

3. The Vegetation History of the Lower Rother Valley: Stratigraphy and Pollen Data for the Shirley Moor Region

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The results of lithostratigraphic and pollen analytical investigations have been used to reconstruct the mid-Holocene depositional and vegetational history of Shirley Moor, a large embayment in the lower Rother valley. The lithostratigraphic survey revealed, above bedrock or a bluish-grey clay, a peat layer buried by up to 4.5 m of silty sand. Material for pollen analysis was collected from a site adjacent to Chapel Bank where the peat, overlying weathered bedrock, accumulated from c. 6250 to c. 3600 cal. yrs BP. The basal pollen assemblages, with high Quercus then Poaceae pollen values, indicate rising water-levels and are possibly coeval with deposition of the bluish-grey (brackish) clay found underlying the peat at some locations. From c. 5350 cal. yrs BP Alnus glutinosa-dominated fen carr occupied the Rother valley. This community, persisting for at least c. 1700 calendar years, appears to have been self-sustaining. Peat cessation seems to have been followed by a period when sedimentation rates in the lower Rother were considerably reduced. Comparison with sites on Walland Marsh suggests that marine conditions (depositing the upper silty sands) did not return to the lower Rother until after c. 2300 cal. yrs BP. The mid-Holocene dryland vegetation of Chapel Bank consisted of Tilia-dominated woodland. There is little evidence in the pollen record for human activity in the vicinity of Chapel Bank. High Tilia values (c. 10% TLP minus Alnus glutinosa) occur through to the end of peat formation. This is in contrast to sites in the Brede and Pannel valleys where a phase of forest clearance (and the disappearance of Tilia from the pollen record) is recorded c. 4000 cal. yrs BP.

Introduction

The study of the Holocene vegetation history of south-eastern England was long neglected because of the apparent absence of deposits suitable for pollen analysis. However, since the early 1980s knowledge of past vegetation of the region has expanded through the study of peat buried within the alluvium of the major river valleys and adjacent coastal areas. Pollen diagrams were published, for example, from the Ouse valley (Thorley 1981), Pevensey Levels (Moffat 1986) and Combe Haven (Smyth and Jennings 1988). The presence of an extensive buried peat bed across Walland Marsh and the valleys feeding into the western side of the Romney Marsh depositional complex (Green 1968; Waller *et al.* 1988; Long and Innes 1995) has facilitated research into both the vegetational history of adjacent dryland areas and wetland vegetation dynamics, and this complex has now proved to be the most important source of new information (Fig. 3.1).

Waller (1987) investigated the vegetational history of

the upland areas formed by the Cretaceous Hastings Beds adjacent to the south-western edge of this marshland. The most complete record of Holocene vegetation development available for south-eastern England exists for the Pannel valley (Waller 1993), while detailed studies of the mid-Holocene are available from the Brede valley (Waller 1994a). During the latter period the valley floors were occupied by fen carr, with *Alnus glutinosa* particularly abundant. The slopes of the Brede and Pannel valleys were covered with *Tilia*-dominated woodland before a phase of clearance dated to c. 4000 cal. yrs BP.

The vegetational history of Walland Marsh has also been investigated in some detail (Tooley and Switsur 1988; Long and Innes 1995; Waller *et al.* in press). These studies provide information on wetland vegetation processes (successional pathways), regional movements in water-levels, changes in coastal configuration and even climate change (Waller *et al.* in press). Fen carr prevailed during the early stages of widespread peat formation on Walland

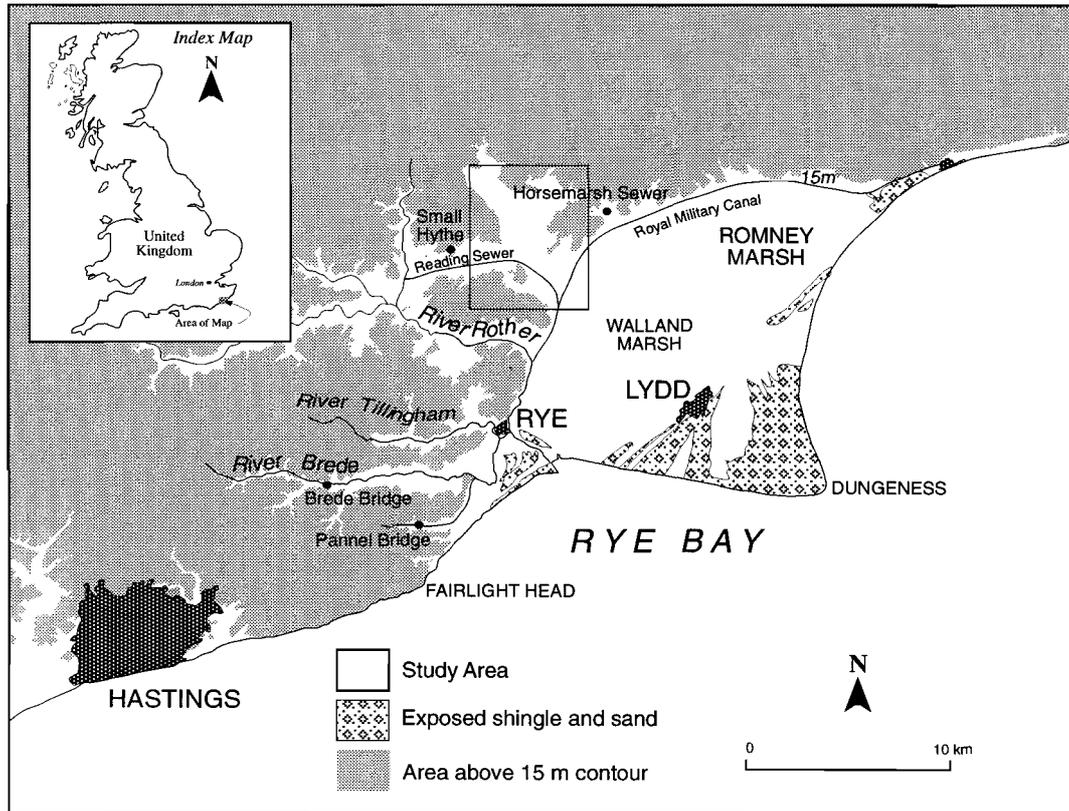


Fig. 3.1. The Romney Marsh area.

Marsh from *c.* 5300 cal. yrs BP onwards. Vegetation dominated by *Alnus glutinosa* persisted for *c.* 2000 cal. yrs BP at sites towards the northern edge of Walland Marsh, sustained by the flow of eutrophic water from the upland. In contrast, acidophilous vegetation with *Sphagnum* developed at the southern end of Walland Marsh. Here, bog development was promoted by isolation from base-rich water and by climatic change, namely the onset of wetter conditions at *c.* 2600 cal. yrs BP. At intermediate sites a shift from fen carr to acidophilous vegetation at *c.* 4000 cal. yrs BP coincides with a reduction in the rate of relative sea-level (RSL) rise.

The aims of this paper

The work described in this paper extends the existing database into Shirley Moor and the lower reaches of the Rother valley, north of the Isle of Oxney (Fig. 3.1). Information on wetland vegetational history and sediment accumulation rates was required from this area to confirm the spatial extent of the *Alnus glutinosa*-dominated communities already identified in the Brede and Pannel valleys and in the northern parts of Walland Marsh (Waller 1993, 1994a; Waller *et al.* in press), and to clarify temporal trends which indicated, in areas on the edge of the marshland, a slowing down in the sediment accumulation rate after *c.* 4000 cal. yrs BP and the early cessation of peat growth.

The dryland vegetational history of the upland surrounding Shirley Moor was of particular interest because of the geological contrast with the area further to the southwest. The former is dominated by the Wadhurst Clay and the Weald Clay with Tunbridge Wells Sand, in contrast to the predominantly sandier lithologies of the Ashdown Beds of the slopes above the Brede and Pannel valleys.

Shirley Moor (Fig. 3.1) was chosen for investigation owing to the number of peninsulas (e.g. at Reading Sewer and Shirley Farm) and islands within the former wetland area (e.g. Chapel Bank). Peninsulas and islands are often the focus for human activity in wetland areas, the occupation of the dryland/wetland ecotone enabling a wide variety of resources to be exploited. Examples from other coastal lowland areas in England where this is seen to be the case include Meare-Westhay island in the Somerset Levels (Coles and Coles 1986) and Whittlesey island in the East Anglian Fenland (Hall 1987; Pryor 1991). The results of an archaeological survey undertaken alongside the pollen investigations will be reported elsewhere (Long *et al.* forthcoming).

The study area

Shirley Moor is located close to the north-western corner of Walland Marsh (Fig. 3.1). This former wetland area is approximately 9 km², and is drained by the Tenterden and Cradlebridge Sewers which flow southwards into a valley

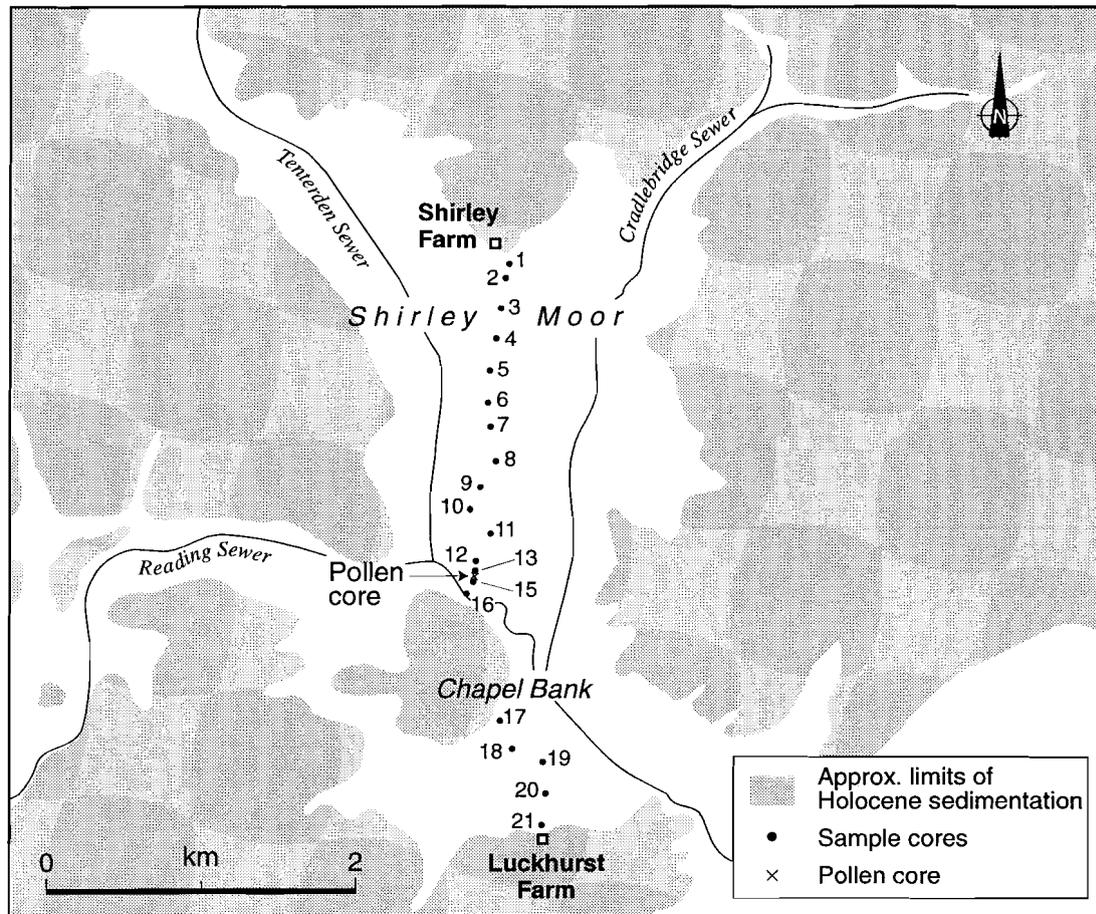


Fig. 3.2. Lithostratigraphic transect across Shirley Moor.

which once contained the Rother but is now drained by the Reading Sewer (Eddison 1985, 1988, 1995) (Fig. 3.2). To the south and west of Shirley Moor the slopes and interfluvies, including Chapel Bank, are developed on Wadhurst Clay, while to the north and east they are composed of Tunbridge Wells Sand and Weald Clay and rise to a maximum of 60 m O.D. The latter forms low-grade agricultural land and woodland, while Shirley Moor itself is a productive agricultural area.

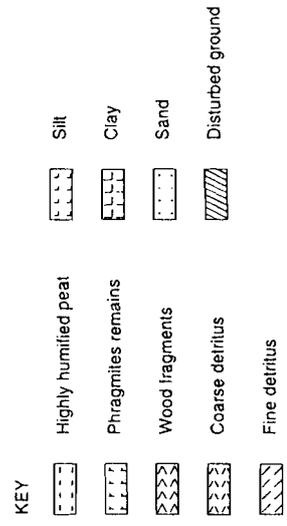
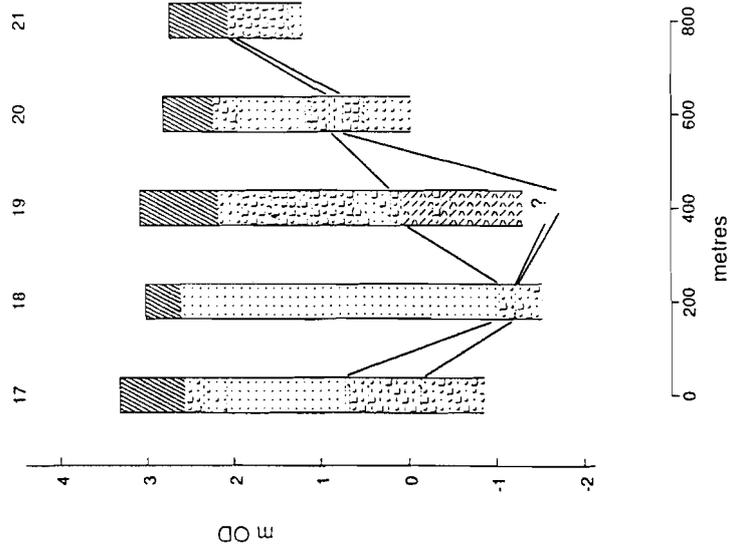
The Holocene lithostratigraphy of the Rother valley has previously been studied by Burrin (1988) and Waller *et al.* (1988). In the lower Rother valley investigations revealed the presence of organic material buried beneath clastic sediments of marine/brackish origin in the upper reaches of the Rother, in the Rother valley south of the Isle of Oxney and to the west of Chapel Bank near Small Hythe (Waller *et al.* 1988). A maximum of *c.* 5 m of peat was recorded at Small Hythe. Over the deeper parts of the bedrock sub-surface the peat was also underlain by a marine/brackish bluish-grey clay. Peat had previously been identified in the Shirley Moor area by Shephard-Thorn *et al.* (1966).

Lithostratigraphy of Shirley Moor

The lithostratigraphy of Shirley Moor was investigated using a gouge auger. Sixteen boreholes were sunk to the north of Chapel Bank, in a transect from Shirley Farm (TQ93223249) to Chapel Bank (TQ92953015). A further 5 boreholes were sunk south of Chapel Bank, between TQ93262932 and TQ93492866. The distance between boreholes was usually 200m, with further detail obtained from the northern edge of Chapel Bank (Fig. 3.2). Sediment characteristics were described using the system of Troels-Smith (1955) and the transects are illustrated using symbols modified from Troels-Smith (Waller *et al.* 1995).

In the northern section, the bedrock sub-surface drops steeply away from Shirley Farm, from 1.20 m OD in borehole 1 to below -3.13 m OD in borehole 2 (Fig. 3.3). Bedrock, consisting of very stiff grey clays and stiff greenish-grey sandy silts with occasional fragments of sandstone, was found at depths of below -4 m OD in boreholes 5–7, in the central part of the transect. Two boreholes, 8 and 11, penetrated to *c.* -5 m OD without reaching bedrock. At these sites the deepest sediment recovered was a soft bluish-grey clay with black mottling. A similar deposit was found above bedrock in borehole 7.

CHAPEL BANK SOUTH



CHAPEL BANK NORTH

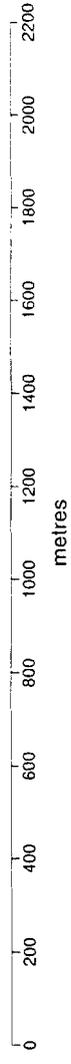
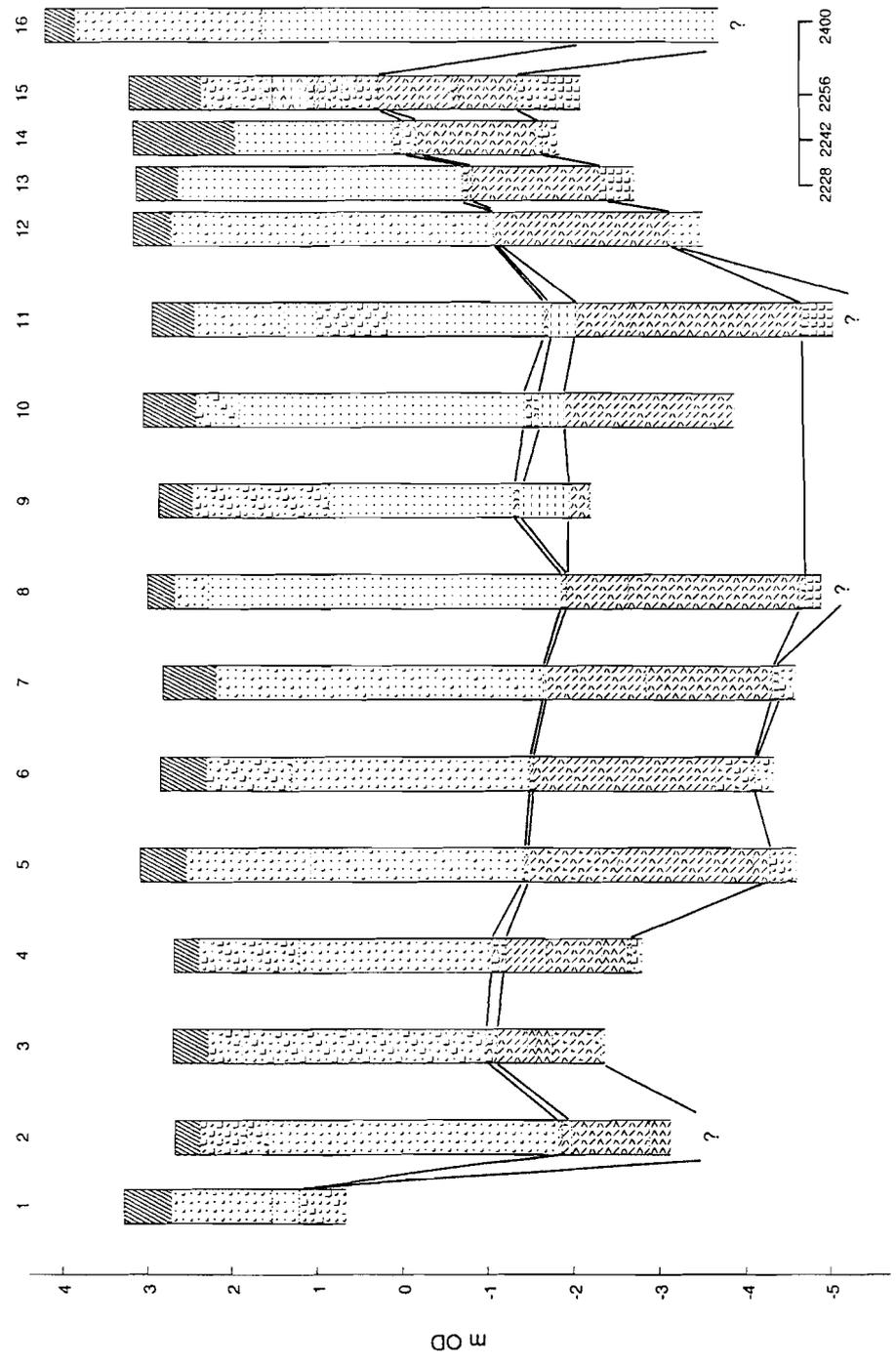


Fig. 3.3. Lithostratigraphy of Shirley Moor.

The contacts between the basal clastic sediments and the overlying peat were invariably gradual. Peat was found between -4.71 m OD and 0.27 m OD, and was thickest (c. 3 m) in borehole 11. In general the peat was unhumified and consisted of a mixture of fine and coarse detritus. Leaf (*Salix* spp. and *Alnus glutinosa*) and wood fragments were recorded in many boreholes and large pieces of wood were encountered at both the northern and southern ends of the transect. In boreholes 9–11 a highly humified layer was found towards the top of the peat. Above the upper peat contact, which was generally recorded at c. -1.25 m OD, a thin (<20 cm) transitional organic silty clay was usually recorded. The overlying sediment reached a maximum thickness of 4.5 m and consisted of grey to black silty sands. Fine laminations usually of clay and shell fragments suggest that the latter were deposited, at least in part, under the influence of marine/brackish conditions. In some boreholes there was a fining upwards sequence and sediment with a higher silt and clay fraction was recorded beneath the disturbed surface layer. In borehole 15 the sediments above the main peat unit were all fine-grained and contained further layers of peat up to 40 cm thick, which are thought to be eroded and re-deposited from the main unit. Borehole 16 was anomalous in that light grey silty sands and medium grey sands were recorded from the modern surface at 4.19 m OD down to -7 m OD. This material lies within a discrete bedrock channel adjacent to Reading Sewer and the northern edge of Chapel Bank.

To the south of Chapel Bank the bedrock sub-surface is shallower and the Holocene sediments thinner (Fig. 3.3). Bedrock declines to a minimum altitude of -1.30 m OD close to borehole 18. The overlying sequence is very similar to that recorded to the north of Chapel Bank, with peat extending to 0.90 m OD in borehole 20, followed by grey and dark grey clastic sediments. The latter consist mainly of silty sands and sands.

A Russian corer was used to collect material for analysis from a site adjacent to borehole 14. Two metres of sediment was obtained, including the peat and the sediment immediately above and beneath it. This location was chosen as being the closest site to the edge of Chapel Bank, where the peat possessed a transitional upper contact. The lithology of the pollen core is summarized in Table 3.1.

Radiocarbon dates

Three radiocarbon dates have been obtained from the sample core (Table 3.2). All dates are quoted in calendar years before the present (BP). Calibrations are based on the CALIB program version 3.0.1 (Stuiver and Reimer 1993) using the bidecadal dataset and intercept method. Sediment accumulation rates and intermediate ages are based on linear interpolation between the means of these dates.

Table 3.1. The lithology of the pollen core.

Unit	Description	Depth (cm)	Altitude m (OD)
VI	Dark grey sand; <i>Nig.</i> 3, <i>Strf.</i> 0, <i>Elas.</i> 0, <i>Lim. sup.</i> 0: Ga4	above 305	above 0.10
V	Dark grey silty clay; <i>Nig.</i> 3, <i>Strf.</i> 1, <i>Elas.</i> 0, <i>Lim. sup.</i> 0: As3, Ag1	305–318	0.10 to -0.03
IV	Black highly organic silty clay; <i>Nig.</i> 4, <i>Strf.</i> 0, <i>Elas.</i> 0, <i>Lim. sup.</i> 0: As1, Ag1, Dh+ Dg+, Sh2	318–324	-0.03 to -0.09
III	Very dark brown detrital peat with wood; <i>Nig.</i> 4, <i>Strf.</i> 0, <i>Elas.</i> 0, <i>Lim. sup.</i> 0: Dg2, Dh2, Dl+, Th ⁺ Wood pieces: <i>Salix</i> 423–422, <i>Alnus glutinosa</i> 422–412, 411–408, 400–393, 374–371, 360–357, 353–352, 347–346, 337–335.	324–472	-0.09 to -1.57
II	Stiff very dark grey clayey silt; <i>Nig.</i> 3, <i>Strf.</i> 0, <i>Elas.</i> 0, <i>Lim. sup.</i> 0: As1, Ag3, Ga+	472–480	-1.57 to -1.65
I	Stiff dark greenish-grey with olive brown mottling silty clay; <i>Nig.</i> 3, <i>Strf.</i> 0, <i>Elas.</i> 0, <i>Lim. sup.</i> 0: As2, Ag2	below 480	below -1.65

Table 3.2. Radiocarbon dates.

Depth (metres from surface)	Altitude (metres OD)	Date (radiocarbon years BP)	Calibrated age (BP) ± 2 sigma	Lab. code	Stratigraphic position
3.18 to 3.30	-0.03 to -0.15	3390±70	3829–3465	Beta-87707	Top of peat
4.05 to 4.16	-0.90 to -1.01	4410±70	5290–4837	Beta-87706	CB-3/CB-4 boundary
4.62 to 4.72	-1.47 to -1.57	5400±80	6385–5931	Beta-87705	Base of peat

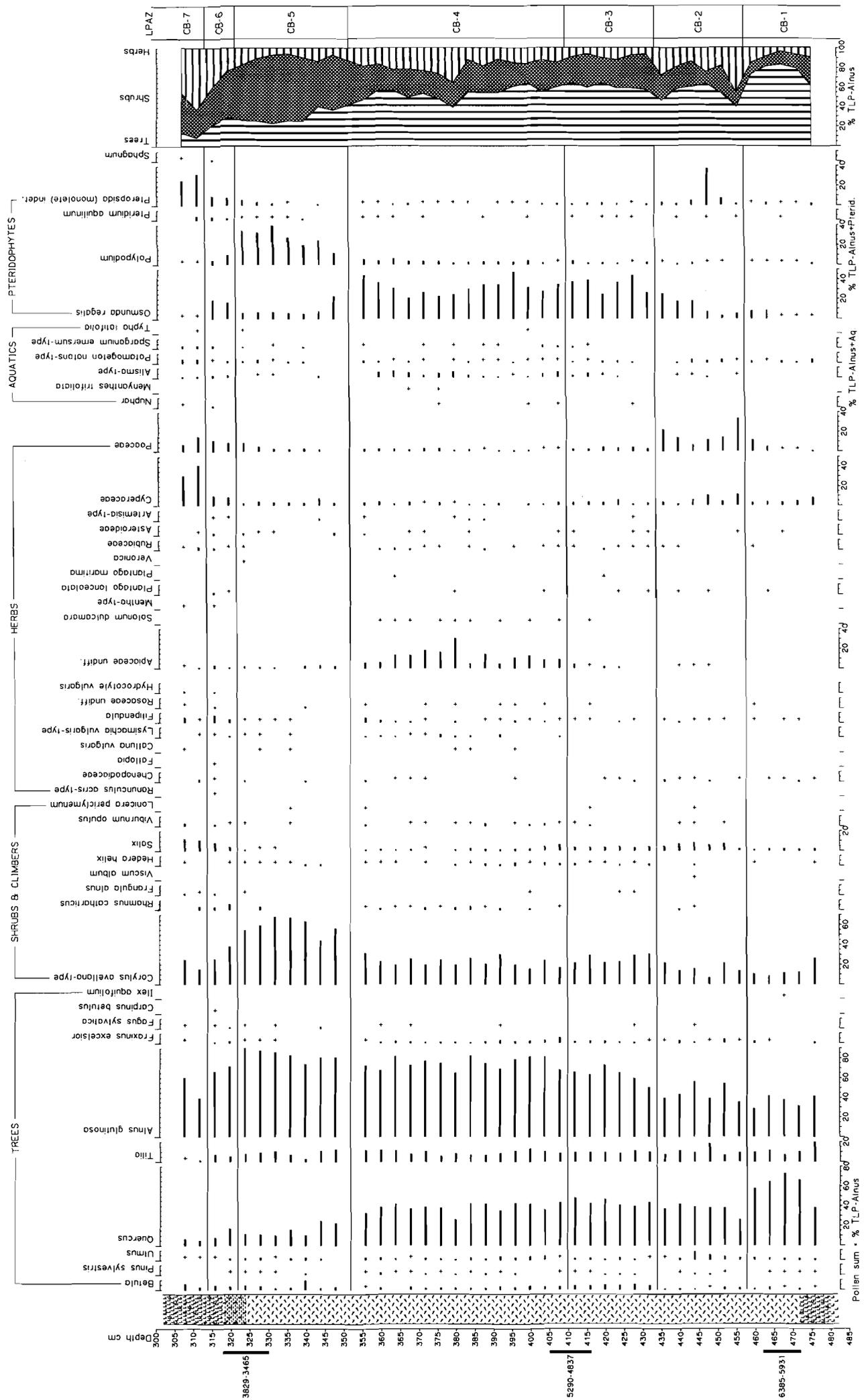


Fig. 3.4. Percentage pollen diagram.

Methods

Samples for pollen, extracted from the core at 4 cm intervals, were subjected to standard treatments (Moore *et al.* 1991). *Lycopodium* tablets (Stockmarr 1971) were added to enable the calculation of absolute pollen frequency (concentrations and accumulation rates). More than 300 grains of land pollen (excluding *Alnus glutinosa*) were counted per sample, except where pollen concentrations dropped below 10,000 grains cm⁻³, which occurred between 340 and 352 cm, coinciding with the presence of wood. Nomenclature for pollen types follows Bennett (1994). The representation of *Alnus glutinosa* at this site is consistently >25% total land pollen (TLP). Following Janssen (1959) and the work of Waller (1993, 1994a) in the Brede and Pannel valleys, *Alnus glutinosa* has been excluded from the pollen sum used to calculate percentages, both for the relative pollen diagram (Fig. 3.4) and for those provided with the description of the pollen assemblage zones. Local pollen assemblage zones (LPAZs) have been defined numerically using the constrained cluster analysis program CONISS (Grimm 1987). The data were transformed using Least Squares transformation, and pollen zones were defined on the basis of total sum of square values >1.7.

The problem of proportional representation (see Moore *et al.* 1991) arising from the use of percentage pollen data can be circumvented by calculating absolute pollen frequencies, either pollen concentrations (grains cm⁻³) or accumulation rates (grains cm⁻² yr⁻¹). Unfortunately, the absolute pollen data from Chapel Bank exhibit a high degree of temporal variation (Fig. 3.5). This situation is commonly encountered with fen peats and can be attributed to the lack of sediment homogeneity (Waller 1993, 1998). The pollen concentration data are nevertheless useful and are presented here because, by showing sustained changes in the representation of all taxa, they provide information on variations in the sediment accumulation rate. The curve for total concentration is based on Total Land Pollen + Aquatics + Pteridophytes.

Description of the Chapel Bank pollen diagram

The seven local pollen assemblage zones defined are described below.

CB-1 476–458 cm: *Quercus*, *Alnus glutinosa*, *Corylus avellana*-type, *Tilia*.

An assemblage dominated by tree and shrub pollen. *Quercus* (c. 60% TLP minus *Alnus glutinosa*) and *Alnus glutinosa* (c. 35% TLP) are the most prominent taxa, followed by *Corylus avellana*-type and *Tilia*. Of the herbs recorded only Poaceae and Cyperaceae are consistently represented. Total pollen concentrations increase from c. 160,196 to c. 1,095,696 grains cm⁻³ at the base of the peat unit (472 cm), although they decline to lower values (c. 222,303 grains cm⁻³) above 468 cm.

CB-2 458–434 cm: *Alnus glutinosa*, *Quercus*, *Corylus avellana*-type, *Tilia*, Poaceae.

CB-2 is defined by high Poaceae percentage and concentration values (max. 33% TLP minus *Alnus glutinosa*). *Alnus glutinosa*, *Salix* and Cyperaceae values also exceed those recorded in CB-1, while *Tilia* and *Corylus avellana*-type percentages are little changed and *Quercus* frequencies are consistently lower (c. 40% TLP minus *Alnus glutinosa*). Pteropsida (monolete) indet. spores attain a peak of 36% (TLP minus *Alnus glutinosa* + Pter.) at 448 cm, above which *Osmunda regalis* values rise steadily.

CB-3 434–410 cm: *Alnus glutinosa*, *Quercus*, *Corylus avellana*-type, *Tilia*, *Osmunda regalis*.

Alnus glutinosa values rise from c. 45% to c. 73% TLP during CB-3. *Corylus avellana*-type (c. 25% TLP minus *Alnus glutinosa*) and *Osmunda regalis* (c. 35% TLP minus *Alnus glutinosa* + Pter.) percentages are consistently higher than in CB-2.

CB-4 410–352 cm: *Alnus glutinosa*, *Quercus*, *Corylus avellana*-type, *Tilia*, *Osmunda regalis*, Apiaceae undiff.

CB-4 is defined by high Apiaceae undiff. percentage values (max. 30% TLP minus *Alnus glutinosa*) although *Alnus glutinosa*, *Quercus*, *Corylus avellana*-type and *Tilia* continue to be well represented. A number of taxa are only recorded consistently in this assemblage, including *Rhamnus catharticus*, *Lysimachia vulgaris*-type, *Solanum dulcamara* and *Alisma*-type. Above 385 cm herb pollen increases to >20% TLP minus *Alnus glutinosa*. High Apiaceae undiff. pollen concentrations (max. 34,104 grains cm⁻³) are recorded between 380 and 368 cm. Two peaks in total pollen concentrations occur towards the top of zone.

CB-5 352–322 cm: *Alnus glutinosa*, *Corylus avellana*-type, *Quercus*, *Tilia*, *Polypodium*.

High frequencies of *Corylus avellana*-type pollen (max. 68% TLP minus *Alnus glutinosa*) and *Polypodium* spores (max. 39% TLP minus *Alnus glutinosa* + Pter.) are recorded. *Quercus* and *Osmunda regalis* percentages decline correspondingly. Total pollen concentrations, low at the start of CB-5 (c. 15,633 grains cm⁻³), increase sharply at 336 cm.

CB-6 322–314 cm: *Alnus glutinosa*, *Corylus avellana*-type, *Quercus*, *Tilia*, *Osmunda regalis*.

Corylus avellana-type percentages are lower than in the preceding assemblage, while *Osmunda regalis* values are higher. Cyperaceae and Poaceae frequencies exceed those recorded in CB-3, CB-4 and CB-5.

CB-7 314–308 cm: *Alnus glutinosa*, Cyperaceae, *Corylus avellana*-type, Pteropsida (monolete) indet.

High Cyperaceae (c. 40% TLP minus *Alnus glutinosa*), *Salix*, Poaceae and Pteropsida (monolete) undiff. percentage values are recorded. *Alnus glutinosa* continues to be well represented although the pollen of other previously common tree taxa, *Quercus* and *Tilia*, is scarce. Total pollen concentrations rise steadily to a max. 1,091,020 grains cm⁻³ at 308 cm, continuing a trend evident from the top of CB-5.

Table 3.3. The habitats of plants contributing to pollen types based on ecological preferences.

Dryland taxa	Either habitat	Wetland taxa
<i>Ulmus</i> ; <i>Tilia</i> ; <i>Pteridium aquilinum</i>	<i>Betula</i> ; <i>Quercus</i> ; <i>Fraxinus excelsior</i> ; <i>Corylus avellana</i> -type;	

Interpretation

A number of difficulties arise specifically from using sediment deposited within fen systems for pollen-based vegetation reconstruction. One is distinguishing the environment (wetland or dryland) of origin for many taxa. An attempt has been made here (Table 3.3) to divide the main palynomorph types (>2% TLP minus *Alnus glutinosa*) into wetland and dryland taxa based on ecological criteria (Grime *et al.* 1988; Rodwell 1991, 1995). This forms the basis for dividing the interpretation and discussion sections of this paper into wetland and dryland vegetation history, although it is recognized that a large number of taxa could be derived from either dryland or wetland communities.

When interpreting the Chapel Bank pollen data it is important to understand the size and characteristics of the pollen source area, that is the area from which pollen will be recruited into the depositional sequence. Three source areas can be distinguished: local, extra-local and regional (Jacobson and Bradshaw 1981). For the purpose of interpreting diagrams from fen peats (see Waller in press) these terms can be defined as follows: local pollen originates from the wetland plants growing at and immediately around the sampling site, as on the floor of the Rother valley, extra-local pollen originates from dryland areas within a few hundred metres of the sampling site, for example on Chapel Bank, while regional pollen is derived from distances of more than several hundred metres.

With fen carr occupying the lower Rother valley for most of the period covered by the pollen diagram, the Chapel Bank assemblages are dominated by local pollen. This is not only due to the quantity of pollen produced locally, particularly by *Alnus glutinosa*, but also because the representation of dryland taxa is reduced in such circumstances as a result of the filtration of pollen grains when transported through the trunk space (Tauber 1965).

The core for pollen analysis was chosen from close to the upland edge to maximize the representation of extra-local pollen. Borehole 14 is now approximately 200 m from the limit of the Holocene deposits, though the sequence extends down to bedrock, showing that at the start of peat formation it was located at the dryland/wetland edge. Not only does the quantity of pollen deposited decline with distance away from source (Birks and Birks 1980; Moore *et al.* 1991), but dispersal characteristics result in differential representation of taxa in the extra-local and regional pollen components (Waller 1998). Of the dryland

tree pollen present at Chapel Bank, *Tilia* and *Fraxinus excelsior* pollen is poorly dispersed. In the case of the former the grains are large and sticky and are produced in midsummer when wind velocities within the canopy are lowest (Greig 1982; Huntley and Birks 1983). These taxa are therefore likely to be under-represented in the regional pollen rain. Conversely taxa with well dispersed pollen such as *Quercus* and *Ulmus* will be over-represented (Andersen 1970). Assuming that the vegetation of the extra-local and regional source areas are the same, sites close to the upland edge afford the best opportunity to determine accurately the composition of dryland vegetation.

Wetland vegetation history: Shirley Moor

The basal Chapel Bank assemblage (CB-1) reflects the vegetation changes occurring at and immediately adjacent to the site as waterlogging resulted in peat formation over a formerly dry surface of bedrock. The high pollen concentrations at 476 cm and 472 cm, the samples immediately below the peat, suggest that water-levels rose gradually. The high *Quercus* values of CB-1 probably therefore reflect the tolerance of oak to waterlogging and the survival of existing trees within marginal fen woodland. Pollen values for *Alnus glutinosa* are sufficiently high at the base of the diagram to suggest that alder-dominated fen carr was already established within the lower Rother valley by 6385–5931 cal. yrs BP (Beta-87705).

The CB-2 assemblage (*c.* 5800 to 5350 cal. yrs BP) indicates a further rise in water-levels in the Rother valley, with lower *Quercus* and increased *Alnus glutinosa* pollen values reflecting the local establishment of fen carr. The values of *Salix* recorded in CB-2 are, given the under-representation of this genus in the pollen record (Huntley and Birks 1983), sufficient to suggest that willow was also an important constituent of the local vegetation. The early stages of fen carr are frequently characterized by the co-dominance of *Salix cinerea* and *Alnus glutinosa* (Rodwell 1991) and *Salix* leaves were commonly encountered towards the base of the peat in the litho-stratigraphic survey. *Osmunda regalis*, values for which increase during CB-2, is another typical component of fen carr vegetation. The CB-2 assemblage is also distinguished by high Poaceae values. The Poaceae pollen is probably derived from reedswamp, which would be consistent with rising water-levels. However, the absence of extensive

Phragmites macrofossil remains, with *Alisma*-type and *Potamogeton natans*-type pollen also recorded, suggests the occurrence of marginal aquatic areas close to, but not at, the site.

The lower Poaceae values recorded in CB-3 (c. 5350 to 4500 cal. yrs BP) coupled with the rising percentages of alder suggest the extensive development of fen carr on the floor of the Rother valley. With the representation of *Osmunda regalis* high throughout CB-3 the local vegetation appears analogous to modern fen carr, the *Alnus glutinosa*-*Carex paniculata* woodland of Rodwell (1991) or the *Osmundo-Alnetum* communities of Wheeler (1980). Rodwell (1991) suggested that with ageing such vegetation is most likely to be dominated by *Alnus glutinosa* with *Salix cinerea* being shaded out. The pollen assemblage in CB-3 suggests this may have been the case at Chapel Bank, with *Alnus glutinosa* continuing to increase its pollen contribution, and a slight decline in *Salix* percentages.

Alnus glutinosa pollen and *Osmunda regalis* spores also dominate CB-4 (c. 4500 to 4250 cal. yrs BP), an assemblage distinguished by an increase in Apiaceae undiff. pollen. Members of the Apiaceae (e.g. *Peucedanum*, *Apium* and *Oenanthe*) commonly occur as part of the field layer in fen systems. Amongst the other fen carr taxa recorded are the shrubs *Rhamnus cartharticus*, *Salix* and *Viburnum opulus* and the herbs *Filipendula*, *Lysimachia vulgaris*, *Solanum dulcamara* and probably Rubiaceae and Cyperaceae. A *Lysimachia vulgaris* sub-community of Rodwell's (1991) *Alnus glutinosa* - *Carex paniculata* woodland is indicated. The aquatics present in CB-4, *Alisma*-type, *Potamogeton natans*-type and *Spartanium emersum*-type are indicative of base-rich hydrological environments. Conditions are likely to have been suitable for these taxa within water courses flowing through the fen carr vegetation.

High *Alnus glutinosa* percentages are maintained throughout CB-5 (c. 4250 to 3650 cal. yrs BP), with the highest values recorded at Chapel Bank occurring at the top of this assemblage. *Osmunda regalis* frequencies decline and there is a marked increase in *Polypodium* spores. This shift probably reflects changes in the immediate site conditions. Within fen woodland *Polypodium* occurs as an epiphyte on *Alnus glutinosa*, and the proximity of alder to the site during CB-5 is demonstrated by the presence of wood in the core. It is more difficult to interpret the high *Corylus avellana*-type pollen values and the decline in *Quercus*, as the environment of origin for these pollen types is not clear (Table 3.3). Drier conditions may have resulted in hazel colonizing the valley floor (see Discussion). However, the decline in *Quercus* (which might also be expected to invade fen carr in such circumstances) and the continued dominance of *Alnus glutinosa* suggest that the fluctuations in *Corylus avellana*-type and *Quercus* representation are the result of changes in dryland vegetation. Although the designation *Corylus avellana*-type includes pollen grains belonging to the

wetland species *Myrica gale*, the overwhelming majority of grains in CB-5 were attributable to hazel (*Corylus avellana*).

Pollen zone CB-6 appears transitional and coincides with the switch from the deposition of the organic silty clay (unit IV) to the grey clay (unit V). The increased representation of Cyperaceae and Poaceae and the decline in *Alnus glutinosa* suggest more open local vegetation and possibly a trend towards wetter conditions.

This trend continues in CB-7, with the decline in *Alnus glutinosa* and further increases in Poaceae and particularly Cyperaceae. The latter taxa suggest the presence of transitional sedge fen and reedswamp communities prior to the arrival of high energy marine/brackish environments and the deposition of the grey sands (unit VI). There is, however, no increase in the pollen of salt-tolerant plants (e.g. Chenopodiaceae and *Plantago maritima*) in CB-7. Alternatively, this and the preceding assemblage may represent a distinct, slow phase, of freshwater sedimentation prior to marine inundation (see Discussion). This hypothesis is supported by the high pollen concentrations which also suggest a slowing down in the rate of sediment accumulation at this time.

Dryland vegetation history: Chapel Bank

Tilia values of up to 20% TLP minus *Alnus glutinosa* are found at the base of the Chapel Bank sequence. Such frequencies, given that *Tilia* is under-represented in pollen diagrams because of poor pollen dispersion, are sufficient (Huntley and Birks 1983) to indicate that lime-dominated woodland occurred close to the site prior to peat formation. The initial decline in *Tilia* frequencies in CB-1 coincides with peat formation and may be attributed to waterlogging. Lime is less tolerant of such conditions than *Quercus* and would not have survived in the immediate vicinity of the site. However, *Tilia* values of c. 10% TLP minus *Alnus glutinosa* continue from CB-1 through into CB-5 (c. 6250-3650 cal. yrs BP) demonstrating that lime continued to be an important component of the vegetation of Chapel Bank island throughout this period. *Quercus* and *Corylus avellana* (the latter probably as an understorey shrub) also appear to have been common constituents of the dryland woodland, while *Betula* and *Ulmus* appear to have been scarce.

Ulmus values are low throughout the Chapel Bank sequence. However, *Ulmus* pollen percentages fall from a peak of 10% to <2% (TLP minus *Alnus glutinosa*) at 444 cm. The chronology available suggests this reduction occurred c. 5600 cal. yrs BP (4850 BP). It may therefore be a weak (or distant) manifestation of the elm decline, which occurs in the Pannel and Brede valleys at c. 5000 BP (Waller 1993, 1994a), and has been recorded at sites across north-west Europe.

There is little evidence of human interference with the dryland vegetation of Chapel Bank during peat formation. The *Ulmus* decline is poorly defined and in any case could

be a consequence of disease (Rackham 1980; Perry and Moore 1987; Girling 1988). Moreover, *Tilia*, noted for its sensitivity to human interference (Turner 1962), shows no such decline. Increases in herb pollen such as Poaceae in CB-2 and Apiaceae undiff. in CB-4 are likely to be a product of changing wetland conditions. Only occasional *Plantago lanceolata* grains and *Pteridium aquilinum* spores are recorded and other herbs often associated with anthropogenic activity, such as *Rumex* and *Urtica*, are absent.

As previously noted, the increase in *Corylus avellana*-type pollen and the decline in *Quercus* in CB-5 may reflect vegetational changes occurring on Chapel Bank. This shift is suggestive of disturbance (although not necessarily human-induced), as hazel would be expected to flower more profusely following the opening up of the canopy. However, if this change occurred on the dryland, it is surprising that the representation of *Tilia* and herb pollen remains substantially unchanged.

The overall decline in tree pollen during CB-6 and CB-7 may be proportional, a product of the increase in locally produced herb pollen. These assemblages coincide with the end of peat formation and the increases in Cyperaceae and Poaceae appear to be the result of wetland vegetation change. Anthropogenic indicators remain scarce. The pollen concentration data are suspect due to likely changes in the sediment accumulation rate and cannot help to resolve the problem of proportionality arising from the percentage pollen data.

Discussion

Wetland vegetation: main components and mechanisms of change

The deepest Holocene sediment recorded in the lithostratigraphic survey was the bluish-grey clay with black mottling in boreholes 7, 8 and 11. The colour, texture and altitude of this sediment suggest that it can be correlated with an extensive marine/brackish deposit found underlying the major peat unit of the lower Rother valley (Waller *et al.* 1988). The boundary between the clay and the overlying peat at the Newenden, Small Hythe and Blackwall Bridge sections, as with this transect, occurs at depths of below -3 m OD. Deposition of this unit ceased and extensive peat formation commenced prior to 5852–5321 cal. yrs BP (IGS/C14/14) at Wittersham (Welin *et al.* 1971) and possibly as early as *c.* 6850 cal. yrs BP, a date derived from the equivalent stratigraphic boundary in the Brede valley (Waller 1994a). Peat formation in both valleys began while RSL was still rising and marine/brackish sediments continued to be deposited over Walland Marsh (see Long *et al.* 1998), presumably reflecting relatively high inputs of freshwater and their sheltered locations.

Without more precise details of the timing of extensive peat development in the lower Rother valley it is difficult

to interpret the basal Chapel Bank assemblages with peat formation beginning 6385–5931 cal. yrs BP (Beta-87705). Altitudinal comparison suggests paludification at the Chapel Bank site commenced at -1.57 m OD, during the deposition of the main peat unit of the lower Rother. However, compaction of the underlying soft bluish-grey clays is likely to have altered the altitude of the regressive overlap, now at -4.31 m OD in borehole 7. It is possible therefore that the basal assemblages CB-1 and CB-2, indicative of rising water-levels, are coeval with the deposition of the bluish-grey clay and represent the landward advance of marginal aquatic communities, and that the increase in alder and other fen carr taxa at the beginning of CB-3 marks the beginning of widespread peat formation in the lower Rother valley. The amount of compaction required is, however, difficult to calculate as while the dryland/peat contact would initially have been higher than the bluish-grey clay/peat contact, the altitude at which basal peats form is variable (Shennan 1986).

The fen carr vegetation which occupied the Rother valley from *c.* 5350 cal. yrs BP, and probably through to *c.* 3650 cal. yrs BP, strongly resembles the mid-Holocene wetland vegetation of the Brede valley (Waller 1994a). At both sites, as well as high *Alnus glutinosa* and *Osmunda regalis* values, a wide range of shrub and herb taxa associated with fen environments are recorded. Such rich fen systems are likely to have been promoted by the flow of base-rich water from the river catchments. The alder-dominated communities recorded at Horsemarsh Sewer and sites across the northern half of Walland Marsh (Waller *et al.* in press) are similar in composition, although *Salix* and *Betula* pollen is more abundant and fewer herbs are recorded. The latter probably represent a nutrient-poor facies.

Although the input of base-rich water will have been important in promoting alder-dominated fen carr, the persistence of this community on the floor of the Rother valley area requires further explanation. *Alnus glutinosa* is generally regarded as forming seral (non-stable) vegetation which results in aeration and acidification (Walker 1970). Grime *et al.* (1988) suggested that *Alnus glutinosa* trees live for a maximum of 300 years and that germination is usually limited in mature woodland. The *c.* 1700 calendar years over which *Alnus glutinosa* pollen values exceed 50% TLP at Chapel Bank is equivalent to approximately five generations of trees. McVean (1953) argued that *Alnus glutinosa* populations could be self-sustaining against a background of rising water-levels. A number of authors (Kidson and Heyworth 1973; Smith and Morgan 1989; Waller 1993, 1994a) have therefore suggested that at coastal sites the persistence of alder-dominated fen carr can be attributed to rising RSL. In the Romney Marsh area, Long and Innes (1993) and Waller *et al.* (in press) indicate rising RSL between *c.* 7000 cal. yrs BP and 4000 cal. yrs BP. A decline in the rate of RSL rise after *c.* 4000 cal. yrs BP would potentially lead to drier conditions. However, alder growth seems to have

continued after *c.* 4000 cal. yrs BP, not only in the lower Rother valley, but also at sites in the northern half of Walland Marsh. It is unlikely therefore that external factors alone are responsible for the longevity of the mid-Holocene *Alnus glutinosa*-dominated carr communities of the Romney Marsh region. The over-representation of alder in the pollen record may be giving a false impression of stability. Alternatively, stability may be linked to variations in the production and decomposition of organic material (Waller *et al.* in press), with low water-levels resulting in high rates of decomposition and slow rates of sediment accumulation and *vice versa*.

Peat formation ended on Walland Marsh as a result of marine inundation which took place from *c.* 2500 cal. yrs BP onwards (Waller *et al.* in press). The date from the top of the peat at Chapel Bank, 3829–3465 cal. yrs BP (Beta-87705) appears therefore to be anomalously old. This may in part be a reflection of the amount of sediment (10 cm) extracted for dating. However, the Chapel Bank date is compatible with evidence obtained from two other sites on the inland periphery of the Romney Marsh depositional complex. At Horsemarsh Sewer (Waller *et al.* in press) peat, overlain by 0.83 m of sediment, ceased to form 3456–2993 cal. yrs BP (Beta-87704). At Brede Bridge (Waller 1994a), only 1.5 m of organic sediment was deposited after 4232–3834 cal. years BP (SRR-2646), compared with 6 m in the preceding *c.* 2000 cal. yrs BP. Chapel Bank, Horsemarsh Sewer and Brede Bridge all suggest that a dramatic decline in the sediment accumulation rate occurred after *c.* 4000 cal. yrs BP. While the radiocarbon chronologies are insufficient for precise correlation, this change appears to be linked to the *c.* 4000 cal. yrs BP slowing-down in the rate of RSL rise in the Romney Marsh region. Although peat formation continued on Walland Marsh for more than 1000 calendar years, this slowing-down produced a shift towards acidic plant communities at sites in the southern half of Walland Marsh which were isolated from base-rich water. The transitional organic clay (unit IV) and the thin grey clay (unit V) at Chapel Bank, which appears to be freshwater in origin, may therefore represent more than 1000 calendar years of sedimentation with marine conditions (and the deposition of the grey sand, unit VI) not returning to the lower Rother valley until after *c.* 2300 cal. yrs BP (see Long *et al.* 1998). A period of slow sediment accretion would account for the highly humified layer recorded towards the top of the peat in some boreholes during the lithostratigraphic survey.

The dominance of fen carr taxa in the Chapel Bank sequence and the absence of inorganic lenses within the peat suggest that the channel sediments found in borehole 16 (144 m away from the pollen core sampling site) post-date, and were therefore incised through, the peat. In composition, the sediments from borehole 16 strongly resemble the channel deposits found at Newenden, Small Hythe, the Royal Military Canal and at the western end of the Stone Bridge to Snargate section (Waller *et al.* 1988).

This body of sediment probably delimits a medieval course of the river Rother (Eddison 1985, 1988, 1995).

Evidence for past human activity at Chapel Bank

As previously noted the high *Tilia* values recorded at Chapel Bank indicate that lime-dominated woodland occurred adjacent to the site. Comparable percentages have been recorded during the mid-Holocene at Horsemarsh Sewer (Waller *et al.* in press) and at sites in the Brede and Pannel valleys (Waller 1993, 1994a). This suggests that, in spite of geological differences between the Wadhurst Clay of Chapel Bank and the sandier lithologies of the Ashdown Beds found to the south, the dryland woodlands of the region were similar in composition prior to human disturbance. This uniformity is apparent at a larger scale, since high lime values have been recorded at sites across southern England (Birks *et al.* 1975; Greig 1982; Bennett 1989).

Tilia pollen percentages fall during the mid-Holocene at sites in the Pannel and Brede valleys (Waller 1993, 1994a, 1998). Both gradual upcore reductions and abrupt declines in representation (dated at both sites to *c.* 4000 cal. yrs BP) occur. In contrast, after initial declines, lime values at Chapel Bank and Horsemarsh Sewer remain substantially unchanged through to the end of peat formation at *c.* 3650 cal. yrs BP and *c.* 3200 cal. yrs BP respectively. The gradual declines in *Tilia* values recorded in the Brede and Pannel valleys were attributed to an expansion in the wetland area by Waller (1994b). Just as poor pollen dispersion results in a marked fall in *Tilia* representation away from source (see Interpretation) so any increase in the distance between a pollen site and dryland will result in lower *Tilia* values (Waller 1994b). This mechanism may be responsible for the decline in *Tilia* pollen values at the base of the Chapel Bank sequence. The absence of any subsequent upcore fall in *Tilia* frequencies may be attributable to the steep sides of the buried bedrock sub-surface, so that the distance between the pollen site and dryland remained relatively constant through time. Reconstructing the relationship between the pollen site and the dryland edge at Chapel Bank during peat formation is, however, difficult because of the subsequent incision of the sand channel recorded at borehole 16.

The sharp decline in *Tilia* pollen recorded at Brede Bridge and Pannel Bridge are accompanied by increases in taxa indicative of both pastoral and arable anthropogenic activity (Waller 1993, 1994a). A phase of late Neolithic/early Bronze Age woodland destruction was envisaged by Waller (1994a). That no such decline is recorded at either Chapel Bank or Horsemarsh Sewer suggests that this clearance phase did not affect dryland areas bordering the north-western edge of the marshland. This conclusion is surprising, in that the Shirley Moor area was originally chosen for analysis because it was

thought particularly well suited to human occupation. The absence of activity at this time could reflect geographical differences in, for example, the suitability of the soils for cultivation. Unfortunately, because of the end of peat formation and lower rates of sedimentation, the timing of the destruction of the *Tilia*-dominated forests of these northern regions is not presently known.

Conclusions

Peat formation at the Chapel Bank site lasted from *c.* 6250 to *c.* 3600 cal. yrs BP. *Alnus glutinosa*-dominated fen carr prevailed on the floor of the lower Rother valley for most of this period. Similar communities occurred across the western side of Walland Marsh during the mid-Holocene, promoted by base-rich water from the river valleys. Fen carr with alder seems to have been self-sustaining, persisting for a long period despite changes in the rate of RSL rise. Sedimentation appears to have virtually ceased in the lower Rother valley and other sites peripheral to the marshland from *c.* 3600 cal. yrs BP until

marine inundation occurred sometime after *c.* 2300 cal. yrs BP.

During the mid-Holocene the dryland vegetation of Chapel Bank consisted of woodland with *Tilia*. Vegetation of a similar composition occurred on the geologically contrasting slopes of the Brede and Pannel valleys. A late Neolithic/early Bronze Age phase of woodland disturbance recognized in the latter valleys is not evident at Chapel Bank. There is also no evidence in the Chapel Bank pollen diagram of anthropogenic activity, despite the superficial attraction of the site for prehistoric occupation.

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