetosa*-type).

<u>Sample 11 (UP 154 cm)</u>

2.17 The pollen assemblage from sample 11 is almost identical to that from sample 13 with evidence of a mosaic of wet habitats including alder fen carr, bogs and wet and possibly drier grassland, with mixed deciduous woodland.

<u>Sample 10 (UP 142 cm)</u>

2.18 Similar habitats are suggested as above (samples 14-11) but there is one definite grain of wheat (emmer/spelt) (*Triticum*), and an increase in herbs which could be associated with meadows and arable land. Cereal grains are large and do not travel far and suggests that there was some cultivation quite near at this time This has been dated to 2570 to 2510 cal BC and 2500 to2460 cal BC (Beta-297295) although this may be incorrect (see Carruthers below) as it may have been contaminated by younger material. This could also have resulted in the incorporation of the wheat grain.

Sample 9 (UP 126 cm)

2.19 The pollen assemblage from this sample is similar but grains of heather and bog myrtle are missing, suggesting the disappearance of any heath perhaps as a result of increased waterlogging. Remains of foraminifera, planktonic organisms that are only found in brackish and salt water are present. This is the only possible evidence from the pollen analyses of any marine influence at this site.

Samples 8-2 (UP 114, 102, 90, 78, 54 and 42 cm)

2.20 These six samples all contain similar pollen assemblages. There are variations when one taxon may have a high value and depress other values, but the taxa present remain the same. There continues to be evidence of a mosaic of habitats including alder fen carr, fens, bogs and, on drier ground, mixed deciduous woodland, grassland and heath. There is no further evidence of cereal growth or any marine influence on the vegetation. Sample 6 (UP 90 cm) has been dated to 2870 to 2610 cal BC and 2600 to 2590 cal BC, in the Neolithic .

Sample 1 (UP 30 cm)

2.21 A date of 1000 to 840 cal BC, the Iron Age, has been made from this sample. The pollen assemblage is again similar to those from samples below suggesting that the same mosaic of habitats was present. However, tree and shrub pollen is down to 405 TLP and herb pollen up to 55% TLP. This is mostly grass and may be indicative of pasture with slightly raised values of herb taxa which may be associated with meadows/pasture: ribwort plantain, buttercup-type, cinquefoil-type (*Potentilla*-type), sorrel-type and bracken (*Pteridium*).

2.22 The analysis of the upper peat shows that there was a variety of wetland and drier habitats present throughout, although the proportions of the different vegetation types may have varied as the site was affected by water table levels. There is slight evidence of some cereal growth at about 2500 cal BC and possible indications of grazing either in meadows or open woodland towards the top of the sequence.

2.23 The pollen sequences from the two peat layers at Ince Marshes are very similar to those derived from peat layers at Knowsley Park, Merseyside (Innes, 1994) and Newton Carr, Hoylake, NW Wirral (Cowell & Innes, 1994). Their peat layers were associated with rises in sealevel and thus the peat layers at Ince Marshes can also be correlated with sealevel changes.

Acknowledgements

2.24 Thanks to Sandra Bonsall (Oxford Archaeology North) for the pollen preparation, and to the Geography Department, Lancaster University for the use of their laboratory.

3 ANALYSIS OF THE PLANT MACROFOSSILS

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Methods

3.1 Twenty samples from points c.12cm apart through the upper and lower peat profiles were assessed for plant macrofossils (see Table 1 for actual depth measurements). Fairly wide spacing was used in the assessment so that additional samples could be taken at a later date if specific changes needed to be studied in detail. Wherever possible, the same levels were examined for both pollen and plant macrofossils in order to maximise the level of interpretation at each depth. Radiocarbon samples were taken from seven of the sample points, as listed in Table 2.

3.2 A multidisciplinary approach has been used in this project, with samples for pollen first being removed from the cores by Sylvia Peglar, followed by samples for radiocarbon dating, and then samples for plant macrofossils from the same locations in the cores. A fairly small diameter (8 cm) core was taken from the upper peat and sampling was kept to a minimum depth (2 cm) to maximise the resolution, so this meant that the plant macrofossil sample volumes were quite small, amounting to c.100ml peat when loosened and placed in a measuring cylinder. Samples for AMS dating were taken from intact peat at the centre of the core, so as to minimise the possibilities of contamination.

3.3 Larger bulk samples (c.1 litre) were taken from the lower peat, because this was the method used by geotechnical engineers to sample from depth (RSK pers. comm.). Although this meant that depth measurements were less precise, it was still possible to take pollen samples, radiocarbon samples and plant macrofossil samples from the same large, intact lump of peat, thus ensuring that the data still ties together. A total of 300ml of loosened peat was processed from each of the bulk samples.

Processing

3.4 The 100ml peat (or 300ml from the lower peat) was disaggregated gently by hand in a bucket of warm water. The contents of the bucket were then washed through a graduated stack of sieves (meshes of 3mm, 1mm and 250 microns) and rinsed through with clean water, taking care not to allow the sieves to become blocked and overflow. Although not all of the compacted peat lumps were disaggregated in this way, the gentle method ensured that items such as delicate leaf fragments could be observed on the surfaces of compacted lumps, rather than being lost through the use of chemicals. Some teasing apart of peat lumps was undertaken in a petri dish under the dissecting microscope during full analysis in order to fully characterise the deposits.

3.5 During full analysis all of the residues were sorted for wood fragments, twigs, charcoal fragments, insect fragments, fruits and seeds. The extracted material and sorted sieve residues have been stored in water.

3.6 Because large charcoal fragments were observed in bulk samples 18 and 16 at the assessment stage the remaining peat was rapidly processed in order to recover as much identifiable charcoal as possible. No other plant macrofossils were extracted from these extra samples, however, due to time constraints. The charcoal from samples 16 and 18 was dried and sent to Dana Challinor for identification. The results are given in the sample descriptions below.

Results

3.7 The results of the plant macrofossil analysis are presented as a species list in Table 1, and in the sample descriptions below. Nomenclature and much of the habitat information follow Stace (2010). Hill *et. al.* (1999) was also consulted for ecological information and for salinity data. The radiocarbon dates are listed in Table 2 and a summary of the main changes in vegetation is given in Table 3.

3.8 The following section outlines the sequence of environmental changes taking place in the area surrounding cores BH405 and BH406, starting from the base of the lower peat, sample 22.

The Lower Peat

Sample 22 (base of LP)

3.9 The presence of fluvioglacial deposits beneath the lowest sample suggest that the growth of the lower peat was initiated in the early post-glacial period, when the climate was warming and sea levels were rapidly rising. This was confirmed by the date of 10050 to 9660 cal BC and 9570 to 9550 cal BC (Beta-297299). Sample 22 consisted of a moss-rich peat (primarily Sphagnum sp.) with some evidence of woodland, including downy birch (*Betula pubescens*). Well-preserved seeds and female catkin bracts confirmed the identification of this indicator of wet peaty soils. Downy birch rapidly spread across the British Isles in the Early Holocene, and it was only as climatic warming progressed that silver birch (*B. pubescens*) became the more common species of birch in Britain, as it is today (Godwin, 1976). A variety of aquatic and marsh plants was present amongst the plant macrofossils at Ince, including pondweed (*Potamogeton* spp.), horned pondweed (*Zannichellia palustris*), rigid hornwort (*Ceratophyllum demersum*) and sedges (*Carex* spp.). The presence of hornwort suggests that temperatures had already risen to a level where this thermophilous aquatic species could survive (Ammann et al 2007, 2479).

3.10 According to the National Vegetation Classification (NVC) species such as downy birch, willow and common reed (*Phragmites* sp.) characterise fen carr-type woodland that has become established on topogenous fen peats (e.g. W2; Rodwell 1991). The presence of sphagnum moss in this sample (though not in samples above this within the lower peat) indicates that it is the more acidic, base-poor sub-community that was represented in the sample. However, some in-wash of nutrients may have occurred from time to time, since four water-milfoil nutlets (*Myriophyllum* sp.; an aquatic plant of base-rich soils) were recovered. A few small fragments of charcoal were present, but whether or not this indicates human activity in the area is uncertain. Traces of burning were observed in all of the lower peat samples, sometimes seen as charred monocot leaves and stems and at other times present as identifiable fragments of charcoal (see samples 16 and 18 described below).

Sample 21 (bulk sample 6)

3.11 This sample produced the first confirmation from plant macrofossils that woodland existing immediately in the sampled area, since poorly preserved tree leaves were observed in the laminated peat. In addition, seeds and female catkin bracts of downy birch were common, and there were occasional willow (Salix sp.) catkin bud scales. A few fragments of moss (but not sphagnum) and a range of aquatics/marsh plants were represented, including utricles and seeds of probable Cyperus sedge (*Carex* cf. *pseudocyparus*). In view of the dominance of grass-type pollen in samples 21 and 20 (Peglar, above) a fairly open reedswamp with birch/willow scrub appears to have existed at this time, with taller wetland plants such as common reed (*Phragmites* sp.) and wild angelica (*Angelica sylvestris*) dominating some areas. The main differences between samples 21 and 22 are the absence of tree leaves in sample 22 and the absence of sphagnum moss in sample 21. It is likely that similar habitats existed in both periods, but that tree cover was patchy, interspersed with boggier areas, and being strongly influenced by changes in water level. It is interesting to see that at no point in this lower section of the profile was there plant macrofossil evidence for marine influence, suggesting that the coast was some distance from Ince Marshes at this time.

Sample 20 (bulk sample 5)

3.12 This sample contained a similar range of downy birch seeds and catkin scales as sample 21, as well as some leaf fragments. However, the main component appeared to be monocotyledonous stem fragments and rootlets (abbreviated to 'monocots' from here onwards). Monocots include a wide range of grass-like plants such as rushes, sedges grasses and reeds. Seeds of rush and sedge were present in sample 20, and common reed rhizome fragments were present, confirming the marshy nature of the vegetation. Samples 21 and 20 were very similar although the evidence for birch/willow scrub in the immediate area was slightly reduced in sample 20, and a smaller range of other taxa was recorded. The presence of a few water-milfoil nutlets in sample 20 indicated that some base-rich areas existed in the area.

Sample 19 (bulk sample 4)

3.13 There was plant macrofossil evidence from sample 19 that burning of monocot vegetation occurred, although human involvement is uncertain. Included in this charred vegetation was the first evidence for great fen-sedge (*Cladium mariscus*), along with waterlogged gypsywort (*Lycopus europaeus*), cf. bogbean (cf. *Menyanthes* sp.) and violet (Viola sp.). Together with the pollen, this suggests that open marshy vegetation was the principal habitat. Birch (not identifiable to species level) was still present in the locality but at much lower levels. Changes in the pollen (described by Peglar above) suggested that sedge-fen was developing around this time, peaking at sample 17.

3.14 A radiocarbon date of 8730 to 8460 cal BC (Beta-297298) confirmed that peat continued to accumulate through the Mesolithic as sea levels continued to rise and warming of the climate progressed. However, no obvious marine influences were noted at this stage.

Sample 18 (bulk sample 3)

3.15 At the time that sample 18 accumulated wood had been burned in greater quantities and plant macrofossil evidence for birch was low. Large fragments of charcoal were frequent, including some roundwood. A few of the larger fragments were sent to Dana Challinor for identification with the following results:

> "Sample <18> : Salix/Populus sp. - 15 fragments (6 roundwood, moderate or strong ring curvature, with radial cracks); Indeterminate - 18 fragments"

3.16 There were notable heterogenous rays which suggests that *Salix* rather than *Populus*, but this is not considered to be a reliable characteristic, so the identification is left as *Salix/Populus* sp. The roundwood suggests some smallish branches." (Challinor, pers. com.).

3.17 Willow bud scales were present in samples <20> and <21> but virtually no traces of these two taxa were present above sample 18. The pollen evidence also demonstrated that birch / willow scrub was in decline from sample 20 onwards. Birch is a good fuel wood, and the sap, leaves, bark and timber have a variety of uses. Willow and poplar, on the other hand, do not burn well as unseasoned wood, so the possibility of the charcoal having been created by natural fires within a wetland situation are extremely unlikely (Dana Challinor, pers. comm.). In fact, in his book about Hatfield forest Oliver Rackham suggests that "trees like oak and lime burn like wet asbestos, and nobody has ever succeeded in burning down a native wood" (Rackham, 1989). Although the reduction in willow and birch undoubtedly relates to climatic warming to some extent, it is also likely that human activities played a part in their decline at Ince Marshes around ten thousand years ago.

3.18 Increases in the range of marsh/aquatic taxa (including hemp-agrimony (*Eupatorium cannabinum*), marsh pennywort (*Hydrocotyl vulgaris*) and charred bulrush (*Typha angustifolia*)), and the presence of possible common reed stem fragments, nodes and rhizomes suggested that more open marshy conditions existed on the site, perhaps in part due to the removal of tree cover by humans. Sedge-fen was the dominant vegetation, with taller species such as bulrushes and common reeds probably dominating the landscape.

Sample 16 (bulk sample 1)

3.19 The uppermost bulk sample examined from the lower peat consisted primarily of monocot stem fragments and stem bases (including common reed). However, several fragments of wood and wood charcoal were also present. The charcoal was identified by Dana Challinor as follows:

> "Sample <16> : Salix/Populus sp. - 16 fragments (4 roundwood - faint ring curvature); Indeterminate - 11 fragments"

3.20 A radiocarbon date of 7520 to 7300 cal BC (Beta-297297) was obtained from this level, confirming that the lower peat accumulated throughout the Mesolithic period as a result of climatic warming. The thick deposit of light grey brown silty clay lying above the lower peat presumably signifies a further rise in sea level leading to flooding episodes.

However, as before, no definite evidence for marine influence on the vegetation was found in the peat either side of the clay. Very few identifiable plant macrofossils were present in sample 16 although frequent fragments of hemp agrimony seed amounting to about fifteen achenes were present. Hemp agrimony grows in a range of damp habitats but is currently only coastal in distribution in Scotland (Stace, 2010). It is possible that habitat preferences have gradually changed over such a long period of time. Silt deposition occurred at the end of the Mesolithic period, with accumulation of the upper peat beginning around 4840 to 4690 cal BC (Beta-297296).

The Upper Peat

Sample 14 (actual depth 109 to 111cm)

3.21 This sample, located at the base of the upper peat, consisted of a fairly open, *Phragmites*-rich peat. Common reed nodes and monocot stem fragments were abundant, some of which were found to be charred. Common reed occurs in both freshwater and saline habitats, from fens and bogs to the edges of salt-marshes and estuaries. Some marine influence may have persisted as the peat started to accumulate, although no obligate halophytes have been found in any of the pollen or plant macrofossil samples from Ince. Very few identifiable fruits or seeds were recovered from this sample, the only taxa recorded being sedges (*Carex* sp.) and celery-leaved buttercup (*Ranunculus sceleratus*). These taxa are fairly widely found in freshwater and marshy habitats, as well as coastal areas in Scotland, Wales and Ireland for the latter species (Stace, 2010). A radiocarbon date of 4840 to 4690 cal BC (Beta-297296) was obtained from this level, demonstrating that the upper peat started to accumulate in the Early Neolithic period. By this time the climate had warmed to the extent that lime, alder and ash had spread to the area (Peglar, above).

Sample 13 (178 to 180cm)

3.22 Wood fragments dominated the plant macrofossil assemblage from sample 13, and the first traces of alder fruits and cones were recorded. The few other identifiable macrofossils included pondweed and several sedge nutlets. Occasional monocot stem fragments and rhizomes were also present. Alder carr was growing close to the sampling point at this time, although the fact that at no point in the profile were alder fruits and seed abundant suggests that a patchwork of open sedge fen and alder scrub probably existed, rather than a dense tree cover.

Sample 12 (166 to 168cm)

3.23 This sample contained frequent fruits of great fen-sedge (*Cladium mariscus*), and the main component of the peat was monocot stem fragments (including common reed, but also possibly fen-sedge). The growth of fen-sedge (a plant of wet, base-rich sites) could indicate soil disturbance on the surrounding drier limestone slopes, causing an influx of nutrients. However, burning can also bring about a release of nutrients. Traces of burnt common reed indicated that human activity may have been taking place in the area, though natural fires are also a possibility. The peat at this level was subject to oxidation, resulting in poor preservation. Perhaps the establishment of fen woodland in some areas caused drying of the surface levels of peat. The only other identifiable plant macrofossil present was a nutlet of club-rush that was morphologically most similar to grey club-rush (*Schoenoplectus* cf. *tabernaemontani*). This form of club-rush is most often found near the sea, though it also grows in marshes and dune-slacks (Stace, 2010). Because only one tentatively identified seed was recovered it is not possible to confirm that marine influences affected the area at this time, but it is a possibility, particularly since tree pollen fell, maybe due to a raised water table (Peglar, above).

Sample 11 (154 to 156cm)

3.24 Major changes in the nutrient-status of the peat appear to have occurred between samples 12 and 11, since ericaceous plant macrofossils made a brief appearance at this point (154cm), not being found again as plant macrofossils until sample 6 (90cm). Ericaceous roots and twigs were present, giving the peat a fibrous, felty texture. Traces of heather seed and a leaf (*Calluna vulgaris*), and a few ericaceous fruits were also found. Heather and bog myrtle pollen were also fairly frequent (Peglar, above). Rapid soil deterioration leading to heathland development can occur as a result of clearance and repeated grazing on poor soils (Godwin, 1976), though no evidence for human activity on the site was found. In addition to heathy vegetation, wet ground taxa were also present, such as bulrush (*Typha angustifolia*), rushes (*Juncus* sp.), and great fen-sedge. Either a patchwork of marsh and heathland existed at this time, or two successive vegetation types have been compacted into the two centimetres of peat examined in the sample. Once established, dense rooted heathers would have dried out the upper surfaces and lead to oxidation and the loss of softer plant tissues, such as monocot stems.

Sample 10 (142 to 144cm)

3.25 The peat core at this point was very hard and dry, and crumbly. The sample contained very poorly preserved plant remains including small fragments of wood, mosses and occasional wetland taxa such as marsh pennywort (*Hydrocotyle vulgaris*), sedge and bullrush. Reedswamp and fen are the likely vegetation types represented. Because a pollen grain of hulled wheat was recorded from this sample – the only cereal-type grain observed in any of the samples (Peglar, above) - a sample was submitted for radiocarbon dating. However, the date obtained of 2570 to 2510 cal BC and 2500 to 2460 cal BC (Beta-297295) is problematic as an earlier date was recovered from a better-preserved sample higher up the profile (see sample 6). Because sample 10 was located at the top of the third section of core 405 and because it was very loose in texture it is more likely that contamination had occurred in sample 10 than sample 6 (where the radiocarbon sample was taken from within an intact, firm section of peat). However, the fact that the pollen grain was from a hulled wheat is important, as discussed below. Whilst it may have been displaced it is clearly not from a modern species of wheat, so it confirms arable cultivation as having taken place in prehistoric times.

Sample 9 (126 to 128cm)

3.26 Monocot stem fragments and common reed nodes dominated sample 9, and rush seeds were frequent. Some of the monocot stem was charred, perhaps suggesting management for grazing during the Neolithic period, or the flushing out of game. Natural fires are also a possibility. Poorly preserved wood fragments were infrequent and an alder seed was present. Three seeds of cf. grey club-rush (*Schoenoplectus* cf. *tabernaemontani*) were present, possibly indicating some marine influence at this time. This suggestion was backed up by the identification of foraminifera characteristic of brackish or salt water in the pollen samples (Peglar, above). Some of the other macrofossil genera contain species that are found in saltmarsh habitats, for example *Phragmites*, some species of rush (*Juncus* sp.) and some species of spike-rush (*Eleocharis* sp.), so it is possible that the extent of marine influence is difficult to detect in the samples and has been under-estimated.

Sample 8 (114 to 116cm)

3.27 This peat sample was fairly humified. Decayed wood and monocot stems were roughly equal in frequency. Some small fragments of wood charcoal were present. Great fen-sedge fruits were the most frequent macrofossil. The presence of sedge and spike-rush suggests sedge-rich, open fenland vegetation. No clear evidence was found to determine whether tree re-growth was being suppressed by grazing or periodic burning, but tree pollen was temporarily lower in this sample than in those above and below it (Peglar, above).

Sample 7 (102 to 104cm)

3.28 Wood fragments dominated sample 7, including some twigs. *Sphagnum* moss leaves were also abundant, as were great fen-sedge fruits. The scarcity of heather pollen and frequency of *Sphagnum* suggested increased wetness at this time. A few poorly preserved birch (*Betula* sp.) seeds were present, perhaps suggesting a period of fen scrub re-growth.

Sample 6 (90 to 92cm)

3.29 A radiocarbon date of 2870 to 2610 and 2600 to 2590 cal BC (Beta-297294) was obtained, placing this level in the Late Neolithic period/Early Bronze Age. This date (90cm depth) is slightly later than the date from 142cm depth (sample 10), as described above. This slight inversion of dates with c. 50cm of peat between them is probably due to a problem with the date from sample 10, since the core at sample 6 was intact and not compacted or loose. However, it is also possible that this date was at fault.

3.30 Sample 6 contained frequent Sphagnum leaves although these were probably of a different species than in sample 7, being much smaller. The main component of the peat was decaying monocot stems and possibly heather roots. Occasional heather (*Calluna vulgaris*) seeds were present, including a burnt seed, and heather pollen was recorded (Peglar, above). This is the start of an extended period of heathland development on the site, with ericaceous plant macrofossils being recovered from all of samples 6 to 2. The nutrient-poor acidic conditions indicated by Sphagnum enabled heathers to become established on the drier areas, and this probably led to drying out and the exclusion of fenland taxa from this point onward. At first common reed and bulrush continued to occupy wetter areas (samples 6 and 5), but by the time samples 4 to 2 were forming rushes and one or two wetland herbs were the only taxa other than heathers.

Sample 5 (78 to 80cm)

3.31 The main component of sample 5 was fibrous, decaying monocot stem bases and stem fragments. Some of the fibrous material might have been derived from heather roots and shoots, since *Erica/Calluna* sp. fruits were present. A few burnt ericaceous twigs were present, suggesting occasional burning may have been taking place. As noted above, bulrush, rush and sedge were also present.

Sample 4 (66 to 68cm)

3.32 An increase in the growth of woody vegetation was indicated in sample 4, as wood fragments were the main component of the peat. Although some of this was heather-type roundwood, most of it came from larger trees. Small fragments of charcoal indicated that burning was taking place, so it is possible that the un-burnt wood fragments also relate to clearance. The plant macrofossil evidence suggest that a mixture of wet areas with Sphagnum and a few aquatics (pondweed, marsh pennywort, rushes) and drier areas with heather and possibly scrub existed. The presence of fine white silt in the plant macrofossil sample suggested that flooding or inwash from the cultivation of land nearby may have occurred at this time.

Sample 3 (54 to 56cm)

3.33 The loose, matted felt-type structure of the peat in sample 3 and presence of frequent ericaceous roots, fruits, charred heather (*Calluna vulgaris*) shoot tips and a few seeds indicated that heathland was the dominant vegetation type in the location of borehole 405. Heather pollen was also frequent (Peglar, above).

Sample 2 (42 to 44cm)

3.34 This sample contained a similar mix of habitat indicators as were found in sample 4, including wood fragments, heather (occasionally charred), and frequent rush seeds. The presence of buttercup (*Ranunculus acris/bulbosus/repens*) and cinquefoil (*Potentilla* sp.) seeds suggests that some drier, grassy areas existed at this time, perhaps providing grazing for livestock. The pollen assemblage was similar to sample 3. Woods and heath still dominated the area.

Sample 1 (30 to 32cm)

3.35 At the top of the upper peat, below a thick deposit of grey brown silty sandy clay, sample 1 consisted of poorly preserved, soft wood peat. The only identifiable plant macrofossils to survive were frequent wood fragments, several rush seeds, an aquatic crowfoot-type buttercup (*Ranunculus* subg. *Batrachium*) and some fragments of insects. Grass pollen was the principal type present, with alder, oak and hazel indicating the continued presence of woodland and alder carr (Peglar, above). Since monocot seeds and stems are unlikely to survive where oxidation of the peat has taken place it is possible that grasses, common and rushes had originally been the main components but only the more resistant, woody remains have survived. Inundation and burial of the peat by silt occurred after 1000 to 840 cal BC (Beta-297293) according to the radiocarbon date from the top of the peat, making the accumulation of peat end in the Late Bronze Age.

Acknowledgements

3.36 I am very grateful to Elizabeth Huckerby at Oxford Archaeology North for giving me access to her unpublished Mickle Trafford evaluation report, and for helping me to track down reports from the Merseyside area.

4 GENERAL DISCUSSION

4.1 The analysis of both pollen and plant macrofossils from identical sample points in the same cores has greatly enhanced the quantity and quality of data being retrieved. This is because each source of evidence has provided a slightly different type of data. Pollen mainly provides information about local and regional vegetation changes, whilst plant macrofossils give a more detailed picture of vegetation changes at the site itself. Differences in levels of identification can also be useful, for example fruits, seeds and vegetative material can often be identified to species level, providing the maximum ecological information, whilst some pollen is only identifiable to a broad group of species. Pollen, however, is often present in much larger quantities in peat than identifiable plant macrofossils, so can be used to demonstrate environmental changes in a more statistically significant form.

4.2 Summarised changes in the vegetation are presented in Table 3. A classic sequence of succession was found to be present in the lower peat deposits, from the early Holocene fairly open reedswamp with willow, birch and juniper, to gradual colonisation of the area by pine. Following an increase in hazel, mixed deciduous woodland became established on the drier ground, with oak, elm and later, lime moving into the area. Pollen from the upper peat showed that there was a remarkable persistence of deciduous woodland through time, although alder carr probably dominated the area close to the sampling point for most of the time that the upper peat was accumulating. Because of the low frequency of elm pollen at Ince it has not been possible to define the elm decline, but according to work carried out by the North West Wetlands Survey on Merseyside the date in this region is around 4034-3790 cal BC (5120±50 BP; SRR 2929) This is the date obtained at Park Road, Meols, on the North Wirral coast (Cowell and Innes 1994, 204). This puts the elm decline between samples 14 and 6 (bearing in mind possible problems with the radiocarbon date from sample 10).

4.3 The plant macrofossils demonstrated that at times drier heathland was the dominant vegetation type in the immediate area (upper peat only), whilst at other times wetter sphagnum bog, *Phragmites* reedswamp or sedge-fen were present. Evidence for small-scale burning was common, being recorded in eleven of the twenty plant macrofossil samples. Although large fragments of charcoal were only common in two samples, 16 and 18 in the lower peat, it is clear that coastal areas of the Liverpool basin were being heavily exploited by humans in the Mesolithic (Cowell and Innes 1994, 173). It is often difficult to recognise small-scale clearances in pollen diagrams of this period, particularly when the woodland was probably located some distance from the site on drier, higher ground. However, the fact that willow/poplar charcoal was identified on the site suggests that deliberate burning rather than natural fires had been taking place at Ince. As notes above, these very sappy woods do not easily catch fire in a wetland location, so it is likely that fires from transient camps were represented in the samples or some sort of deliberate clearance and burning.

4.4 In the lower part of the upper peat (sample 10) a single pollen grain of hulled wheat hinted at arable agriculture taking place in the area. As described above, there are questions over the integrity of this deposit, particularly in the light of the inversion of dates in samples 10 and 6. However, it is significant that the pollen grain was from a hulled wheat (either emmer or spelt) rather than one of the free-threshing wheats grown today. This means that the grain had not come from a modern source but had possibly been transported down the profile from Later Neolithic or Bronze Age levels. Therefore, its presence at least confirms that some arable cultivation was taking place in the area in prehistoric times, or perhaps that cereals had been brought to the area, since pollen can be transported on the chaff of hulled wheats (Robinson & Hubbard 1977). More substantial evidence from sites such as Bidston Moss on the Wirral confirms that cereal cultivation was taking place in at least some parts of the Liverpool basin from the Earlier Neolithic onwards (Cowell & Innes 1994, 39). In the Late Prehistoric period, however, areas such as Ince would have become very wet as climatic deterioration spread across the country. Very little evidence for arable cultivation was found in peat from the central mosslands of Merseyside by Cowell and Innes (1994, 131) and few other sites in the area provided deposits that continued, un-truncated, into this period. The archaeological evidence suggests that settlement occurred away from wetland areas, on drier sandstone soils and along river valleys.

4.5 It is interesting to note that evidence for marine influence was minimal and tentative, with no obligate halophytes being identified in the pollen or plant macrofossil assemblages and at best only a few 'salt-tolerant' taxa such as grey club-rush and *Phragmites* being present in any quantity. This suggests that the area samples was not affected by tidal waters of the River Mersey, perhaps because the peat basin was physically isolated from the estuary. Further investigations at Ince Marshes might change this picture, particularly in the upper part of the sequence when sea levels were at their highest.

Comparisons with other sites in the area

4.6 Very few sites in the immediate area of Ince Marshes have been examined for plant macrofossils, particularly sites that cover the Mesolithic to Late Bronze Age periods, but several sites in the Mersey estuary and wider region have been analysed for pollen, particularly sites studied by the North West Wetlands Survey. At Walker's Heath, Cheshire (Leah et al 1997) it was suggested that human activities had modified the vegetation from the early Mesolithic, as appears to be the case at Ince Marshes. Pollen analyses at Knowsley Park , Merseyside (Innes 1994) produced a similar succession as was found at Ince, suggesting that the spread of tree species occurred in a fairly uniform fashion across the region as the climate ameliorated and soils became capable of supporting their growth.

4.7 Excavations at Ditton Brook on Merseyside revealed Late Mesolithic temporary hunting camps with evidence of fires and frequent stone tools (Cowell & Philpott 2000). Pollen analysis produced evidence for alder wood and areas of wetland (Innes in Cowell & Philpott 2000), as was found in much of the upper peat sequence at Ince. It is clear that the Mersey estuary was an important hunting area in the early post-glacial period, providing accessible locations for hunting and fishing along the coast and allowing easier access inland to more heavily forested landscapes along the river valley.

4.8 Evidence from later periods suggests that, in places, more easily worked, drier soils may have been used for small-scale arable agriculture from the Neolithic period onwards. Palaeoenvironmental analysis of palaeochannel sediments near Mickle Trafford, c. 5 miles to the south of Ince Marshes, produced a Neolithic to Early Medieval pollen profile with some evidence for small-scale arable cultivation (Elizabeth Huckerby, pers. Comm.). Although only an evaluation with two radiocarbon dates, three possible clearance phases linked to cereal cultivation and pastoral farming were identified; one in the Neolithic, one possibly in the Bronze Age, and a major clearance with extensive farming that probably dated to the Late Iron Age/Early Roman period.

4.9 As farming methods and tools improved in later prehistoric times it became possible to grow arable crops on heavier loams and clays in the Liverpool basin. Excavations at Brook House Farm, Bruen Stapleford, on Merseyside produced low levels of charred cereal remains in roundhouses dating from the Bronze Age to Late Iron Age, demonstrating that mixed farming (including the cultivation of hulled wheats and barley) was taking place close to the Mersey estuary, albeit probably at a low level (Carruthers, 2002a). Similar low levels of charred cereal remains were also found in a small Romano-British rural settlement at Birch Heath, Tarporley, to the south-east of Ince Marshes (Carruthers, 2002b). It is unfortunate that few peat deposits in the area continue into the Iron Age and later periods as combined pollen and macrofossil evidence may help to determine whether arable agriculture was as limited as the charred evidence suggests, or whether the survival and recovery of macrofossils in clay soils is an important factor that needs to be taken into account. Future excavations in the Liverpool area may be able to throw some light on these questions.

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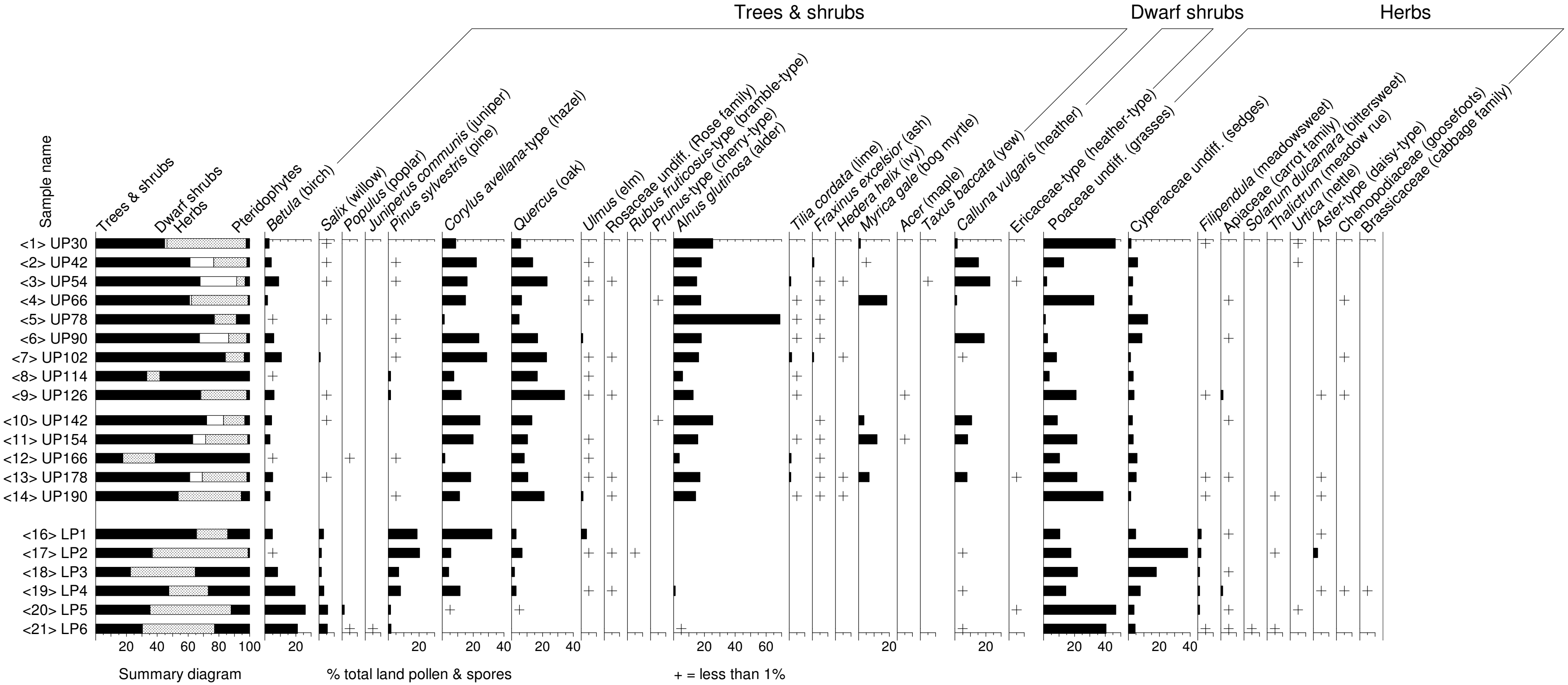
FIGURES / TABLES

Figure 1: Ince Marshes pollen and spore diagram

INCE MARSHES

Pollen and spore percentages



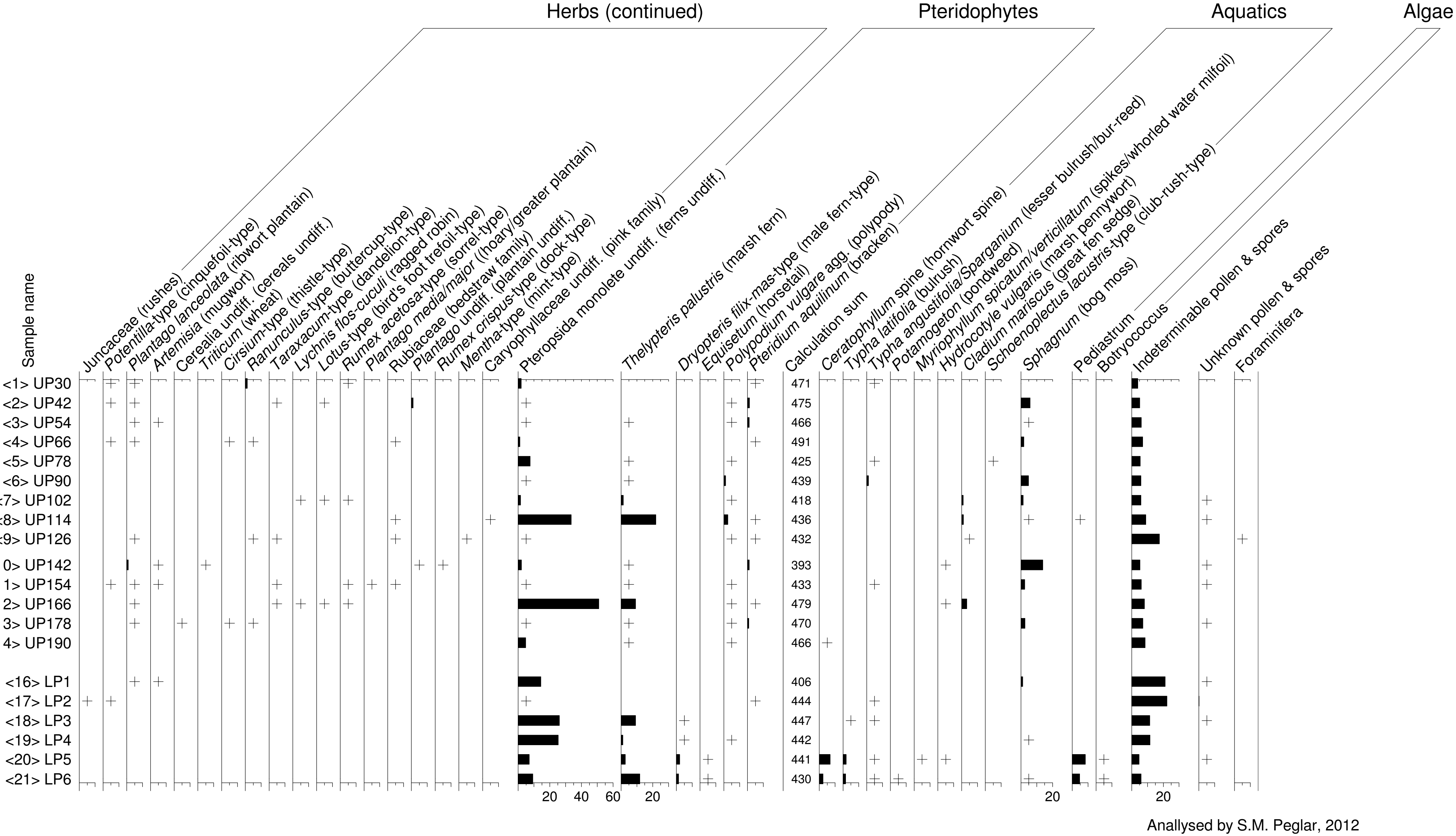

Herbs (continued)
Pteridophytes
Aquatics
Algae
Sample name
Juncaceae (rushes)
Potentilla-type (cinquefoil-type)
Plantago lanceolata (ribwort plantain)
Artemisia (mugwort)
Cerealia undiff. (cereals undiff.)
Triticum (wheat)
Cirsium-type (thistle-type)
Ranunculus-type (buttercup-type)
Taraxacum-type (dandelion-type)
Lychnis flos-cuculi (ragged robin)
Lotus-type (bird's foot trefoil-type)
Rumex acetosa-type (sorrel-type)
Plantago media/major (hoary/greater plantain)
Rubiaceae (bedstraw family)
Plantago undiff. (plantain undiff.)
Rumex crispus-type (dock-type)
Mentha-type (mint-type)
Caryophyllaceae undiff. (pink family)
Pteropsida monolete undiff. (ferns undiff.)
Thelypteris palustris (marsh fern)
Dryopteris filix-mas-type (male fern-type)
Equisetum (horsetail)
Polypodium vulgare agg. (polypody)
Pteridium aquilinum (bracken)
Calculation sum
Ceratophyllum spine (hornwort spine)
Typha latifolia (bulrush)
Typha angustifolia/Sparganium (lesser bulrush/bur-reed)
Potamogeton (pondweed)
Myriophyllum spicatum/verticillatum (spikes/whorled water milfoil)
Hydrocotyle vulgaris (marsh pennywort)
Cladium mariscus (great fen sedge)
Schoenoplectus lacustris-type (club-rush-type)
Sphagnum (bog moss)
Pediastrum
Botryococcus
Indeterminable pollen & spores
Unknown pollen & spores
Foraminifera
<1> UP30 471
<2> UP42 475
<3> UP54 466
<4> UP66 491
<5> UP78 425
<6> UP90 439
<7> UP102 418
<8> UP114 436
<9> UP126 432
<10> UP142 393
<11> UP154 433
<12> UP166 479
<13> UP178 470
<14> UP190 466
<16> LP1 406
<17> LP2 444
<18> LP3 447
<19> LP4 442
<20> LP5 441
<21> LP6 430
20 40 60
20
20
20
Anallysed by S.M. Peglar, 2012

Table 1: Ince Marshes plant macrofossils

Table 1: Plant macrofossils in peat cores from from Ince Marshes

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	18	19	20	21	22
Actual Depth	30cm	42cm	54cm	66cm	78cm	90cm	102cm	114cm	126cm	142cm	154cm	166cm	178cm	190cm	bulk1	bulk3	bulk4	bulk5	bulk6	base
herbs of grassland/heath/disturbed ground																				
Ranunculus acris/bulbosus/repens (buttercup achene) DG		1																		
Potentilla sp. (cinquefoil achene) DGMY		5									1									1
Viola sp. (violet seed) EGSW																	3			
Labiatae cf. *Stachys* sp. (cf. woundwort nutlet) MGD															1	1				
Valeriana officinalis L. (common valerian fruit) G																			2	
woods/scrub/fen taxa																				
Urtica dioica L. (stinging nettle achene) CDn																		1	6	
Betula pubescens Ehrh. (downy birch seed) Whawp																		12	21	7
Betula pubescens Ehrh. (downy birch female catkin bract) WHawp																		2	5	3
Betula sp. (indeterminate birch female catkin bract) WSF																			3f	
Betula sp. (poor birch seed, no wings) WSF							4									2	3	13	39	12
Alnus glutinosa L. (alder seed) WSF									1		1		1							
Alnus glutinosa L. (alder catkin) WSF													2							
Salix sp. (willow bud scales) WSF																		3	4	
heathland taxa																				
Calluna vulgaris (L.) Hull (heather seed) Emsp			+++			[1] 2					1									
Calluna vulgaris (L.) Hull (heather shoot tip) Emsp			[9]																	
Calluna vulgaris (L.) Hull (heather leaf) Ep		[1]	[4]	[1]							1									
Erica tetralix L. (cross-leaved heath leaf) Mew		[1]																		
E. cinerea L. (bell heather seed) E																				
Erica sp./*Calluna vulgaris* (heather, ling capsules) EM		[2] 3	[6] 86		2						4									
bog/marsh/aquatic taxa																				
Ceratophyllum demersum L. (rigid hornwort achene) P																			1	7
Ranunculus sceleratus L. (celery-leaved buttercup achene) MP														1						
Ranunculus subg. *Batrachium* (crowfoot achenes) P	1	1								cf. 1										2
Myriophyllum sp. (water-milfoil nutlet) Pc																		2		4
Rumex cf. *hydrolapathifolium* (cf. water dock achene) P																			3	1
Lycopus europaeus L. (gypsywort nutlet) FGwP																7	1f		1	
Mentha sp. (mint nutlet) MPG											1									
Menyanthes trifoliata L. (bog bean nutlet) MFw																1	cf.1f			
Eupatorium cannabinum L. (hemp -agrimony achene) wGHP															15+	1				
Hydrocotyle vulgaris L. (marsh pennywort fruit) M		1		2			5			1						1				
Angelica sylvestris L. (wild angelica fruit) GFMP																			1	
Lemna sp. (duckweed fruit) P																			1	
Potamogeton sp. (pondweed fruit) M				1									3					2	2	8
Zannichellia palustris L. (horned pondweed achene) Mc																				2
Juncus sp. (rush seed) MPw	++	+++	+	++	+	+			+++	+	++							+		

Table 1: Plant macrofossils in peat cores from from Ince Marshes

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	18	19	20	21	22
Typha angustifolia L. (lesser bulrush seeds) MPw					11	3				1	18					[1]				
Eriophorum vaginatum L. (hare's-tail cottongrass nutlet) Mp																		cf.1		
Schoenoplectus cf. *tabernaemontani* (C.C.Gmel.)Palla.(cf. grey club-rush nutlet) Mp, coastal									3			1								cf.1
Eleocharis sp. (spike-rush nutlet) MPw								1											3	
Cladium mariscus (L.)Pohl (great fen-sedge nutlet) FPc							31	8			2	15			1	cf.[1]f	cf.[2]f			
Carex cf. pseudocyparus-type (utricle with nutlet) MPw								2		1				1		2	3		2	2
Carex sp. (trigonous *pseudocyperus* -type sedge nutlet) MPw														2			4		4	3
Carex sp. trigonous other nutlet MPw		1															7		2	
Carex sp. (grey lenticular sedge nutlet) MPw													14			6	3	8	12	5
Indeterminate Cyperaceae nutlet					1f															
Poaceae NFI (small grass seed)						1														
main peat components																				
wood fragments	+++	++		+++		+	+++	[+] ++	++	++	+	++	+++		++		++	+		++
roundwood		++	++	+	++	++	+	+		++	+		+			+	++	+	++	++
tree leaf fragments																		++	+++	
wood charcoal		[+]		[++]	[+]	[+]	[+]	[+]			[+]				[+++]	[+++]		[+]		[+]
fibrous ericaceae stems and roots			+++																	
Sphagnum spp. moss, detached leaves and shoot tips				+		+++	+++													+++
Other mosses NFI							+			++						+		++	+	+
Indeterminate monocotyledonous stem frags (includes Phragmites stems)	+			++	+++	+++	[+]	+	[+]	+	+	++	++	+++	+++	[++] ++	[+] +	+++	[+] +	++
Phragmites-type rhizomes and nodes				1	18				13		1	++[+]	+	[4] 21	11	9	1	6	2	3
Insect fragments	++	+		+		+	+					++	+	++	+	+	+	+	+	++
TOTAL	1	12[4]	86[19]	3[1]	14	6[1]	40	11	4	4	29	16	20	4	17	21[2]	25[2]	44	112	58
approximate sample volume (ml)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	300	300	300	300	300	300

KEY: [ ] = charred; no brackets = waterlogged: FREQUENCY + = 1-2 items; ++ = 3-10; +++ = >10 HABITAT PREFERENCES: C=cultivated; D=disturbed; E=heaths; F=fens; G=grassland; M=marsh/bog; P=ponds/ditches etc. S=scrub; W=woods; SOILS a=acidic; c=calcareous; p=peaty; w = wet to damp

Table 2: Ince Marshes radiocarbon dates

TABLE 2: INCE MARSHES RADIOCARBON DATES

Beta Analytic no.	Sample no.	depth	material	measured radiocarbon age	conventional radiocarbon age	2 sigma calibration
Beta-297293	40501	30cm upper peat	peat	2820±30 BP	2770±30 BP	cal BC 1000 to 840 (cal BP 2940 to 2790)
Beta-297294	40506	90cm upper peat	peat	4170±30 BP	4140±30 BP	cal BC 2870 to 2610 (cal BP 4820 to 4560) AND cal BC 2600 to 2590 (cal BP 4550 to 4540)
Beta-297295	40510	142cm upper peat	peat	4010±30 BP	3970±30 BP	cal BC 2570 to 2510 (cal BP 4520 to 4460) AND cal BC 2500 to 2460 (cal BP 4450 to 4410)
Beta-297296	40514	190cm upper peat	peat	5900±40 BP	5890±40 BP	cal BC 4840 to 4690 (cal BP 6790 to 6640)
Beta-297297	40616	Bulk 1 lower peat	peat	8360±50 BP	8340±50 BP	cal BC 7520 to 7300 (cal BP 9840 to 9250)
Beta-297298	40619	Bulk 4 lower peat	peat	9370±50 BP	9330±50 BP	cal BC 8730 to 8460 (cal BP 10680 to 10410)
Beta-297299	40622	Base of lower peat	peat	10170±50 BP	10140±50 BP	cal BC 10050 to 9660 (cal BP 12000 to 11610) AND cal BC 9570 to 9550 (cal BP 11520 to 11500)

Table 3: Ince Marshes summarised vegetation changes (to be read from the base upwards)

Table 3: Summarised pollen and plant macrofossil results from Ince Marshes (to be read from the bottom upwards)

	Borehole no.	Depth from top of core (cm)	Actual depth (cm)	Pollen code	Sample no.	2 sigma calibrated date (cal BP)	Summarised vegetation description (pollen and macrofossil evidence)	
UPPER PEAT	405 (i)	30	30	UP 30	1	2940 to 2790	The sequance ends in the Late Bronze Age with a more open, damp meadow/pasture pollen assemblage, but with alder carr still present locally and oak/hazel woodland slightly reduced on drier land. Evidence for heathland had almost disappeared in this sample and Poaceae was the dominant pollen group. Unfortunately the drier, more oxidised peat produced very few macrofossils.	PASTURE/MEADOW WITH ALDER CARR AND OAK WOODS IN THE AREA
		42	42	UP 42	2		Heathland was still being burnt locally and some drier areas now supported herbs such as buttercup and cinquefoil (macros). Wetter areas contained sedges and reeds and the same mix of alder carr and deciduous woodland existed in the wider area.	HEATH AND ALDER CARR
		54	54	UP 54	3		This sample was primarily composed of matted, felty ericaceous vegetation, including abundant heather/heath capsules and some burnt shoots. Heather pollen was also frequent. Further afield the same mixture of alder carr and drier woodlands on higher ground existed (pollen), though there was less evidence for marshy, wet vegetation (pollen and macros)	HEATH WITH SIGNS OF BURNING, ALDER CARR
	405 (ii)	4	66	UP 66	4		Alder carr, heath and reedswamp continued in the area (pollen and macros). Wood fragments and occasional burnt heather occurred throughout samples 6 to 2.	REEDSWAMP, HEATH AND ALDER CARR
		16	78	UP 78	5		Tall monocot vegetation including bulrushes (seeds) occupied the site with heathy areas (heather capsules) and abundant alder carr in the area (pollen).	REEDSWAMP, HEATH AND ALDER CARR
		28	90	UP 90	6	4820 to 4560 and 4550 to 4540	Heathland returned to the site (pollen and macros) but sphagnum moss was still frequent, suggesting that a patchwork of dry and wetter areas existed.	HEATH, SPHAGNUM BOG AND ALDER CARR
		40	102	UP 102	7		A similar mosaic of fen, bog and deciduous woodlands on drier land (pollen) existed. Frequent sphagnum moss made up much of the peat matrix in samples 7 and 6, and abundant great fen-sedge nutlets and several marsh pennywort fruits in this sample demonstrated that wetter fen pools and marsh existed on the site. There was a minor increase in birch pollen and a few poorly preserved seeds suggesting that either silver or downy birch were growing on the peaty soils that had by now turned acidic.	SPHAGNUM BOG WITH ALDER CARR AND LOCAL WOODLAND
		52	114	UP 114	8		Charcoal fragments and/or burnt ericaceous material (samples 6 to 2) become a constant factor from this point upwards, indicating probable low-level human exploitation of the area. Ferns were frequent (spores) and a mosaic of alder fen carr, sedge-fen (in particular, great fen-sedge; macros), bogs and oak/lime/hazel woodland on drier ground (pollen) existed in the area.	ALDER CARR, SEDGE-FEN, PROBABLE LOW-LEVEL HUMAN ACTIVITY
		64	126	UP 126	9		Pollen (foraminifera) and macros (grey club-rush) suggest possible marine influence in the area causing a loss of heathland. Macro preservation was poor but rushes and Phragmites (a plant of saltmarsh and estuaries as well as inland bogs) were dominant. Oak woodland was at its peak (pollen) in the wider region.	ALDER CARR, OAK WOODS, PROBABLE MARINE INFLUENCE

Table 3: Summarised pollen and plant macrofossil results from Ince Marshes (to be read from the bottom upwards)

	Borehole no.	Depth from top of core (cm)	Actual depth (cm)	Pollen code	Sample no.	2 sigma calibrated date (cal BP)	Summarised vegetation description (pollen and macrofossil evidence)	
	405(iii)	4	142	UP 142	10	4520 to 4460 and 4450 to 4410	The only definite cereal pollen grain (hulled wheat) from Ince was recorded and herb pollen increased, possibly indicating small-scale arable cultivation. However, the peat was very loose and crumbly at this point (the top of the third section of core from borehole 405) and the radiocarbon date conflicts with the date from sample 6. Only four identifiable macros were present, all of which were from marshy taxa. A question remains over this sample as to whether contamination ocurred or not.	REEDSWAMP, ALDER CARR, HEATH, TRACE OF ARABLE CULTIVATION OR CONTAMINATION?
		16	154	UP 154	11		This sample contained the earliest macrofossil evidence of heathland on the site, though it was not frequent or charred (unlike in samples 2 to 6). Ericaceous pollen was also frequent as was bog myrtle. Tree pollen recovered to its previous levels but the dominant vegetation type on site was probably a patchwork of reedswamp (including frequent bulrush; seeds) and drier grassland with heathy vegetation and some ruderal weeds (pollen).	HEATH AND REEDSWAMP ON SITE, ALDER CARR
		28	166	UP 166	12		The main taxa were open, marshy fenland plants including great fen-sedge (frequent nutlets and pollen), Phragmites rhizomes and ferns (incuding marsh fern spores). The fall in tree pollen at this point (in particular, alder and hazel) could relate to human activity in the area, since some evidence of burning marsh vegetation was present. There were also smaller amounts of wood in the peat sample than in sample 13. Elm pollen frequency was too low at Ince to identify the elm decline but it has been dated to 5120±50 BP on the Wirral (Cowell & Innes 1994, 204) so probably occurs between samples 14 and 6. The uncertain identification of a grey club-rush nutlet, which mainly occurs near the sea, provides possible evidence of marine influence. A marine incursion close to the site could be another explanation for the short-lived drop in tree pollen, though the evidence is tentative.	SEDGE-FEN, SHORT-LIVED REDUCTION IN SCRUB. MARINE INFLUENCE?
		40	178	UP 178	13		Frequent wood fragments (including branchwood), an alder seed and catkin fragments indicated that alder carr was now present on, or very close to, the site. Several sedge nutlets, sphagnum spores, bog myrtle and heather pollen indicate that a mosaic of wet, open, drier heathy and scrubby areas existed. Heathland macrofossils were not present until sample 11 so this may have been a short distance from the site at the time sample 13 accumulated.	ALDER CARR LOCALLY DOMINANT
		52	109	UP 190	14	6790 to 6640	During the 2500 year gap between the end of the LP and start of UP development alder, lime and ash spread to the area. Together with oak, hazel and elm these trees dominated the pollen assemblage. Poaceae were also abundant and the few macrofossils surviving in the compacted peat indicated that sedge-fen interspersed with alder-carr dominated the area, with larger trees on drier ground.	SEDGE-FEN AND ALDER CARR WITH OAK/LIME/ASH/HAZEL WOODS
CLAY BELOW UPPER PEAT		57-59			15			

Table 3: Summarised pollen and plant macrofossil results from Ince Marshes (to be read from the bottom upwards)

	Borehole no.	Depth from top of core (cm)	Actual depth (cm)	Pollen code	Sample no.	2 sigma calibrated date (cal BP)	Summarised vegetation description (pollen and macrofossil evidence)	
LOWER PEAT	406	Bulk 1		LP1	16	9840 to 9250	A significant rise in hazel pollen and fall in sedge pollen occured at this level. The monocot peat contained high levels of large charcoal (with willow/poplar identified) but few identifiable macrofossils were recovered from the poorly preserved compacted peat. The presence of silts above this level indicates sea level rises and silt inundation, but no definite evidence for marine taxa was found in the pollen or macros either side of the clay deposit.	REEDSWAMP, SEDGE-FEN, HAZEL AND ELM RISE
		Bulk 2		LP2	17		(Pollen only) Sedge-fen was present with a little oak/hazel woodland on drier ground and pine growing further afield. Pine was at its highest in this sample and sedge pollen was abundant.	SEDGE-FEN
		Bulk 3		LP3	18		Sedge-fen was present with regional oak/hazel woodland and declining birch/willow scrub. Pine was present. Significant numbers of large charcoal fragments including willow/poplar (a species unlikely to burn in natural fires) suggested human activities in the area.	WILLOW/POPLAR CHARCOAL - POSSIBLE HUMAN ACTIVITY
		Bulk 4		LP4	19	10680 to 10410	Tree pollen dominated (nearly 50%) with significant levels of pine, hazel and oak and decreasing birch and willow. The first trace of elm pollen was found. Poor peat preservation and the presence of tree rootlets, together with some pollen from disturbed ground taxa suggested the drying out of some areas. Two burnt great-fen sedge nutlets and sedge/grass-type vegetation could indicate low-level human activity in the area or natural fires. A change from reedswamp to sedge-fen is likely.	SEDGE-FEN, PINE/OAK/HAZEL WOODS, FIRST ELM POLLEN
		Bulk 5		LP5	20		The pollen and macro samples were similar to sample 21 with reedswamp and some birch and willow scrub but the peat mainly consisted of of sedge/reed stems rather than tree leaves. The first pollen from hazel and oak were recorded. The absence of juniper from this point onwards is likely to be due to climatic warming.	BIRCH/WILLOW SCRUB, FIRST ARRIVAL OF HAZEL AND OAK
		Bulk 6		LP6	21		Freshwater reedswamp occurred with the pollen assemblage dominated by Poaceae (grasses, including Phragmites). There was evidence for birch, willow, poplar and juniper growing nearby (presence of downy birch leaves, seeds and remains of catkins; 30% tree pollen). Pine probably grew some distance away. Ferns and horsetails (particularly marsh fern) were present.	REEDSWAMP AND BIRCH/WILLOW/ JUNIPER SCRUB
		Tub (base)			22	12000 to 11610 and 11520 to 11500	The sequence starts in the early post-glacial period when climatic warming enabled plant species to gradually migrate across the British Isles. (Macros only) A fairly open landscape existed at Ince with sphagnum bog and freshwater reedswamp. A variety of submerged and emergent aquatic plants grew in wetter areas. Downy birch was growing nearby but no leaves were present so the seeds and catkin fragments may have been blown a short distance to the site.	SPHAGNUM BOG, REEDSWAMP AND BIRCH SCRUB
CLAY BENEATH LOWER PEAT		Tub (clay)			24			