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Ancient Monuments Laboratory
Report 208/88

THE HULLBRIDGE (ESSEX) SURVEY; RESULTS OF THE PALYNOLOGICAL INVESTIGATION.

Robert G Scaife PhD BSc FRGS

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SUMMARY

The Hullbridge project was established in 1982 and has produced a detailed survey of the archaeology and sediments of the Essex river estuaries. This survey has been carried out by P Murphy (Centre for East Anglian Studies, Norwich) and T J Wilkinson (Essex Archaeological Unit, Chelmsford). In addition to detailed recording and excavation of a number of archaeological sites found below high water mark, a detailed picture of the local biogenic and minerogenic stratigraphy has been constructed. Over much of the Hullbridge area, an old land surface on which later prehistoric activity took place was drowned by rising sea level which deposited estuarine clays. A typical sequence, comprising a basal buried soil and peat overlain by estuarine sediments, is found at a number of sites. This paper gives the results of pollen analyses carried out on 5 soil, peat and sediment sequences found in the Blackwater and Crouch river estuaries.

The aim of this study was to ascertain if pollen was present in these sediments and to provide data on the character of the region's vegetation. The results of these analyses have shown that a mixed deciduous woodland dominated the terrestrial areas of the Hullbridge Bsin. This woodland comprised *Quercus*, *Tilia* and *Corylus*, but other arboreal elements were also present (*Ulmus*, *Fraxinus*, *Fagus*). Little evidence for anthropogenic disturbance has been noted. Changes from dry land to brackish water/estuarine conditions are clearly seen in the pollen record at all of the sites analysed with abundant records of halophytic plants.

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The Hullbridge project, established in 1982 has surveyed in detail, the archaeology and sediments of the Essex river esturaries. Over much of the area, an old land surface on which later prehistoric activity took place, was drowned by rising sea level which deposited estuarine clays. This paper gives the results of a pollen study of 5 soil, peat and sediment sequences found in the Blackwater and Crouch river estuaries. These analyses have shown that a mixed deciduous woodland dominated the terrestrial areas of the Hullbridge Basin. This comprised Quercus, Tilia and Corylus. Other arboreal elements were also present (Ulmus, Fraxinus, Fagus). Little evidence for anthropogenic disturbance has been noted. Changes from dry land to brackish water/estuarine conditions are evidenced in the pollen record at all of the sites analysed.

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CONTENTS

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1.a. INTRODUCTION

A preliminary field survey of the East Essex coastline was carried out in 1982 by P. Murphy (Centre for East Anglian Studies, University of East Anglia) and Dr T.J. Wilkinson (Essex Archaeological Unit, Essex County Council, Chelmsford). Subsequently, further annual surveys of the River Crouch and River Blackwater estuaries have recorded in detail the various lithostratigraphical and biostratigraphical units and the archaeological sites discovered. During this survey, a multi-disciplinary approach was adopted. Environmental studies have included the faunal remains, plant macrofossils, diatoms, soil, sediments and radiocarbon dating. Excavations of a number of archaeological sites have also been carried out in response to the continuing erosion of areas lying below high water mark in the River Crouch and Blackwater estuaries. The most important of these is the Neolithic site located at the Stumble (NGR TL 9014 0725) on the Blackater estuary close to Osea Island. Accounts of these surveys and excavations are given in Murphy 1983; Murphy and Wilkinson 1982;

Wilkinson and Murphy 1982,1985, 1986, 1987 and Wilkinson *et al.*1983,1984.

1.b. POLLEN ANALYSIS

Pollen analyses have been carried out on a number of the minerogenic and biogenic deposits located by Murphy and Wilkinson in their survey of the Crouch and Blackwater estuaries. These sediments comprise largely freshwater, brackish water and marine clay/silts and peaty clays and peats. The aims of this pollen study can be summarised as follows;

i) To ascertain if pollen was present in the range of sediments found at these sites.

ii) If pollen was found, to provide data on the character of the vegetation of this region and especially during the principal periods of archaeological activity.

iii) Because there is strong evidence for eustatic changes in these Essex basins, it is hoped that the results of pollen analysis and radiocarbon dating will allow the construction of a date/sea level change curve. This would provide a framework within which future archaeological and palaeoecological studies can be placed.

iv) To produce a palaeogeographical map of this region including its associated vegetation.

This study is being carried out in two phases. In this, the first phase (and report), attention is concentrated on points (i) and (ii)

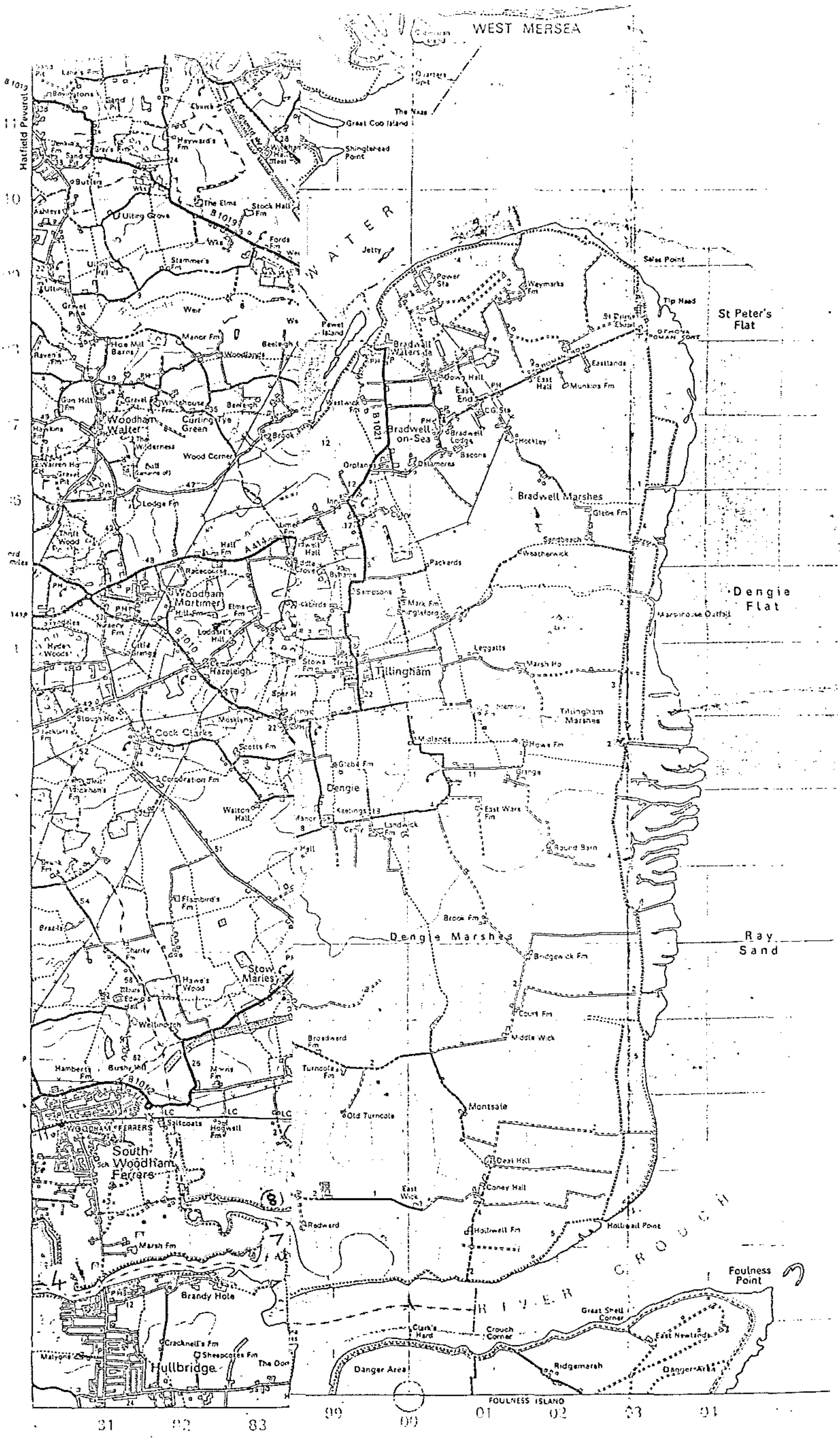

WEST MERSEA
St Peter's Flat
Dengie Flat
Ray Sand
Foulness Point
Bradwell-on-Sea
Tillingham
Dengie
Dengie Marshes
Bradwell Marshes
Woodham Walter
Woodham Mortimer
Hazeleigh
Cock Clarks
Stow Maries
South Woodham Ferrers
Hullbridge
RIVER CROUCH
Danger Area
FOULNESS ISLAND
81
82
83
99
00
01
02
03
04

FIG. 1

above. The results of this are presented here. Phase two will address the wider problem of sea level change and its effect on the Essex estuary systems and which will be reported and published at a later date when all archaeological data, radiocarbon assays and ordnance datum information is collated (Murphy and Wilkinson forthcoming).

1.c. METHODOLOGY

Samples for pollen analysis were obtained directly from open coastal sections, sections exposed in trenches dug in foreshore localities and core samples. The locality of the sites from which pollen data have been forthcoming is shown in figure 1. Because of the high minerogenic content of the various sediment types which were analysed, pollen extraction techniques were necessarily rigorous. Standard pollen extraction techniques were used (Moore and Webb 1978) but with the addition of 'extra' treatments in hydrofluoric acid and micro-mesh sieving (10μ) for removal of the inorganic fraction. Pollen was found to be very variably preserved. At some sites and in some levels, no pollen was found (especially Crouch Site 9). Pollen diagrams have, however, been constructed from four principal sites; Blackwater sites 3, 18 and 28 and Crouch site 8. Average pollen counts of between 200 and 800 grains were made for each sample analysed. The results of these analyses are presented in pollen diagram form (figures 2-5). Pollen has ben calculated as a percentage of total pollen (TP) and spores as a percentage of total pollen plus spores. Each site which has been analysed is discussed here individually.

2. BLACKWATER SITE 3 (Maylandsea NGR TL9182 0427).

2.a. INTRODUCTION

At Blackwater site 3 (for location see figure 1), the sedimentary sequence comprises predominantly grey estuarine clays overlying a fibrous peat which rests on the underlying head deposit. Murphy (1985,45) has described the section (see Table 1 below).

Foreshore surface at c. -0.12 cm OD ie. c. -2.82 m below HWM.

0-50 cm Very soft light grey clay with some dark infilled burrows near top; faint reddish-brown mottling; merging boundary.

50-75 cm Very soft light brownish-grey clay with rare thin discontinuous horizontal organic lenses and laminations; woody rootlets; organic content increasing with depth, merging boundary.

75-100 cm Brown fibrous clayey peat with indeterminate monocotyledonous plant remains; some darker-brown patches and woody rootlets; sharp boundary.

100 cm+ Very firm light grey sandy silt with some small, rounded and sub-rounded flints. (head).

From Wilkinson and Murphy 1986a,45.

TABLE 1; Blackwater Site 3; Stratigraphy.

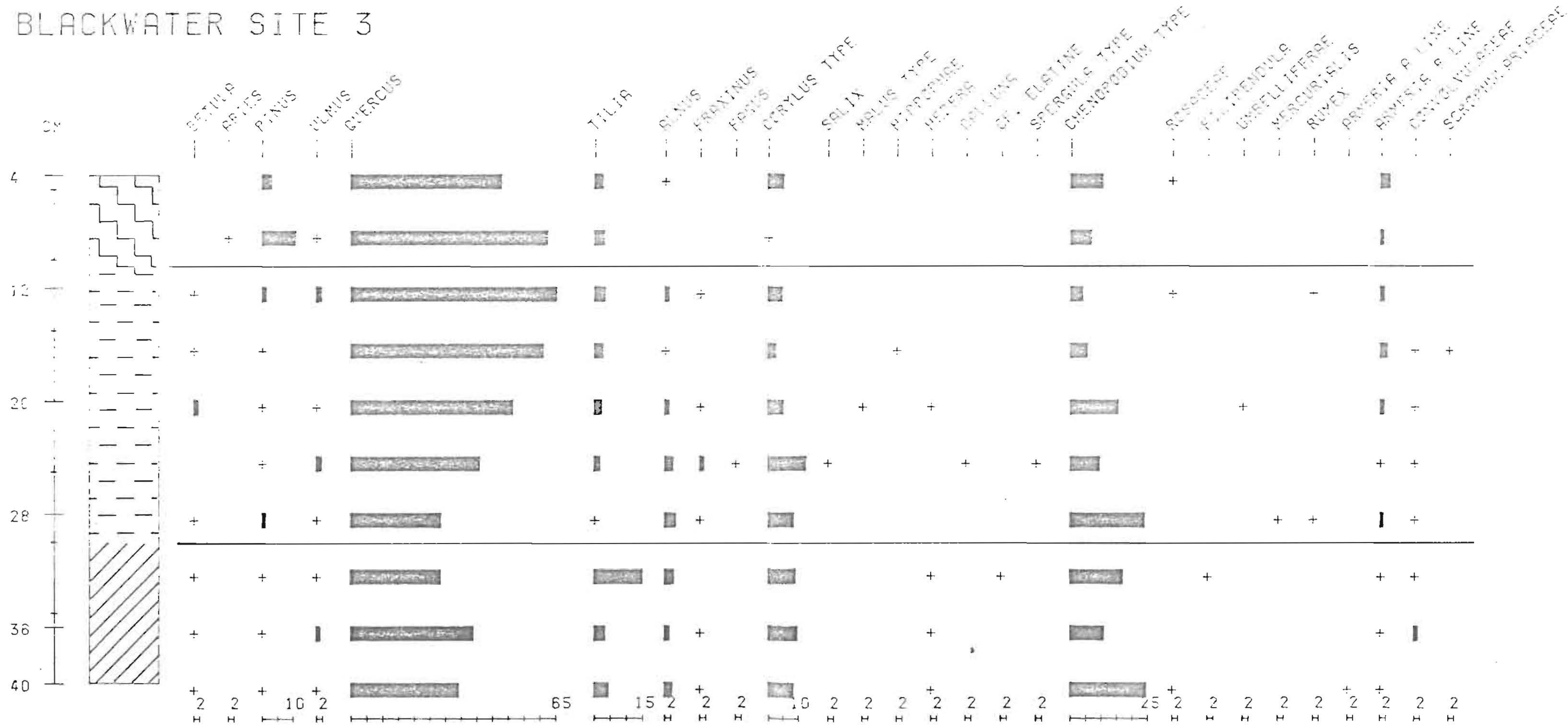
On the lower foreshore, at least one in situ stool of Quercus was found rooted into the underlying head (oak stool 41). This has been radiocarbon dated at 4190+/- 80 bp (HAR-6623). In 1986, another trench was dug in the foreshore to take samples for pollen analysis. The stratigraphy is the same as noted above and was found to contain well preserved pollen. Counts were made and pollen diagrams constructed (figure 2).

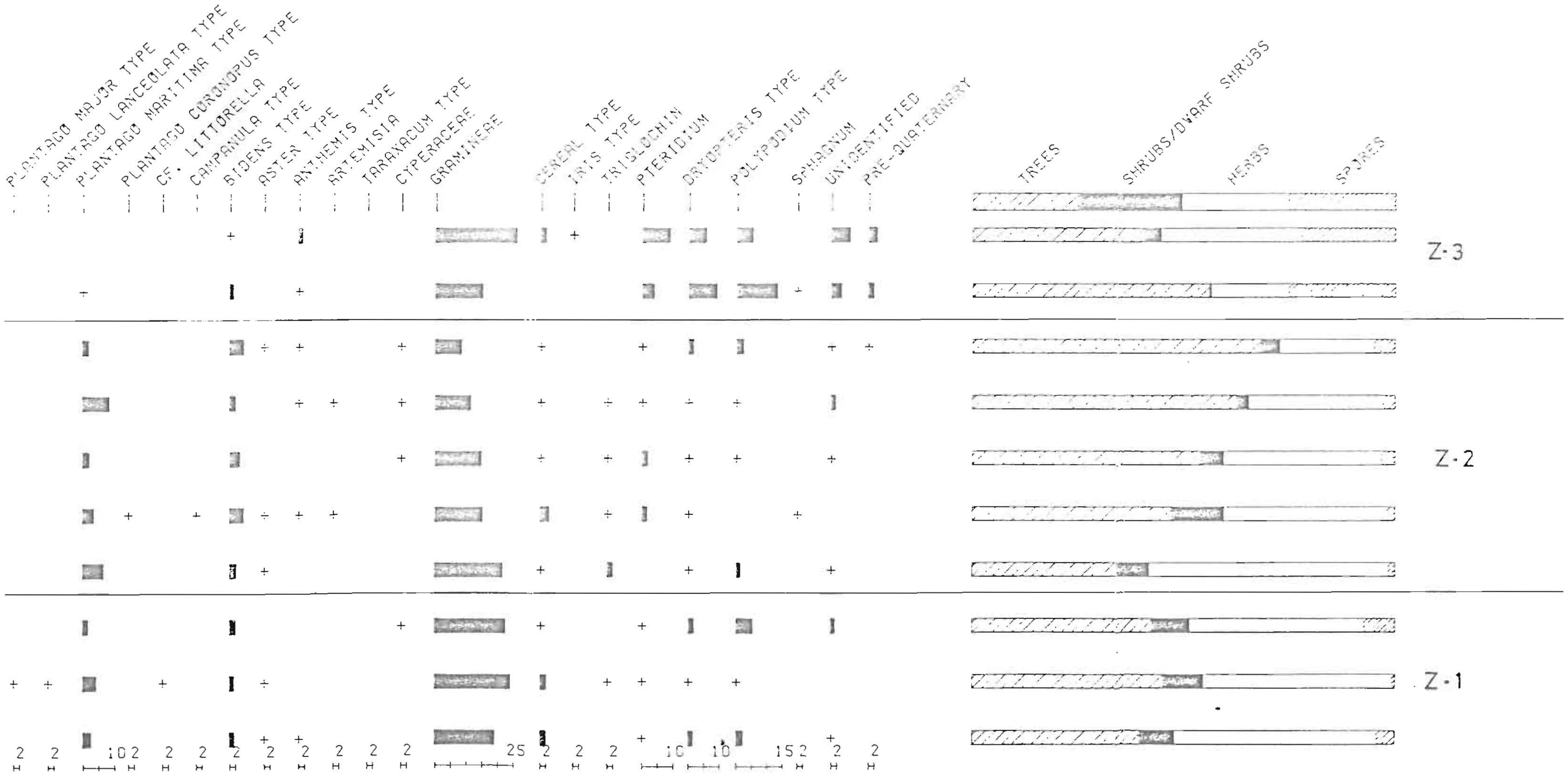
2.b. POLLEN ZONATION

Three pollen zones have been recognised and are briefly described;

Pollen Zone 1; 40-32 cm. This pollen zone spans the transition from the old land surface into fen peat deposits. This pollen zone is delimited by the relatively higher values of _Tilia_ (to 15% TP) than in the subsequent zones. Overall, the zone is characterised by dominant _Quercus_ (to 40% TP), _Corylus_ type (10% TP), _Chenopodium_ type (to 25% TP) and Gramineae (to 23% TP). Other than _Quercus_ and _Tilia_, tree pollen are poorly represented with only low frequencies of Alnus and sporadic occurrences of _Betula_, _Pinus_ and _Ulmus_. Herb types are dominated by Gramineae but with the notable presence of _Plantago maritima_ type, _Bidens_ type and a small number of large Gramineae pollen grains. The latter are more than 45 μ in size and thus fall within the Cereal

BLACKWATER SITE 3




PLANTAGO MAJOR TYPE
PLANTAGO LANCEOLATA TYPE
PLANTAGO MARITIMA TYPE
PLANTAGO CORONOPUS TYPE
CF. LITTORELLA
CAMPANULA TYPE
BIDENS TYPE
ASTER TYPE
ANTHEMIS TYPE
ARTEMISIA
TARAXACUM TYPE
CYPERACEAE
GRAMINEAE
CEREAL TYPE
IRIS TYPE
TRIGLOCHIN
PTERIDIUM
DRYOPTERIS TYPE
POLYPODIUM TYPE
SPHAGNUM
UNIDENTIFIED
PRE-QUATERNARY
TREES
SHRUBS/DWARF SHRUBS
HERBS
SPORES
Z-3
Z-2
Z-1

type category. However, these grains may represent halophytic genera/species which have larger diameter pollen grains (eg Elymus). This is in accord with the other halophytic taxa present in the spectrum (Plantago maritima and Armeria).

Pollen Zone 2; 32-10 cm. This zone spans the main body of peat. Tilia percentages decline from zone 1. Quercus, Corylus type, Chenopodium type, Plantago maritima, Bidens type and Gramineae remain the dominant pollen taxa throughout this zone. The percentage of Quercus (total pollen) increases throughout the zone and attains its highest values in this pollen diagram at the top of the zone (12 cm). Conversely, Alnus, Corylus type, Chenopodium type, Plantago maritima type and Gramineae decline. It can also be noted that halophytic elements are represented by Armeria 'B' line, Triglochin and Plantago maritima type. Chenopodium type, noted above, is also characteristic of near marine environments (see discussion below).

Pollen Zone 3; 10-4cm. This pollen zone extends into the grey marine silts which overlie the peats of pollen zone 2. The zone is characterised by higher values of Pinus (to 10% TP), increasing values of Gramineae and the spores of Pteridium, Dryopteris type, Polypodium and derived pre-Quaternary spores. Overall, the zone is again dominated by Quercus. This shows some decline but which may be in part a statistical response to the increases of other taxa noted within the sum.

2.c. DISCUSSION

This pollen sequence shows the transition from dry land through a peat forming environment to marine conditions.

Pollen zone 1 shows that the environment was dominated by Quercus, Tilia and Corylus woodland. Although Tilia percentages are relatively low in comparison to Quercus, the former is insect pollinated and produces only relatively small numbers of pollen grains. Being entomophilous, their dispersion characteristics are poor and are thus usually underrepresented in pollen spectra/diagrams. It is likely that lime was an important constituent of the local flora perhaps dominant or co-dominant with oak. The pollen evidence does, however, indicate that a marine influence was close by. The high percentages of Chenopodiaceae and the presence of Plantago maritima, Armeria and Gramineae suggest the existance of maritime plant communities perhaps including grass swards and mud-flats (see below).

In pollen zone 2, it is apparent that a peat forming community began to develop, characterised by monocotyledonous humic detritus deposits. This was possibly initiated by rising water tables in response to positive eustatic changes. With rising sea levels these peat-forming communities were transgressed by marine/brackish water conditions which gave rise to the sediments overlying these peat deposts. In pollen zone 2, the vegetation remained dominated by Quercus, Tilia and Corylus. The decline in Tilia noted in this zone is likely to represent the unsuitability of on-site conditions for its growth and thus its reduced pollen input to these peat deposits. The impending incursion by marine conditions is evidenced by the relative increase in halophytic elements. These include Plantago maritima, Armeria, Triglochin, Hippophae and other taxa typical of near shore sandy environments (eg Plantago coronopus).

Pollen zone 3 represents the lowest part of marine sediments in which the pollen is most probably derived from sediment inwash by rivers into an estuarine sedimentary environment. Consequently, the high values of spores (Pteridium, Dryopteris type, and Polypodium) are microfossil elements which may be attributed to the effects of differential preservation. It is likely that pollen grains with less robust exines would have been destroyed during fluvial transport. The allochthonous nature of this pollen spectrum is also indicated by the increase in pre-Quaternary (Cretaceous ?) spores which were similarly derived from erosion of the local lithology. Pinus values (up to 10% TP) are similarly typical of pollen spectra from marine sequences. The saccate pollen grains of most conifers are especially suited to long distance transport in marine or freshwater environments.

Macrofossil analyses of these peaty clays by Peter Murphy show a comparable range of maritime halophytic vegetation elements. These include Suaeda maritima, Spergularia, Triglochin maritima and Armeria which are also present in the pollen record, thus indicating the local nature of their growth. Murphy has also recorded large numbers of Salicornia seeds and it is highly probable that the high percentage values of Chenopodium type pollen are referable to this genus. He found that an important vegetation component at this site was Juncus (Murphy 1986a, 52). Pollen of this taxon is never preserved in fossil form and as such, there is no pollen record which is comparable to the plant macrofossil record.

2.d. CONCLUSION

The pollen sequence obtained from Blackwater site 3 shows an environment dominated by Quercus, Tilia and Corylus woodland. Nearby marine influences were in evidence even in the old land surface and overlying peat deposits. As peat accumulation (caused by positive eustatic movements) took place, Tilia growth occurred further away. The relatively better production and dispersion of Quercus pollen resulted in the consistent presence of Quercus at high values throughout the pollen sequence. This attests to the continued importance of woodland on adjacent areas of land.

3. BLACKWATER SITE 18 (NGR TL942082)

3.a. INTRODUCTION

Samples for pollen analysis were obtained from an open section found along the edge of a drainage ditch. Samples were taken from below the old land surface (see Table 2) throughout a peat deposit some 18 cm thick and into grey marine silts which overlie the peat. These three lithostratigraphic divisions correspond with three principal pollen zones recognised in the pollen diagram (fig. 3).

Section C level at 0=2.29 m below HWM

0-5 cm Slightly firm grey clay with common brown rootlets and other plant material; merging boundary.

5-17 cm Soft light grey clay with rare very small black and yellowish-brown mottles; some plant material; sharp boundary.

17-18 cm Band of plant debris associated with 3 cm diameter horizontal piece of unworked roundwood (context 92); sharp boundary.

130+ cm Greyish brown clayey peat with some fibrous plant material

From Wilkinson and Murphy 1986a,55.

NB. Pollen samples were obtained in a separate pit dug on the foreshore. The stratigraphy was essentially the same as noted in this description. However, the peaty clay sequence extended down into firm grey clayey silt.

TABLE 2; Blackwater site 18; Stratigraphy

3.b. POLLEN ZONATION

These pollen zones are described briefly;

Pollen Zone 1; 40-30 cm. This pollen zone includes the old land surface at 26 cm which was developed in earlier grey marine silts. Palynologically the zone is characterised by dominant Quercus (33% TP), Tilia (to 28% TP) and Corylus type (to 26% TP) in the tree and shrub category. Pinus is also present (to 7% TP). Chenopodium type (25% TP) and Gramineae are dominant in the herbaceous group. Plantago lanceolata, P. coronopus, P. maritima, Bidens type and Artemisia peak at the top of the old land surface/this pollen zone. Spores are dominated by Dryopteris type, Pteridium, and Polypodium. Tilia and Corylus percentages peak in the middle of the zone. Chenopodium type declines from the base.

Pollen Zone 2; 26-8 cm. This pollen zone corresponds with the peat deposits and is characterised by Quercus, Chenopodium type, Plantago lanceolata, P. maritima, Bidens type and Gramineae. Tilia and Corylus pollen percentages are less than in pollen zone 1.

BLACKWATER SITE 18

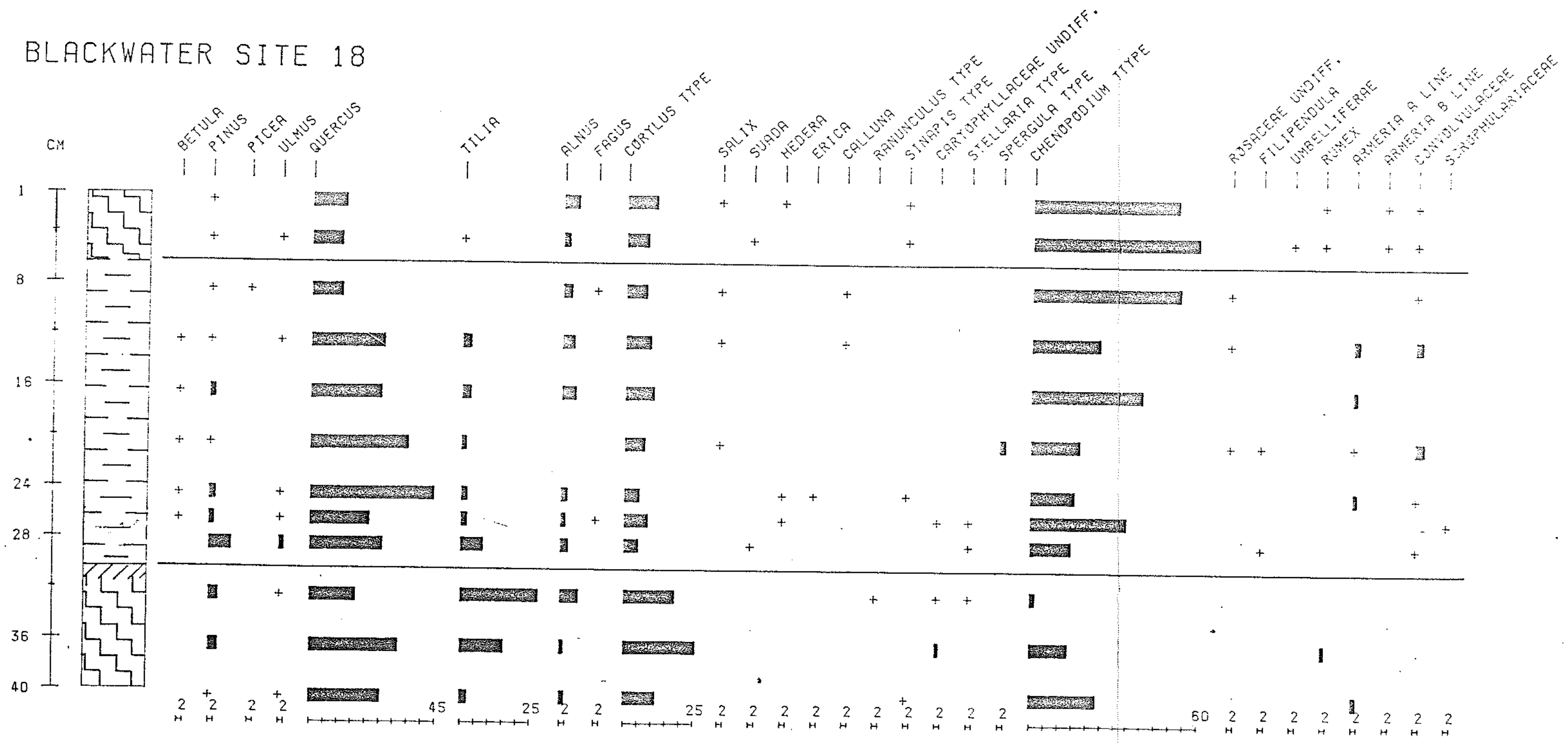


FIG. 3.

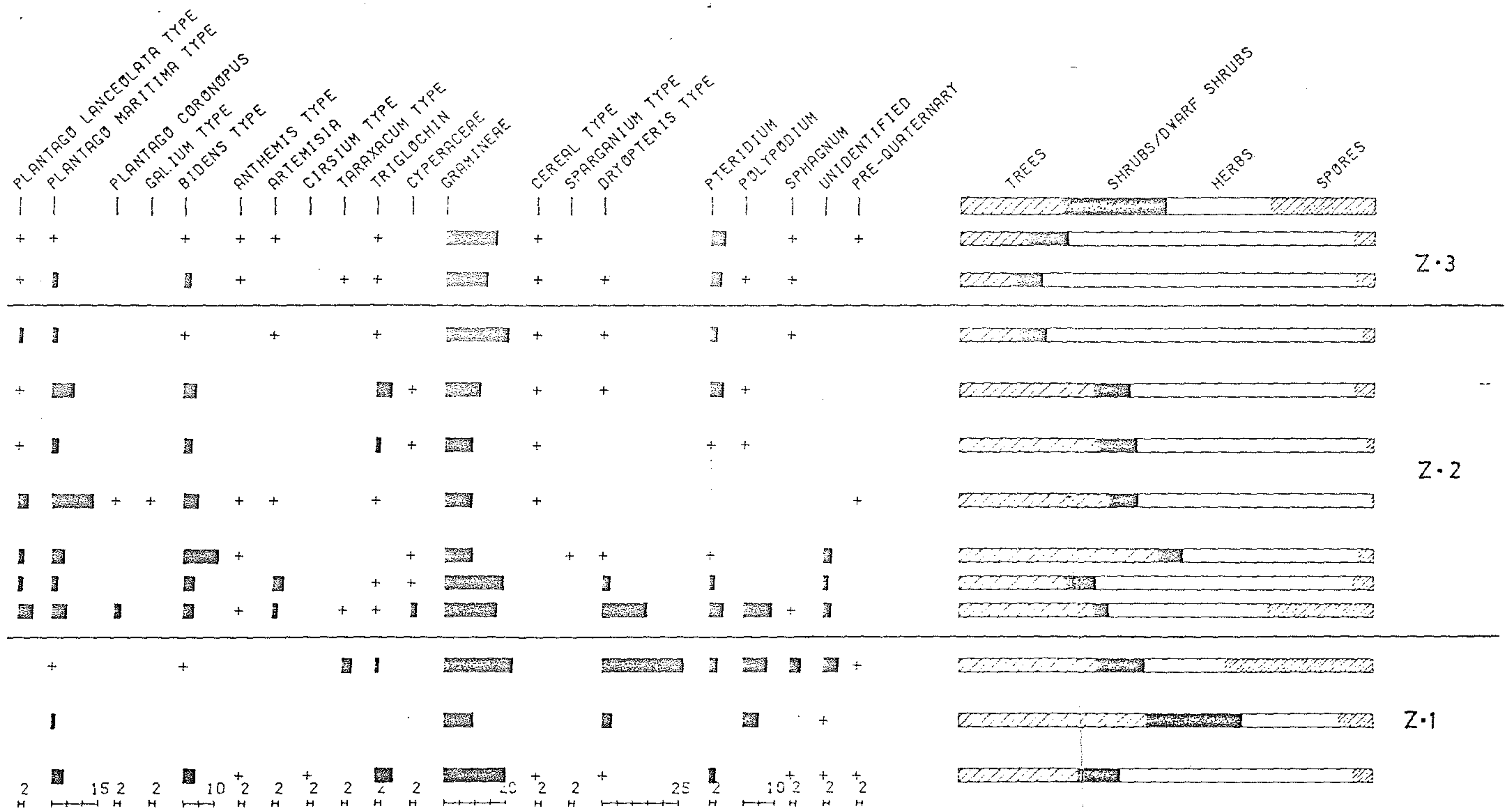

PLANTAGO LANCEOLATA TYPE
PLANTAGO MARITIMA TYPE
PLANTAGO CORONOPUS
GALIUM TYPE
BIDENS TYPE
ANTHEMIS TYPE
ARTEMISIA
CIRSIUM TYPE
TARAXACUM TYPE
TRIGLOCHIN
CYPERACEAE
GRAMINEAE
CEREAL TYPE
SPARGANIUM TYPE
DRYOPTERIS TYPE
PTERIDIUM
POLYPODIUM
SPHAGNUM
UNIDENTIFIED
PRE-QUATERNARY
TREES
SHRUBS/DWARF SHRUBS
HERBS
SPORES
Z·3
Z·2
Z·1

FIG. 3. CONT.

Pollen Zone 3; 8-0 cm. This zone corresponds with the change to grey marine silts. The pollen spectra are dominated by *Chenopodium* type (to 60% TP) and Gramineae (20% TP). Percentages of *Quercus* decline from pollen zone 2. *Corylus* type and *Alnus* are also present.

3.c. DISCUSSION

The top of an old land surface (of Neolithic date) lies at 26 cm in this profile. This soil developed in a marine/estuarine sediment sequence. Consequently, two different pollen spectra are superimposed and comprise a halophytic element and a woodland spectrum. The latter represents vegetation development on the forming soils. As with Blackwater 3, this was dominated by *Quercus*, *Tilia* and *Corylus* woodland. Here, however, *Tilia* percentages are substantially higher attaining 25% of total pollen. As noted above, *Tilia* is underrepresented in pollen spectra because of its diminutive pollen production and insect dispersal characteristics. Although the pollen of *Tilia* was in many cases degraded, (perhaps indicating some differential destruction), it is likely that *Tilia* locally formed the dominant woodland on these soils. However, the sharp decline of *Tilia* in the upper part of the buried soil is thought to be due to human interference. This is consistent with the presence of a Neolithic settlement within 200 metres of this site. The charcoal noted above similarly testifies to anthropogenic disturbance. *Quercus* was also important, perhaps growing in conjunction with *Corylus* and *Tilia*.

Wilkinson and Murphy (1986a,59) have identified the remains of oak trees rooted on the head surface and which have been dated at c.2000 bc. This provides a date for the old land surface which was subsequently sealed by estuarine deposits. In these soils, there is a strong maritime/halophytic element which is somewhat unusual. This flora includes *Plantago maritima* type and *Chenopodium* type as the main elements. It is known (Murphy pers. comm.) that at the time of this soil formation, the high water mark was 0.5 km distant. The presence of these halophytic taxa perhaps attests to their being anemophilous and relatively high pollen producers (NB. there is a possibility that the *Chenopodium* type pollen may in fact derive from terrestrial *Chenopodium* or *Atroplex* species and not halophytic genera).

The peaty clays which overly the old land surface were formed in salt marsh/estuarine mud-flat conditions. Diatom analyses by Dr S Juggins (Wilkinson and Murphy 1986a,62) confirm the conclusions of plant macrofossil analyses by Murphy (Wilkinson and Murphy 1986a) and the pollen data presented here, that these peaty clays were not formed in freshwater conditions. These strongly estuarine deposits reflect a transgressive sequence from marsh to bare intertidal mud flat. Pollen zone 2 is dominated by pollen of plants which are typical of higher salt marsh environments with areas of drier (?grassland sward communities) land present. This is typified by pollen of *Plantago lanceolata*, *P. coronopus*, Gramineae and possibly *Triglochin* and *Armeria*.

In pollen zone 3, intertidal mudflat conditions prevailed, laying down the more or less inorganic estuarine clay which overlies the peaty clay deposit of pollen zone 2. Pollen taxa within this zone reflect the change to open mudflat conditions. Those taxa noted above decline and Chenopodium type becomes dominant. This undoubtedly reflects that conditions were ideal for the growth of Salicornia.

During these marine estuarine conditions, the pollen record of terrestrial vegetation remains, albeit with relatively lower pollen percentages than recorded for the old land surface. This might be expected because pollen sources (tree, shrub and herbs) of terrestrial plants would have been at a greater distance away from the sample site. From this terrestrial element, it can again be shown that the regional vegetation comprised Quercus and Corylus woodland. Although Tilia declined in the levels of the old land surface, it was not ousted completely and continued to be present throughout most of the peaty clay sequence (pollen zone 2). With the exception of a single occurrence, at 4 cm, Tilia is absent in pollen zone 3. It is not possible to state clearly if this reduction represents a real decline in the staus of Tilia, or, as seems more likely, that its pollen was not being dispersed over greater distances.

3.d. CONCLUSION

At Blackwater 18, there is preserved a valuable pollen record for the vegetation growing upon the old land surface at c. 2000 bc. The dominant vegetation comprised Quercus, Tilia and Corylus woodland. Tilia was perhaps of greater importance, at least in the local area. This may have been subjected to anthropogenic pressure from Neolithic activities. The site became subject to marine influences, giving rise to a higher salt marsh community dominated by typical halophytic taxa. With further marine estuarine transgression, this peat forming community gave way to open tidal mudflats, the vegetation of which comprised largely Salicornia (from macrofossil identifications). The continuing sedimentary record also contains some elements of the regional vegetation whose pollen was probably derived in sediments transported from the river catchment into the estuarine sedimentary environment. This woodland comprised largely Quercus and hazel woodland with perhaps, some Tilia.

4 BLACKWATER SITE 28; THE STUMBLE. NGR TL 90140725

4.a. INTRODUCTION

Site 28 in the area known as the Stumble (see figure 1) lies on the North bank of the Blackwater estuary close to Osea Island (NGR TL 90140725). The area has been extensively surveyed by Wilkinson and Murphy (1985,1986,1987) and found to be archaeologically rich. The area has produced surface scatters of Neolithic struck flints, heat shattered flints and flint tempered pottery. Importantly, a substantial number of well preserved wooden structures including hurdles and brushwood structures have also been discovered and excavated (Wilkinson and Murphy 1988). It is thought that the excavated hurdle functioned as a trackway which crossed a small creek or depression within the old land surface. This land surface and features have become exposed by serious erosion especially in the mid-tidal zone. The overlying marine clays have been removed exposing archaeological features resting on this old land surface. Rescue excavations were thus warranted. This area of old land surface is extensive in the Stumble area (being some 100 m east to west) and is developed on underlying head deposits. Resting intact on this surface is a thin humified (lower) peat deposit. This peat deposit is of variable thickness being of greater extent lower down in the intertidal zone where it reaches a maximum thickness of 15 cm

(Wilkinson and Murphy 1985, 27). Higher in the inter-tidal zone, the peat is absent and the old land surface is overlain by grey estuarine clay.

A small, residual patch of eroded salt marsh which contained all of the above mentioned contexts was sampled for pollen and by Murphy for plant macro-fossil remains and Juggins for diatoms. The stratigraphy of this section has been described by Murphy (Wilkinson and Murphy 1986b,66). The section shows almost 80 cm of clays sealing the clayey peat deposits (the lower peat) which in turn rest on the old land surface and head deposits. The section is described as follows (Table 3).

Surviving surface at +0.82 m OD

0-9 cm Soft reddish clay with abundant Spartina rhizomes; sharp boundary.

9-48 cm Soft grey clay; some Spartina roots + rhizomes; small black mottles; merging boundary.

48-76 cm Similar but with larger, more prominant black mottles; merging boundary.

76-83 cm Similar but with fragments of eroded peaty clay; matrix sklightly lighter grey clay; moderately sharp boundary.

83-105 cm Soft brown peaty clay; sharp boundary.

105 cm+ Pale grey slightly firm silty clay loam; rare flint pebbles ("head")

From Wilkinson and Murphy 1987,66.

TABLE 3; Blackwater Site 28; Stratigraphy.

Samples for pollen analysis were taken from a depth of 40 cm downwards, that is , from below the levels where Spartina rootlets and disturbance were prevalent. Samples were prepared at 4 cm intervals to a depth of 108 cm. Preservation of pollen and spores was found to be extremely variable throughout the sequence and which perhaps reflects the relatively dry upper tidal mudflat conditions in which these sediments are thought to have accumulated. It was found that pollen was only preserved in the inorganic sediments of the estuarine clay overlying the peats and from a single sample obtained from the old land surface underlying the lower peat. Pollen was absent in the peaty clay deposits (lower peat) occurring between 82 cm and 100 cm. A single level (88 cm) contained only a small quantity of pollen and spores of taxa usually regarded as being resistant to decay. Thus, this single spectrum at 88 cm can only be regarded as having suffered extreme differential decay. It is unfortunate that the peat sequence does not contain pollen and in this respect it is similar to peat sites analysed from the River Crouch estuary. With increased waterlogging/perhaps higher ground water tables caused by positive eustatic movements, conditions more suited to pollen preservation prevailed. Pollen has been preserved sporadically in a number of levels in the estuarine clays.

BLACKWATER SITE 28

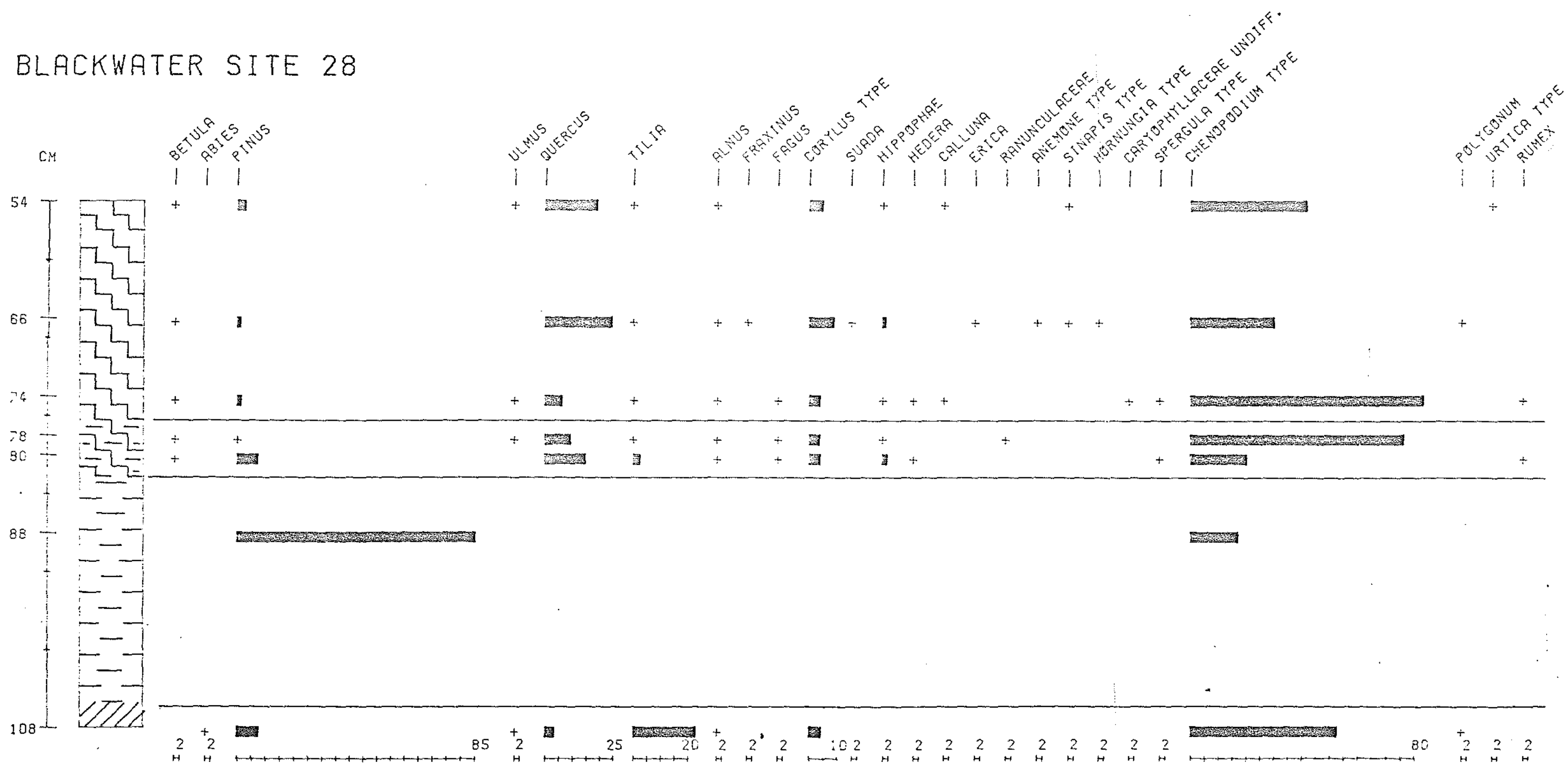


Fig. 4.

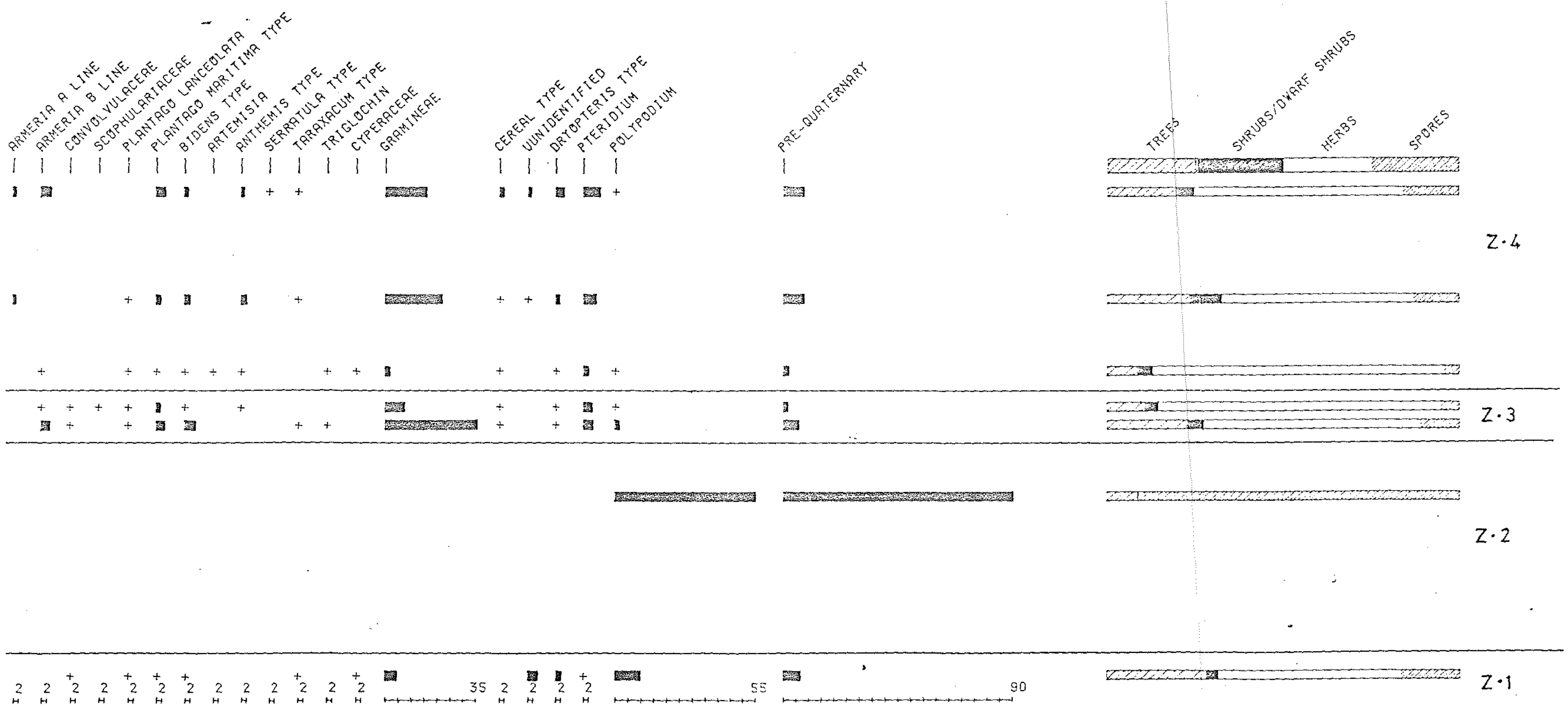

ARMERIA A LINE
ARMERIA B LINE
CONVOLVULACEAE
SCOPHULARIACEAE
PLANTAGO LANCEOLATA
PLANTAGO MARITIMA TYPE
BIDENS TYPE
ARTEMISIA
ANTHEMIS TYPE
SERRATULA TYPE
TARAXACUM TYPE
TRIGLOCHIN
CYPERACEAE
GRAMINEAE
CEREAL TYPE
UUNIDENTIFIED
DRYOPTERIS TYPE
PTERIDIUM
POLYPODIUM
PRE_QUATERNARY
TREES
SHRUBS/DWARF SHRUBS
HERBS
SPORES
Z·4
Z·3
Z·2
Z·1
35
55
90

FIG. 4. CONT.

4.b. POLLEN ZONATION

The pollen spectra recovered from this section can be discussed in 4 sections. These are described briefly;

1) 108 cm. A single sample represents the old land surface discussed above and which is developed in the basal head deposits. This is perhaps the most useful pollen data from this sequence because they are broadly contemporaneous with the Neolithic archaeology of the Stumble. As such, they provide evidence of the vegetation of the area at this time.

The arboreal pollen is dominated by *Tilia* which comprises 20% of total pollen. Relatively small quantities of *Pinus*, *Quercus* and *Corylus* are also present. However,these percentages are depressed in the pollen diagram (figure 4) by high values of *Chenopodium* type which form part of the total pollen sum. Table 4 gives the value of these taxa as a percentage of the arboreal pollen sum. It is clear from this that *Tilia* was the dominant tree with *Quercus* and *Corylus* of some importance. Although *Pinus* values are relatively high (22%AP) it is thought that these may be derived from the local Tertiary lithologies or from the resulting differential preservation of other pollen in favour of *Pinus*. In view of these possibilities it is difficult to postulate the presence of pine forest in the

CM	54	66	74	78	80	88	108
Betula	0.9	1.5	1.5	0.8	1.0		
Abies							1.3
Pinus	9.9	3.0	10.3	2.5	24.5	100	22.0
Ulmus	0.9		1.5	0.8			0.6
Quercus	68.6	68.3	47.8	60.3	49.0		9.3
Tilia	0.9	0.9	1.5	0.8			0.6
Alnus	3.0	0.9	4.4		3.1		1.3
Fraxinus		0.9					
Fagus			2.9	0.8	1.0		
Corylus	16.8	23.8	30.1	24.5	13.3		12.0

TABLE 4; Blackwater Site 28; tree pollen calculated as a percentage of total tree pollen (including Corylus type).

vicinity.

High percentages of Chenopodium type strongly indicate the presence of a maritime halophytic plant community and which compares strongly with the macrofossil investigation of Murphy (Wilkinson and Murphy 1986b,67). It is unfortunately not possible to identify the Chenopodium type category to species or even generic level because of uniform pollen morphology in the different genera. These high Chenopodiaceae values are, however, likely to represent Salicornia spp. whose seeds have frequently been noted in the analyses of Murphy.

2) 88 cm; This single anomalous level taken from within the brown peat is of little value. Pollen was extremely sparse and degraded and only a very limited pollen count of ** grains was made. This spectrum shows the effects of extreme differential preservation in favour of taxa with more robust exines (Pinus, Chenopodium type, and spores).

3) 78-82 cm; In this zone of transition from the lower peat to the overlying grey estuarine clay, pollen preservation was found to be substantially improved. It is possible that rising water-tables due to positive eustatic changes and/or the argillaceous character of the sediments resulted in less oxidation taking place. The 2 pollen levels are dominated by Chenopodium type, Gramineae and a range of herbs. Tilia

is less important than in level 1 (108 cm). Quercus, Corylus type and Pinus are also evident.

The pollen spectrum shows an increase in salt marsh (halophytic) elements which undoubtedly mark the initial phases of transition to marine estuarine conditions. Thus, Hippophae rhamnoides, Armeria 'B' line, Plantago maritima, Chenopodium type and Triglochin (maritima) are important. Other pollen taxa recorded may also include halophytic elements within their type categories. Bidens type, for example, is noted and may include Aster tripolium whose seeds have been found at a number of sites by Murphy (NB. Aster pollen is usually somewhat larger than Bidens type, but here, conditions of preservation and methods used to extract pollen from these sediments will have resulted in shrinkage).

Terrestrial vegetation , which by this time may have been at some distance from the site, continued to be dominated by Quercus and Tilia. The latter has poor production and dispersal characteristics which may have therefore resulted in lower pollen frequencies as conditions became locally unsuited to its growth.

4) 74 cm,68 cm, 54 cm; These three pollen levels were taken from the grey estuarine clay. As might be expected, these pollen spectra again show a dominant halophytic plant

community dominated by Chenopodium type (most probably Salicornia), Armeria/ Limonium, Plantago maritima and Gramineae. These data again correspond with the plant macrofossil studies carried out by Murphy (Wilkinson and Murphy 1986b). However, in addition to this typical estuarine/mud flat flora, Quercus, Corylus and a variety of spores are also present (including derived pre-Quaternary ?Tertiary elements). These undoubtedly represent fluvially transported pollen from the terrestrial river catchment. Although there is a likelihood that some of this derived pollen may be reworked from older sediments, it is also possible that the pollen reflects the vegetation of the landward areas at broadly the same time as sediment deposition. From this it is apparent that Tilia declines markedly in importance whereas Quercus and Corylus remain the principal tree and shrub taxa. It is not clear whether this decline in Tilia can be attributed to anthropogenic causation or to local environmental change brought about by rising sea levels.

4.c. CONCLUSION

A somewhat disparate set of pollen spectra has been obtained from the Stumble site. This reflects the poor preserving conditions at the site which was initially, according to Murphy, an upper salt marsh community. Pollen from the old land surface underlying the lower peaty clay suggests an environment in which Tilia dominated the local woodland, perhaps just inland from the prevailing upper salt marsh conditions which pertained on this site. The lower organic deposits at this site did not yield any pollen and it is thought that the conditions in which this peaty clay formed were perhaps subject to periods of desiccation and oxidising conditions. Following marine inundation and the accumulation of estuarine clay, pollen preserving conditions improved although they were not uniformly good. The pollen spectra from these sediments illustrate the increasing importance of halophytic vegetation (Chenopodium type, Plantago maritima etc.). The pollen record of terrestrial vegetation appears to show a decline in Tilia but with Quercus and Corylus maintaining their importance.

5. THE CROUCH ESTUARY

5.a. INTRODUCTION

An introduction to the Geomorphology and sites studied along the River Crouch estuary has been given by Murphy and Wilkinson (1983). Sediments found in this basin range from the basal London Clay (tertiary) overlain in places by head deposits, fluvial and fluvio-glacial deposits and brickearth. Holocene sediments include a complex of estuarine deposits of estuarine depoits, relict shell ridges and marine alluvium. An old land surface consisting of ground water gleyed soils of the Agney Series is developed on the fine silty estuarine alluvium. The estuarine alluvium is primarily a non-calcareous ground water gley mapped by the soil survey as the Wallasea Series (Sturdy 1976; Wilkinson et al. 1983). Two peat horizons are present in these silts; the Upper and Lower peats. Pollen analyses have been carried out on these two peat sequences at Crouch site 9 (the upper peat) and Crouch site 8 (the lower peat). The results of these analyses are as follows:

6. CROUCH SITE 9

6.a. INTRODUCTION

The site is at the confluence of Stow Creek and the River Crouch (TL 8401 9657; Figure 1). The stratigraphy has been described by Murphy and Wilkinson (1982) as follows (Table 5).

12) 2.50-1.25 m OD Grey clay. Estuarine

7) 1.25-1.06 m OD Reed/monocot peat above pale grey silty clay. (1.06 m OD) containing drifted plant remains. Peat sampled for radiocarbon dating, and monolith taken for lower interface with grey clay.

9) 1.06 to -0.31 m OD Grey clay with localised evidence of slumped blocks of clay surrounded by drifted plant material. At 0.17 to 0.22 m OD a line of the molluscs Scrobicularia was present in the growth position.

11) -0.25 to -0.31 m OD Exposures B and A respectively. A 1 cm thick layer of small fragments of bright red fired clay (less than 5 mm) in very dark grey (10YR 3/1) clay loam matrix with fine charcoal flecks.

13) below -0.31 m OD Grey estuarine clay.

From Murphy and Wilkinson 1982,18.

TABLE 5; Crouch Site 9; Stratigraphy.

The sequence is one of dominantly estuarine clays deposited in an intertidal regime at the edge of an eroding creek bank (Murphy and Wilkinson 1982,18). This is evidence by drifted plant material and

TREES	
Pinus	1.0
Quercus	2.5
SHRUBS	
Corylus type	6.0
HERBS	
Spergula type	1.0
Chenopodium type	1.0
Bidens type	2.0
Anthemis type	0.5
Taraxacum type	8.5
Cyperaceae	0.5
Gramineae	76.5
Unidentified	8.5
SPORES	
Pteridium aquilinum	3.5
Polypodium	0.5

TABLE 7; Crouch Site 9; Pollen data.

collapsed blocks. The peat sequence analysed for pollen comprises monocotyledonous peat (7 above) which covers a wide area and is of Roman date.

6.b. POLLEN ANALYSIS

Pollen was absent or very badly preserved in these peats which perhaps indicates oxidising conditions caused by drying out of the peat or throughflow of alkaline ground water. Pollen was, however, found sufficiently well preserved to enable pollen counts to be made. A count of 200 grains was made from a sample obtained from a depth of c. 1.4 m O.D. This pollen spectrum is given in Table 7.

The pollen spectrum is dominated by pollen of Gramineae (76% total pollen). Tree pollen are few with only a small representation of Quercus (2.5% total pollen), Pinus (1% total pollen) and Corylus type (6% total pollen). Herbs are dominated by Taraxacum type (8.5% total pollen). Other herbs include Spergula type, Chenopodium type, Anthemis type and Bidens type. The large number of unidentifiable pollen types attests to the poor pollen preservation at this site.

6.c. DISCUSSION

The high percentage of grass pollen undoubtedly reflects the primary peat forming vegetation (that is *Phragmites* and other grasses of a fen peat association) identified from the plant macrofossils. The relatively low arboreal pollen percentages may reflect the poor pollen preserving conditions and/or swamping by pollen of local origin. However, it is possible that these low values reflect an absence of tree growth in the local area. This might have resulted from late prehistoric or Roman deforestation.

7. CROUCH SITE 8

7.a. INTRODUCTION

This site contains a fine spread of submerged forest which is developed in the lower peat along the left (north) bank of Clementsgreen Creek and River Crouch (TL 8340 9653). Murphy and Wilkinson (1982,16) have surveyed an area of this submerged forest in detail. Sixteen trunks and ten tree stools were mapped and samples taken for identification. The stratigraphy of this section is as follows (Table 6).

1) Above −1.65 m OD Grey-greysish brown (2.5Y5/0 to 5/1) clay with occasional small fragments of wood peat. Estuarine clay, peat fragments a result of erosion.

2) −1.65 to −2.03 m OD Dark brown (7.5YR 3/2) peat. Woody above, monocot. in lower 10 cm. This is peat of submerged forest and its total thickness varies from 35–44 cm.

3) −2.03 to 2.36 m OD Grey clay as in 1 but penetrated by rhizomes of monocotyledons.

4) −2.36 to 2.73 m OD Vey dark grey silty clay (10YR3/1). Possibly a buried soil developed on 5 and 6 below.

5) −2.73 to 3.05 m OD Grey to dark grey (appears blue grey, 2.5YR 4.5/0) silty clay. Moderately firm. Possibly a reduced version of 6.

6) −3.05 to 3.33 m OD Dark grey brown (2.5Y 4/2) clay-silty clay. Very firm. Mottled and slightly oxidised. Probably London Clay head.

From Murphy and Wilkinson 1982,17.

TABLE 6; Crouch Site 8; Stratigraphy.

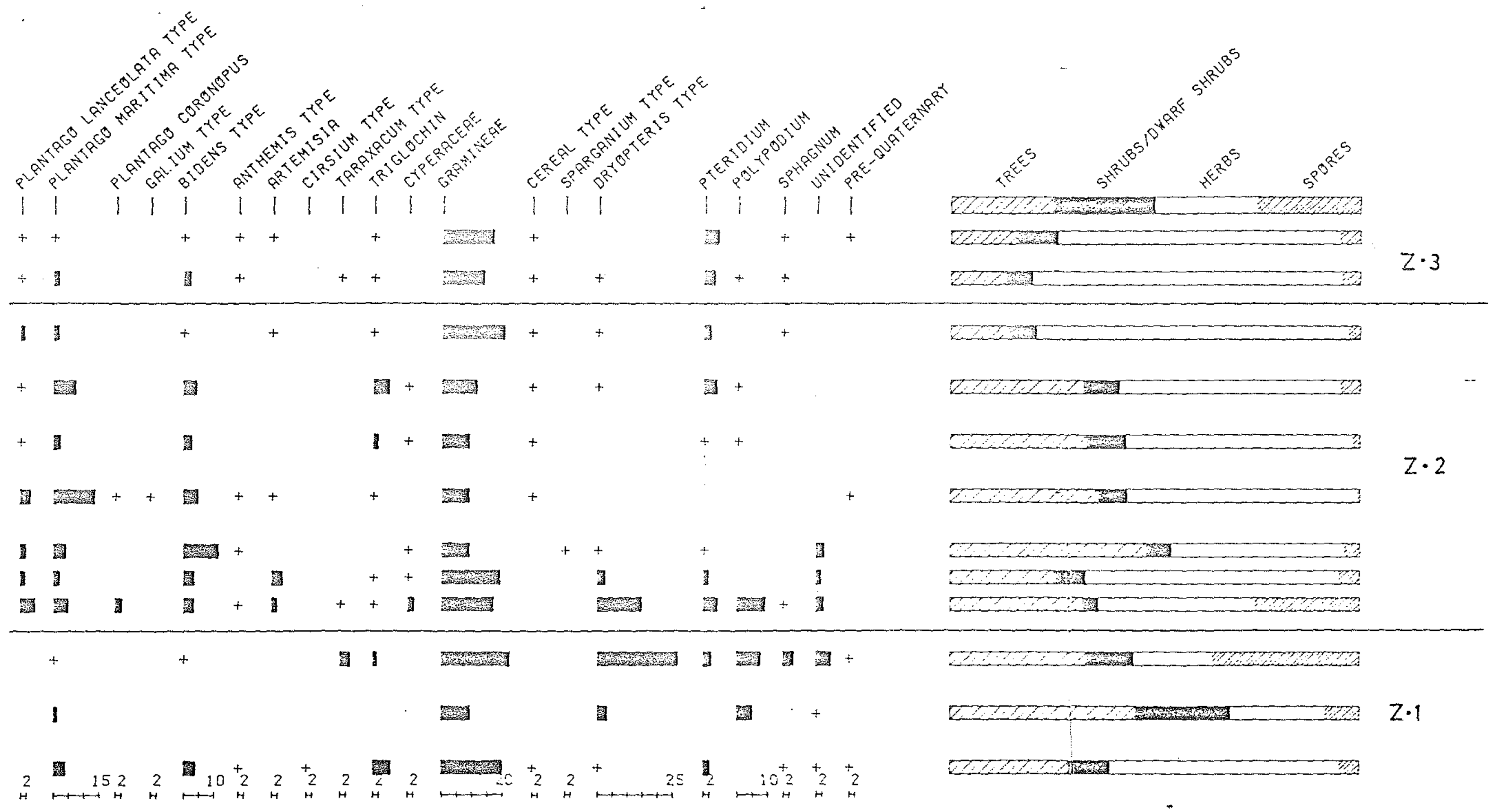
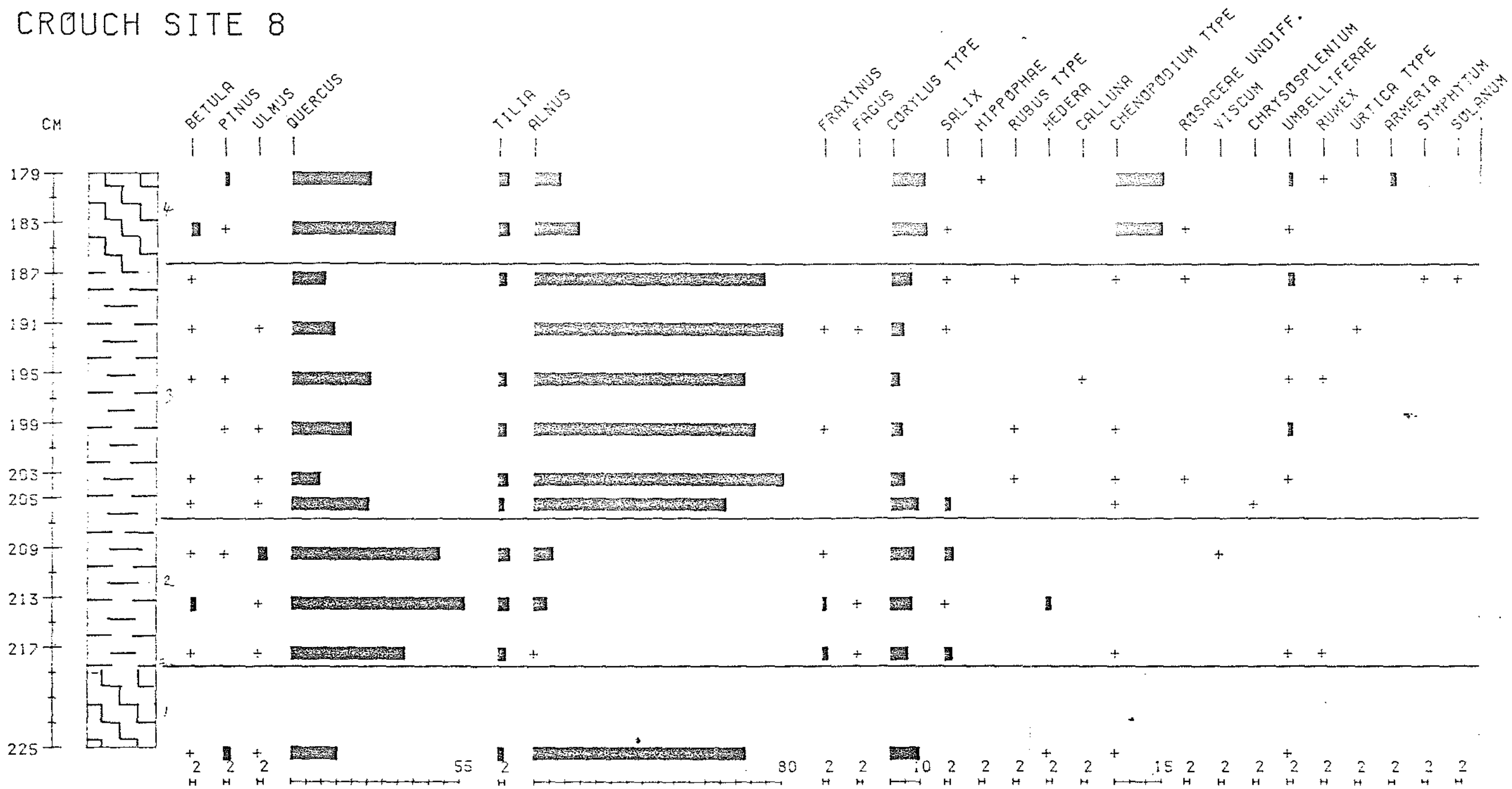

PLANTAGO LANCEOLATA TYPE
PLANTAGO MARITIMA TYPE
PLANTAGO CORONOPUS
GALIUM TYPE
BIDENS TYPE
ANTHEMIS TYPE
ARTEMISIA
CIRSIUM TYPE
TARAXACUM TYPE
TRIGLOCHIN
CYPERACEAE
GRAMINEAE
CEREAL TYPE
SPARGANIUM TYPE
DRYOPTERIS TYPE
PTERIDIUM
POLYPODIUM
SPHAGNUM
UNIDENTIFIED
PRE-QUATERNARY
TREES
SHRUBS/DWARF SHRUBS
HERBS
SPORES
Z·3
Z·2
Z·1

FIG. 3. CONT.



CRØUCH SITE 8
CM
BETULA
PINUS
ULMUS
QUERCUS
TILIA
ALNUS
FRAXINUS
FAGUS
CORYLUS TYPE
SALIX
HIPPOPHAE
RUBUS TYPE
HEDERA
CALLUNA
CHENOPODIUM TYPE
RØSACEAE UNDIFF.
VISCUM
CHRYSØSPLENIUM
UMBELLIFERAE
RUMEX
URTICA TYPE
ARMERIA
SYMPHYTUM
SOLANUM
179
183
187
191
195
199
203
205
209
213
217
225
55
80
10
15

Fig. 5.

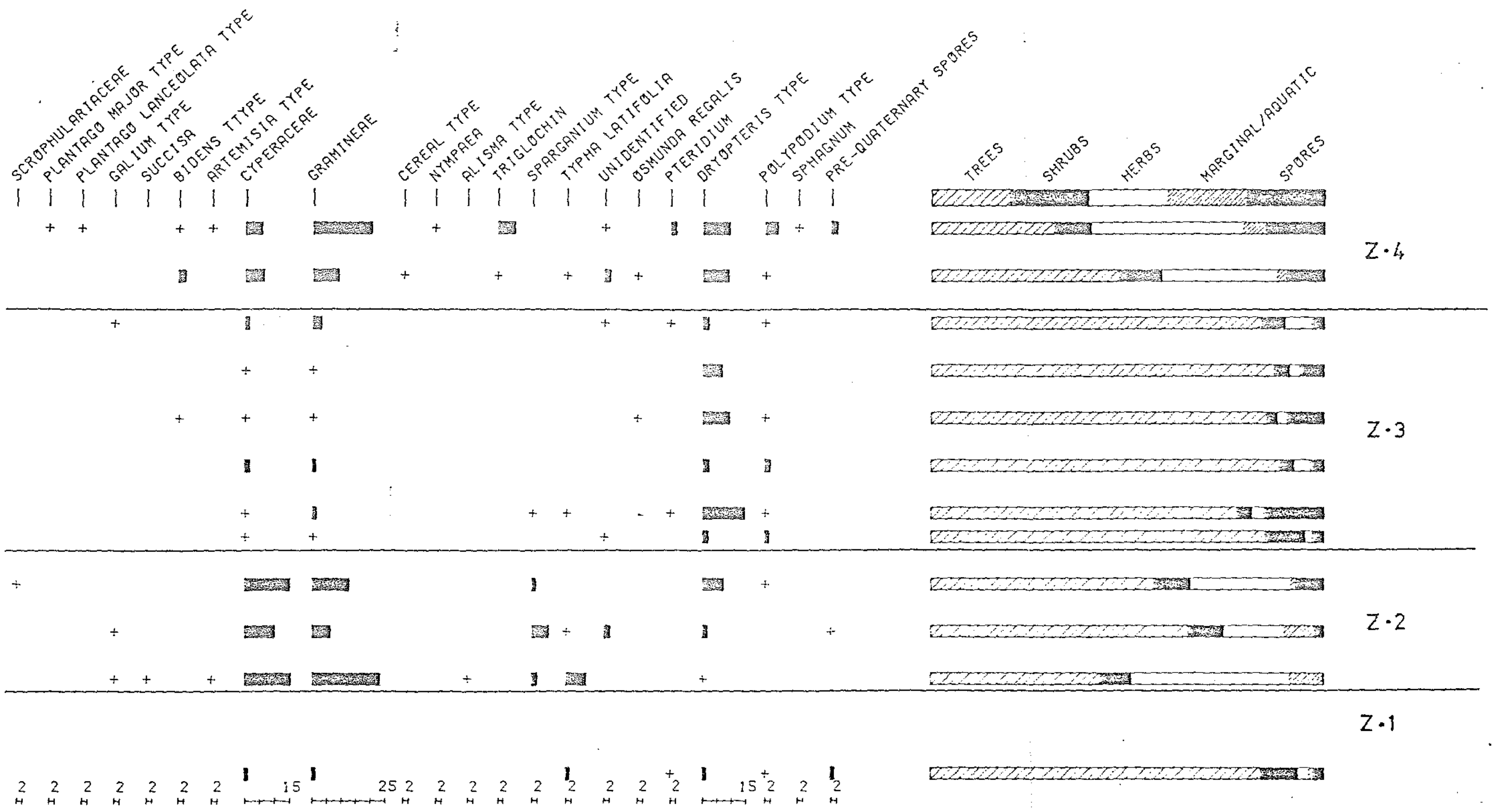

SCROPHULARIACEAE
PLANTAGO MAJOR TYPE
PLANTAGO LANCEOLATA TYPE
GALIUM TYPE
SUCCISA
BIDENS TTYPE
ARTEMISIA TYPE
CYPERACEAE
GRAMINEAE
CEREAL TYPE
NYMPAEA
ALISMA TYPE
TRIGLOCHIN
SPARGANIUM TYPE
TYPHA LATIFOLIA
UNIDENTIFIED
OSMUNDA REGALIS
PTERIDIUM
DRYOPTERIS TYPE
POLYPODIUM TYPE
SPHAGNUM
PRE-QUATERNARY SPORES
TREES
SHRUBS
HERBS
MARGINAL/AQUATIC
SPORES
Z·4
Z·3
Z·2
Z·1

FIG. 5. CONT.

7.b. POLLEN ZONATION

Four pollen assemblage zones are delimited. These are characterised from the base at 225 cm upwards;

Pollen Zone 1; 225-219 cm; grey marine silts. Pollen was preserved in only one horizon (225 cm). This spectrum is characterised by high Alnus percentages (68% TP) with Quercus (15% TP) and Corylus type (10% TP). Pinus and Tilia are also present.

Pollen Zone 2; 219-205 cm; lower peat levels. The arboreal pollen spectra of this zone are dominated by Quercus which increases to 57 % of total pollen. Other arboreal taxa include Betula, Pinus, Quercus, Ulmus, Alnus, Fraxinus (declining) and Fagus. In the shrub category, Corylus type and Salix are the most important (10 % TP and 3 % TP respectively). Herb pollen increases substantially from pollen zone 1 and is dominated by Cyperaceae (to 15 % TP) and Gramineae (to 25 % TP). Herbaceous diversity is not, however, great with other principal types being characteristic of freshwater aquatic marginal plants (Typha latifolia and Sparganium/Typha angustifolia and Alisma type).

Pollen Zone 3; 205-187 cm; upper peat levels. This zone is characterised by a sharp increase in pollen of Alnus to 80 % of total pollen. Other arboreal taxa noted in pollen zone 2 remain. Quercus remains important but in lower percentages due to the within-sum depression of its values caused by increasing Alnus. Salix , Gramineae and Cyperaceae and freshwater marginal taxa decline. Spores are dominated by Dryopteris type which expands to 15 % of total pollen plus spores. Osmunda regalis and Polypodium are also noted.

Pollen Zone 4; 187-179 cm; base of the upper marine silts. Pollen of Alnus declines sharply to 15 % of total pollen. There are statistically corresponding increases in Quercus and Corylus type. Herb pollen similarly becomes more important with increasing Gramineae and Cyperaceae. This zone is also characterised by an increasing number of halophytic types; notably Chenopodium type (to 15 % TP), Armeria and Triglochin (cf. maritima).

7.c. DISCUSSION

This pollen sequence spans the lower peat sequence described by Murphy

(Wilkinson and Murphy 1984) extending from the top of the basal silts, through peat and into grey marine silts. Although the basal silts (pollen zone 1) have been described as of marine origin, pollen evidence fails to show this. Correspondingly high values of Alnus and the presence of Typha latifolia suggest a freshwater deposit (alluvial silts) laid down in/or adjacent to a fen carr community. Alternatively, the pollen and inorganic sediments may have been fluvially transported from further up the river catchment. Local vegetation (dry land) consisted of Quercus, Tilia and Corylus woodland. Although Pinus has its highest values in this level (225 cm), this is a small value and may be regarded as a product of differential pollen preservation and/or differential preservation of this taxon.

Pollen zones 2 and 3 similarly exhibit a local vegetation dominated by mixed deciduous woodland. Quercus and Corylus type appear dominant but there is a strong representation of tree taxa whose pollen production and/or dispersal characteristics are poorer. These taxa include Tilia, Ulmus, Fraxinus and Fagus. It is not possible to state whether these elements were dominant at some distance from the site or whether they were constituents of the oak and hazel woodland. The peats which accumulated in pollen zone 2 formed in an environment of Salix (willow carr) woodland, possibly of very damp character. The relatively high percentages of grasses and sedges were produced by plants growing in this community. Initiation of peat formation and these local fen swamp conditions is likely to have been due to rising sea levels and a ponding back of freshwater in this river system.

This community shows evidence of drying out (pollen zone 3) which resulted in alder carr becoming dominant (Alnetae glutinosae). The high percentages of alder pollen present attests to its dominance on the area sampled.

Pollen zone 4 marks the stratigraphical and ecological change to one of brackish or marine conditions which deposited the highly characteristic grey silts. As noted in the pollen analyses of sites Blackwater 3, 18 and 28, relatively high percentages of _Chenopodium_ type and pollen of other halophytes are present. Although a large pollen type category which includes _Chenopodium_ (goosefoots), _Atriplex_ (oraches) and _Salicornia_ (glassworts), it is the latter taxon which is thought to be represented here. This taxon has produced numerous plant macrofossils noted by Murphy. Other halophytic types (_Armeria_ and _Triglochin_) indicate the presence nearby of upper salt marsh plant communities.

8. OVERALL DISCUSSION AND CONCLUSIONS

Work carried out on the above five sequences encompasses the pollen analyses of buried soils, peats and peaty clays and estuarine/marine sediments. It was expected that pollen preservation and representation in these different sedimentary units might reflect differing pollen sources, transport, sedimentary characteristics. In spite of these variations, a number of broad conclusions as to the character of the vegetation communities represented at the time of deposition can be made. These are briefly discussed;

a) The terrestrial vegetation.

It is clear that the woodland of the later prehistoric period had essentially the same characteristics at all the sites analysed. _Quercus_ and _Corylus_ were ubiquitous and consistent throughout the period represented by these sediments (Neolithic to Bronze Age). Their relatively high pollen production and wind dispersal characteristics are responsible for their widespread representation in all of the sediment types analysed. Other deciduous woodland elements (eg. _Fagus_, _Fraxinus_, _Ulmus_ and _Tilia_) have lesser pollen production and/or poorer dispersal characteristics which have therefore resulted in their less consistent representation in the pollen record at these sites. However, it is clear that the local woodland did comprise, in general, a mixed deciduous component. As noted variously by researchers in southern and eastern England, _Tilia_ was in many areas dominant or co-dominant with *Quercus*. Considering the relatively poor production and dispersal of *Tilia* pollen (being entomophilous), the frequencies noted in Hullbridge sediments suggest that *Tilia* was an important tree in the Hullbridge area. This is attested by the high values of *Tilia* in the buried soil at Blackwater site 18; soil pollen spectra tend to reflect the vegetation growing on site or very close by.

It is interesting to note that percentages of *Betula* are low. As a pioneer coloniser of open ground, its presence might be expected if any form of ephemeral anthropogenic activity (eg. forest clearance for agriculture) was taking place in the region. High values of *Pinus* are noted in many of the pollen spectra analysed. This probably does not indicate that *Pinus* was a dominant tree or even growing within the local region. *Pinus* pollen is frequently overrepresented in sediments as a result of differential destruction of other pollen taxa or due to its long distance dispersal characteristics. It is also frequently overrepresented in marine sediments. These factors are exemplified at the Stumble site (Blackwater site 28) where, at 88 cm, only *Pinus* pollen is represented.

b) Halophytic communities.

A number of halophytic plants are represented in these pollen sequences. These reflect a range of salt marsh vegetation communities from upper salt marsh to open mudflat conditions. It is not possible to delimit to species or even generic level many of the pollen taxa recorded, but, however, *Armeria/Limonium*, *Triglochin* and Gramineae represent the former. The record of Bidens type is likely to represent the *Aster tripolium* noted by Murphy in his study of the plant macrofossils. Substantial quantities of *Chenopodium* type pollen are a valuable indicator of the onset of saline conditions. Whilst this pollen type includes *Chenopodium*, *Atriplex* and *Salicornia* which thus potentially represent a wide variety of ecological conditions, the high percentages recorded here are attributable to *Salicornia*. This is evidenced again by the abundant plant macrofossil records.

c) Fen carr woodland.

In the Crouch river system at site 8, it is apparent that marine condition were not as prevalent as in the Blackwater sites. There is strong evidence for waterlogging of the old land surface (Neolithic date) caused by rising sea levels and the subsequent colonisation by *Salix* (willow). Alder carr then became dominant prior to the laying down of alluvial clays. It might be expected that downstream the effects of marine incursion would be more pronounced.

d) Anthropogenic impact.

There is little evidence for anthropogenic impact on the vegetation represented in the above pollen sequences. As previously noted, there is substantial evidence for mixed oak/lime woodland growing over much of the area. Anthropogenic impact might be highlighted in the pollen spectra by increasing herb pollen totals and, where arable activity was being practised, by cereal type pollen and associated weeds. Although there are fluctuations in the Gramineae totals, it is not possible to separate any potential effects of anthropogenic activity from those giving rise to maritime grassland sward communities. There is little evidence of any cereal cultivation despite the record of charred cereal remains at such sites as the Stumble (Blackwater Site 28). If such arable activity was taking place, the pollen dispersion of these pollen types may have been restricted in what has already been described as a substantially wooded environment.

Only at Blackwater Site 18 is the possibility of anthropogenic disturbance countenanced. This is perhaps shown by the reduction in _Tilia_ pollen in the buried land surface. _Tilia_ is relatively intolerant of human disturbance and it is possible that increasing pressure on the area from the adjacent Neolithic settlement may have caused the local demise of this woodland element.

Phase II of the Hullbridge project will collate all radiocarbon dates, ordnance datum measurements and further pollen analyses of cores obtained from downstream at Bradwell power station. This will facilitate the construction of sea level change curves for the Essex coast and allow the production of palaeogeographic maps of the Hullbridge Basin. Further study of the Stumble site (Blackwater Site 28) will aim at studying the human influence on this area in greater detail.

REFERENCES

Moore, P.D. and Webb, J.A. 1979 'An illustrated guide to pollen analysis'. Hodder and Stoughton, London.

Murphy, P and Wilkinson, T.J. 1982 'The Hullbridge Basin Survey. Interim Report No1'. Essex County Council.

Murpy, P. 1983 'The Hullbridge Survey. Interim Report No 2'. Essex County Council.

Wilkinson, T.J. with contributions by Murphy P. and Manson, K. 1983 'The Hullbridge Survey. July 1983. Interim Report No 3'. Essex County Council.

Wilkinson, T.J. with contributions by Murphy P. and Austin, T.J.F. 1984 'The Hullbridge Survey. Interim Report No 4. April-June 1983'. Essex County Council.

Wilkinson, T.J. and Murphy, P. 1984 'The Hullbridge Basin Survey 1984. Interim Report No 5'. Essex County Council.

Wilkinson, T.J. and Murphy, P. 1986 'The Hullbridge Basin Survey 1985. Interim Report No 6'. Essex County Council.

Wilkinson, T.J. and Murphy, P. 1986 'The Hullbridge Basin Survey 1986. Interim Report No 7'. Essex County Council.

Wilkinson, T.J. and Murphy, P. 1988 'The Hullbridge Basin Survey 1987. Interim Report No 8'. Essex County Council.

APPENDIX 1; RAW POLLEN DATA.

DEPTH CM	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0
BETULA	.0	.0	1.0	2.0	4.0	.0	2.0	1.0	1.0	3.0
ABIES	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0
PINUS	6.0	21.0	4.0	3.0	3.0	2.0	4.0	1.0	4.0	1.0
ULMUS	.0	1.0	5.0	.0	1.0	5.0	3.0	3.0	5.0	3.0
QUERCUS	93.0	122.0	192.0	181.0	160.0	121.0	99.0	97.0	154.0	131.0
TILIA	5.0	6.0	10.0	8.0	7.0	5.0	2.0	51.0	13.0	17.0
ALNUS	1.0	.0	4.0	3.0	4.0	8.0	12.0	10.0	6.0	9.0
FRAXINUS	.0	.0	2.0	.0	1.0	4.0	2.0	.0	4.0	1.0
FAGUS	.0	.0	.0	.0	.0	2.0	.0	.0	.0	.0
CORYLUS	10.0	1.0	14.0	8.0	16.0	37.0	29.0	31.0	38.0	32.0
SALIX	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
MALUS TY	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0
HIPPOPHA	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0
HEDERA	.0	.0	.0	.0	1.0	.0	.0	3.0	1.0	2.0
CALLUNA	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
CF. ELAT	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0
SPERGULA	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
CHENOPOD	20.0	13.0	12.0	16.0	48.0	28.0	83.0	58.0	43.0	94.0
ROSACEAE	1.0	.0	2.0	.0	.0	.0	.0	.0	.0	1.0
FILIPEND	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0
UMBELLIF	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0
MERCURIA	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0
RUMEX	.0	.0	2.0	.0	.0	.0	1.0	.0	.0	.0
ARMERIA	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.0
ARMERIA	6.0	2.0	4.0	7.0	4.0	2.0	4.0	3.0	2.0	1.0
CONVOLVU	.0	.0	.0	2.0	2.0	3.0	1.0	1.0	5.0	.0
SCROPHUL	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0
PLANTAGO	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
PLANTAGO	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
PLANTAGO	.0	1.0	5.0	24.0	6.0	10.0	22.0	5.0	16.0	9.0
PLANTAGO	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
CF. LITT	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
CAMPANUL	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
BIDENS T	1.0	2.0	13.0	5.0	10.0	13.0	7.0	6.0	5.0	5.0
ASTER TY	.0	.0	2.0	.0	.0	1.0	1.0	.0	2.0	1.0
ANTHEMIS	2.0	1.0	1.0	2.0	.0	2.0	.0	.0	.0	1.0
ARTEMISI	.0	.0	.0	1.0	.0	1.0	.0	.0	.0	.0
TARAXACU	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
CYPERACE	.0	.0	1.0	2.0	1.0	.0	.0	1.0	.0	.0
GRAMINEA	50.0	29.0	24.0	33.0	45.0	44.0	74.0	76.0	94.0	72.0
CEREAL T	3.0	.0	3.0	3.0	2.0	8.0	3.0	1.0	7.0	7.0
IRIS TYP	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TRIGLOCH	.0	.0	.0	1.0	1.0	2.0	5.0	.0	2.0	.0
PTERIDIU	18.0	7.0	3.0	3.0	5.0	4.0	.0	1.0	1.0	2.0
DRYOPTER	11.0	19.0	4.0	1.0	3.0	1.0	1.0	5.0	1.0	5.0
POLYPODI	10.0	29.0	6.0	1.0	2.0	.0	4.0	18.0	1.0	8.0
SPHAGNUM	.0	2.0	.0	.0	.0	1.0	.0	.0	.0	.0
UNIDENTI	12.0	6.0	1.0	4.0	1.0	.0	1.0	4.0	.0	3.0
PRE-QUAT	5.0	3.0	2.0	.0	.0	.0	.0	.0	.0	.0

B Table 10; Blackwater Site 3; raw pollen data.

DEPTH CM	.0	4.0	8.0	12.0	16.0	20.0	24.0	26.0	28.0	32.0	36.0	40.0
BETULA	.0	.0	.0	1.0	2.0	1.0	1.0	1.0	.0	.0	.0	.0
PINUS	1.0	1.0	1.0	2.0	4.0	2.0	6.0	3.0	16.0	6.0	3.0	2.0
PICEA	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ULMUS	.0	1.0	.0	2.0	.0	.0	2.0	1.0	3.0	1.0	.0	2.0
QUERCUS	36.0	34.0	37.0	63.0	60.0	75.0	130.0	44.0	55.0	32.0	31.0	54.0
TILIA	.0	2.0	.0	7.0	7.0	3.0	6.0	4.0	16.0	54.0	15.0	5.0
ALNUS	15.0	6.0	10.0	10.0	11.0	.0	6.0	3.0	5.0	12.0	1.0	3.0
FAGUS	.0	.0	1.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
CORYLUS	31.0	24.0	24.0	21.0	24.0	15.0	15.0	17.0	10.0	35.0	25.0	24.0
SALIX	1.0	.0	1.0	1.0	.0	1.0	.0	.0	.0	.0	.0	.0
SUADA	.0	1.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0
HEDERA	1.0	.0	.0	.0	.0	.0	2.0	1.0	.0	.0	.0	.0
ERICA	.0	.0	.0	.0	.0	.0	2.0	.0	.0	.0	.0	.0
CALLUNA	.0	.0	1.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0
RANUNCUL	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0
SINAPIS	1.0	1.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0	1.0
CARYOPHY	.0	.0	.0	.0	.0	.0	.0	1.0	.0	1.0	1.0	.0
STELLARI	.0	.0	.0	.0	.0	.0	.0	1.0	1.0	1.0	.0	.0
SPERGULA	.0	.0	.0	.0	.0	4.0	.0	.0	.0	.0	.0	.0
CHENOPOD	157.0	192.0	182.0	58.0	96.0	37.0	45.0	72.0	30.0	3.0	13.0	50.0
ROSACEAE	.0	.0	1.0	1.0	.0	2.0	.0	.0	.0	.0	.0	.0
FILIPEND	.0	.0	.0	.0	.0	1.0	.0	.0	1.0	.0	.0	.0
UMBELLIF	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
RUMEX	1.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
ARMERIA	.0	.0	.0	5.0	3.0	2.0	4.0	.0	.0	.0	.0	3.0
ARMERIA	1.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
CONVOLVU	2.0	1.0	1.0	6.0	.0	7.0	2.0	.0	2.0	.0	.0	.0
SCROPHUL	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
PLANTAGO	3.0	2.0	4.0	1.0	1.0	7.0	5.0	3.0	10.0	.0	.0	.0
PLANTAGO	2.0	5.0	5.0	17.0	5.0	29.0	12.0	4.0	10.0	1.0	1.0	8.0
PLANTAGO	.0	.0	.0	.0	.0	1.0	.0	.0	4.0	.0	.0	.0
GALIUM T	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0
BIDENS T	1.0	6.0	3.0	10.0	6.0	10.0	33.0	7.0	7.0	1.0	.0	8.0
ANTHEMIS	1.0	1.0	.0	.0	.0	1.0	1.0	.0	1.0	.0	.0	1.0
ARTEMISI	1.0	.0	2.0	.0	.0	1.0	.0	7.0	3.0	.0	.0	.0
CIRSIUM	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
TARAXACU	.0	1.0	.0	.0	.0	.0	.0	.0	1.0	6.0	.0	.0
TRIGLOCH	1.0	3.0	2.0	12.0	3.0	1.0	.0	1.0	1.0	2.0	.0	12.0
CYPERACE	.0	.0	.0	1.0	1.0	.0	1.0	1.0	4.0	.0	.0	.0
GRAMINEA	51.0	44.0	71.0	27.0	21.0	19.0	26.0	40.0	36.0	44.0	9.0	42.0
CEREAL T	1.0	2.0	3.0	1.0	1.0	1.0	.0	.0	.0	.0	.0	1.0
SPARGANI	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0
DRYOPTER	.0	1.0	2.0	1.0	.0	.0	1.0	5.0	36.0	70.0	3.0	1.0
PTERIDIU	14.0	11.0	7.0	10.0	2.0	.0	2.0	3.0	10.0	5.0	.0	4.0
POLYPODI	.0	2.0	.0	1.0	2.0	.0	.0	.0	21.0	16.0	5.0	.0
SPHAGNUM	1.0	1.0	1.0	.0	.0	.0	.0	.0	1.0	7.0	.0	2.0
UNIDENTI	.0	.0	.0	.0	.0	.0	8.0	3.0	5.0	10.0	1.0	2.0
PRE-QUAT	1.0	.0	.0	.0	.0	1.0	.0	.0	.0	1.0	.0	2.0

Table 11; Blackwater Site 18 ; raw pollen data

	A	B	C	D	E	F	G	H
1	DEPTH CM	54.0	66.0	74.0	78.0	80.0	88.0	108.0
2	BETULA	1.0	2.0	2.0	1.0	1.0	.0	.0
3	ABIES	.0	.0	.0	.0	.0	.0	2.0
4	PINUS	10.0	3.0	14.0	3.0	24.0	5.0	33.0
5	ULMUS	1.0	.0	2.0	1.0	.0	.0	1.0
6	QUERCUS	72.0	69.0	65.0	73.0	48.0	.0	14.0
7	TILIA	1.0	1.0	2.0	4.0	8.0	.0	98.0
8	ALNUS	3.0	1.0	6.0	8.0	3.0	.0	2.0
9	FRAXINUS	.0	1.0	.0	.0	.0	.0	.0
10	FAGUS	.0	.0	4.0	1.0	1.0	.0	.0
11	CORYLUS	17.0	24.0	41.0	30.0	13.0	.0	18.0
12	SUADA	.0	1.0	.0	.0	.0	.0	.0
13	HIPPOPHA	3.0	3.0	5.0	1.0	6.0	.0	.0
14	HEDERA	.0	.0	1.0	.0	1.0	.0	.0
15	CALLUNA	3.0	.0	2.0	.0	.0	.0	.0
16	ERICA	.0	1.0	.0	.0	.0	.0	.0
17	RANUNCUL	.0	.0	.0	1.0	.0	.0	.0
18	ANEMONE	.0	1.0	.0	.0	.0	.0	.0
19	SINAPIS	2.0	2.0	.0	.0	.0	.0	.0
20	HORNUNGI	.0	1.0	.0	.0	.0	.0	.0
21	CARYOPHY	.0	.0	1.0	.0	.0	.0	.0
22	SPERGULA	.0	.0	2.0	.0	1.0	.0	.0
23	CHENOPOD	154.0	83.0	889.0	610.0	67.0	1.0	228.0
24	POLYGONU	.0	2.0	.0	.0	.0	.0	1.0
25	URTICA T	1.0	.0	.0	.0	.0	.0	.0
26	RUMEX	.0	.0	1.0	.0	1.0	.0	.0
27	ARMERIA	4.0	3.0	.0	.0	.0	.0	.0
28	ARMERIA	14.0	.0	4.0	2.0	11.0	.0	.0
29	CONVOLVU	.0	.0	.0	1.0	3.0	.0	1.0
30	SCOPHULA	.0	.0	.0	1.0	.0	.0	.0
31	PLANTAGO	.0	2.0	5.0	2.0	3.0	.0	1.0
32	PLANTAGO	13.0	5.0	10.0	13.0	11.0	.0	4.0
33	BIDENS T	5.0	6.0	6.0	5.0	14.0	.0	2.0
34	ARTEMISI	.0	.0	1.0	.0	.0	.0	.0
35	ANTHEMIS	4.0	6.0	1.0	1.0	.0	.0	.0
36	SERRATUL	1.0	.0	.0	.0	.0	.0	.0
37	TARAXACU	1.0	2.0	.0	.0	2.0	.0	2.0
38	TRIGLOCH	.0	.0	4.0	.0	1.0	.0	.0
39	CYPERACE	.0	.0	2.0	.0	.0	.0	2.0
40	GRAMINEA	59.0	61.0	19.0	60.0	118.0	.0	19.0
41	CEREAL T	6.0	1.0	3.0	1.0	2.0	.0	.0
42	UUNIDENT	4.0	2.0	.0	.0	.0	.0	16.0
43	DRYOPTER	12.0	4.0	5.0	1.0	3.0	.0	9.0
44	PTERIDIU	25.0	14.0	21.0	29.0	13.0	.0	4.0
45	POLYPODI	3.0	.0	1.0	1.0	5.0	7.0	46.0
46	PRE-QUAT	32.0	24.0	22.0	14.0	21.0	45.0	31.0

Table 12; Blackwater Site 28; raw pollen data.

DEPTH CM	179.0	183.0	187.0	191.0	195.0	199.0	203.0	205.0	209.0	213.0	217.0	225.0
BETULA	.0	6.0	2.0	3.0	1.0	.0	2.0	2.0	2.0	4.0	3.0	1.0
PINUS	2.0	1.0	.0	.0	1.0	1.0	.0	.0	1.0	.0	.0	6.0
ULMUS	.0	.0	.0	1.0	.0	1.0	1.0	1.0	7.0	2.0	3.0	1.0
QUERCUS	44.0	74.0	39.0	59.0	76.0	55.0	43.0	84.0	120.0	150.0	111.0	41.0
TILIA	5.0	7.0	8.0	.0	7.0	7.0	14.0	5.0	9.0	9.0	7.0	5.0
ALNUS	14.0	31.0	267.0	342.0	200.0	200.0	374.0	205.0	15.0	11.0	3.0	185.0
FRAXINUS	.0	.0	.0	1.0	.0	1.0	.0	.0	1.0	3.0	5.0	.0
FAGUS	.0	.0	.0	1.0	.0	.0	.0	.0	.0	1.0	1.0	.0
CORYLUS	18.0	25.0	23.0	17.0	8.0	10.0	20.0	30.0	19.0	19.0	17.0	26.0
SALIX	.0	2.0	1.0	2.0	.0	.0	.0	6.0	7.0	2.0	7.0	.0
HIPPOPHA	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
RUBUS TY	.0	.0	1.0	.0	.0	1.0	1.0	.0	.0	.0	.0	.0
HEDERA	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.0	.0	2.0
CALLUNA	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0
CHENOPOD	26.0	33.0	1.0	.0	.0	1.0	2.0	2.0	.0	.0	1.0	1.0
ROSACEAE	.0	1.0	1.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0
VISCUM	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0
CHRYSOSP	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0
UMBELLIF	2.0	1.0	7.0	4.0	1.0	4.0	4.0	.0	.0	.0	2.0	1.0
RUMEX	1.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0	1.0	.0
URTICA T	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0
ARMERIA	3.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SYMPHYTU	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SOLANUM	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SCROPHUL	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0
PLANTAGO	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PLANTAGO	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
GALIUM T	.0	.0	1.0	.0	.0	.0	.0	.0	.0	1.0	2.0	.0
SUCCISA	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
BIDENS T	1.0	5.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0
ARTEMISI	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
CYPERACE	9.0	13.0	4.0	2.0	3.0	4.0	3.0	1.0	37.0	26.0	46.0	3.0
GRAMINEA	34.0	19.0	10.0	4.0	2.0	3.0	6.0	2.0	31.0	16.0	69.0	3.0
CEREAL T	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NYMPAEA	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ALISMA T	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
TRIGLOCH	10.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SPARGANI	.0	.0	.0	.0	.0	.0	2.0	.0	3.0	15.0	5.0	.0
TYPHA LA	.0	1.0	.0	.0	.0	.0	2.0	.0	.0	2.0	20.0	3.0
UNIDENTI	1.0	4.0	2.0	.0	.0	.0	.0	1.0	.0	5.0	.0	.0
OSMUNDA	.0	1.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0
PTERIDIU	3.0	.0	1.0	.0	.0	.0	3.0	.0	.0	.0	.0	1.0
DRYOPTER	17.0	21.0	7.0	30.0	30.0	6.0	78.0	6.0	19.0	4.0	1.0	3.0
POLYPODI	7.0	2.0	2.0	.0	1.0	5.0	3.0	4.0	1.0	.0	.0	1.0
SPHAGNUM	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PRE-QUAT	3.0	.0	.0	.0	.0	.0	.0	.0	.0	2.0	.0	3.0
PTERIDIU	3.0	.0	1.0	.0	.0	.0	3.0	.0	.0	.0	.0	1.0
DRYOPTER	17.0	21.0	7.0	30.0	30.0	6.0	78.0	6.0	19.0	4.0	1.0	3.0
POLYPODI	7.0	2.0	2.0	.0	1.0	5.0	3.0	4.0	1.0	.0	.0	1.0
SPHAGNUM	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PRE-QUAT	3.0	.0	.0	.0	.0	.0	.0	.0	.0	2.0	.0	3.0

Table 13; Crouch Site 8; raw pollen data