# ROMNEY MARSH

## Persistence and Change in a Coastal Lowland

*Edited by*
*Martyn Waller, Elizabeth Edwards and Luke Barber*

*www.rmrt.org.uk*

Romney Marsh Research Trust
2010

Published by Romney Marsh Research Trust, Sevenoaks, Kent



ISBN 978-0-9566575-0-3

Printed by Short Run Press, Exeter

The Romney Marsh Research Trust exists to promote, co-ordinate and disseminate research into the historical, social, economic and physical development of Romney and Walland Marshes and their immediate hinterlands. The Trust receives, raises and holds funds to meet grant applications to support and publish research into the Marsh and invites individuals to become Friends of the Romney Marsh Research Trust and to participate in lectures, conferences, field visits and research projects. Details of the Trust and membership are available on the web-site www.rmrt.org.uk.

# Contents


List of Contributors vii

Foreword and publications of members of the Romney Marsh Research Trust from 2002 (*Martyn Waller, Elizabeth Edwards and Luke Barber*) ix

1. The Holocene Coastal Deposits of Sussex: a Re-evaluation (*Martyn Waller and Antony Long*) 1

2. The Mid-Late Holocene Evolution of Southern Walland Marsh and the Origin of the 'Midley Sand' (*Jason Kirby, David Clarke, Tim Shaw and Emma Toole*) 23

3. Holocene Fire Histories from the Edge of Romney Marsh (*Michael Grant and Martyn Waller*) 53

4. Adapting to PPG16: Planning-led Archaeology on the Walland, Denge and Romney Marshes of Kent and East Sussex, 1990–2010 (*Casper Johnson*) 75

5. The Romney Marsh Archaeological Gazetteer: its Creation and Use (*Alan Tyler*) 93

6. Overcoming disaster? Farming Practices on Christ Church Priory's Marshland Manors in the Early 14th Century (*Sheila Sweetinburgh*) 97

7. 'My boddye shall lye with my name Engraven on it': Remembering the Godfrey family of Lydd, Kent (*Terreena Bellinger and Gillian Draper*) 117

8. Aspects of Corporate Landownership and the Fortunes of Livestock Farmers on Walland Marsh and Denge Marsh, *c.* 1730–90 (*Anne Davison*) 141

9. Boom, Slump and Intervention: Changing Agricultural Landscapes on Romney Marsh, 1790 to1990 (*Hadrian Cook*) 155

Index of Places and People 185

# Contributors

LUKE BARBER
Sussex Archaeological Society, Barbican House Museum, 169 High Street, Lewes, East Sussex BN7 1YE. E-mail: research@sussexpast.co.uk

TERREENA BELLINGER
95 Godinton Road, Ashford, Kent TN23 1LN.

DAVID CLARKE
Department of Geography, University of Liverpool, Roxby Building, Liverpool L69 7ZT.

HADRIAN COOK
Centre for Earth and Environmental Science Research, School of Geography, Geology and the Environment, Kingston University, Penrhyn Road, Kingston, Surrey KT1 2EE. E-mail: h.cook@kingston.ac.uk

ANNE DAVISON
50 Park Avenue, Maidstone, Kent ME14 5HL.
E-mail: contact_anne_davison@hotmail.com

GILLIAN DRAPER
Lynton Lodge, 1 Clarendon Road, Sevenoaks, Kent TN13 1EU. E-mail: g.m.draper@kent.ac.uk

ELIZABETH EDWARDS
School of History, Rutherford College,
The University, Canterbury, Kent CT2 7NX.
E-mail: e.c.edwards@kent.ac.uk

MICHAEL GRANT
Wessex Archaeology, Portway House, Old Sarum Park, Salisbury, Wiltshire SP4 6EB.
E-mail: m.grant@wessexarch.co.uk

CASPER JOHNSON
Archaeology, Transport and Environment, East Sussex County Council, County Hall, St Anne's Crescent, Lewes, East Sussex BN7 1UE.
E-mail: Casper.Johnson@eastsussex.gov.uk

JASON R. KIRBY
School of Natural Sciences and Psychology, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF. E-mail: J.R.Kirby@ljmu.ac.uk

ANTONY LONG
Environmental Research Centre, Department of Geography, University of Durham, Science Site, South Road, Durham DHI 3LE.

TIM A. SHAW
School of Natural Sciences and Psychology, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF.

SHEILA SWEETINBURGH
11 Caledon Terrace, Canterbury, Kent CT1 3JS.
E-mail: S.M.Sweetinburgh@kent.ac.uk

EMMA TOOLE
School of Natural Sciences and Psychology, Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF.

ALAN TYLER
22 Albert Road North, Malvern, Worcestershire WR14 2TP. E-mail: alantyler22@aol.com

MARTYN WALLER
Centre for Earth and Environmental Science Research, School of Geography, Geology and the Environment, Kingston University, Penrhyn Road, Kingston, Surrey KT1 2EE.
E-mail: m.waller@kingston.ac.uk

*Romney Marsh: Persistence and Change in a Coastal Lowland*
*(eds. M. Waller, E. Edwards and L. Barber), Romney Marsh Research Trust, 2010, 53–73*

# 3. Holocene Fire Histories from the Edge of Romney Marsh

*Michael Grant and Martyn Waller*

*The Holocene fire history of the Pannel and Brede valleys is evaluated using records of microscopic charcoal from five sites that had previously been studied using pollen analysis. The sites range in age from* c. *9700 cal. yr BC to cal. yr AD 400. Peaks in the deposition of charcoal have been identified and are discussed in relation to climatic, vegetational, anthropogenic and sedimentological influences. A number of peaks in charcoal frequency occur during the early Holocene at Pannel Bridge. These correspond with vegetation changes, as inferred from the pollen record, which indicate the* in situ *burning of vegetation. With Late Mesolithic flint scatters occurring in close proximity, humans may well have been a source of ignition, though the frequency and intensity of burns is likely to also be linked to conducive climatic conditions and/or suitable sources of fuel. The* Tilia*-dominated woodlands of the mid-Holocene appear to have been relatively free from such disturbance, yet immediately after the* Ulmus *decline a phase of burning can be identified at sites from both valleys. Charcoal frequencies increase during the late Holocene, although changes in the nature and rate of sedimentation at the sites investigated are likely to have had an important influence on the charcoal record. This increase is also likely in part to reflect the use of fire in domestic and industrial settings.*

## Introduction

Systematic palaeoenvironmental investigations have been undertaken in the Romney Marsh area since the 1980s. The Holocene vegetation history of the region has been one of the main focuses of this activity, with pollen analysis of the peat and organic-rich sediments undertaken to reconstruct the vegetation of both the former wetland and the adjacent upland/dryland areas (Waller 2002; Long *et al*. 2007). One potential influence on vegetation is fire. Microscopic (<200 μm along the longest axis) charcoal particles commonly occur in deposits used for pollen analysis, providing an opportunity to reconstruct fire, alongside vegetation, history. The technique has been used successfully in similar environments within the UK, including Hartlepool Bay (Tooley 1978), Thatcham (Barnett 2009), Star Carr (Mellars and Dark 1998) and the Severn Estuary (Bell 2000; Bell *et al*. 2002).

Although Rackham (2003) states that most native British woodland is very difficult to burn, even under drought conditions, there is now a large body of evidence to suggest that fire played an important part in the patch dynamics of early Holocene river valley and intertidal environments. Extensive charcoal spreads have been exposed in sediments (dating to *c*. 5400 cal. yr BC) in the Severn Estuary and Bristol Channel (Bell *et al.* 2000; 2002). Charred oak trees found at

Goldcliff and Westward Ho! are associated with Late Mesolithic sites. Whitehouse (2000) reported burnt roots, stumps and trunks (mainly of *Pinus sylvestris* and *Betula*), over a distance of *c.* 5 km$^2$ (dated 3300 to 2300 cal. yr BC), attributed to natural fire, from Thorne Moors, Lincolnshire. A combination of conditions is likely to be required for fire to spread (Moore 2000). These include a source of fuel, such as dead vegetation on the ground, and conducive climate/weather conditions.

Sources of ignition are likely to be both natural (lightning) and resulting from human activity. The latter may be accidental or deliberate with the intention of facilitating hunting, making the vegetation more attractive for game, increasing seed/fruit production (Mellars 1976; Mason 2000), or to clear areas for crop production (e.g. Landnam; Iversen 1941). In addition, the presence of charcoal in association with human activity may not necessarily indicate the *in situ* burning of vegetation, but rather the combustion of material collected for domestic or industrial purposes (pottery production, metallurgy).

The aim of this study is to reconstruct the Holocene fire history of the Brede and Pannel valleys on the western edge of Romney Marsh. The rate of sediment accumulation and sampling interval will determine whether a fire, an instantaneous event, will be detected through the frequency of charcoal on pollen slides (Patterson *et al*. 1987). Some fires are likely to be missed, nevertheless the use of multiple sites (available from this area for the mid-Holocene) should allow fire events which are either local or isolated in time to be distinguished and thereby enable periods of regionally enhanced/reduced burning to be detected. Potential causes of fires can be assessed against the vegetation record in the corresponding pollen samples and the archaeological evidence for the human occupation of the region.

## Study Area

The Brede and Pannel are two of a series of river valleys which extend from the High Weald into the western side of the Romney Marsh alluvial complex (Fig. 3.1). The valleys are separated by west–east trending ridges which rise to 100 m OD and unite to form substantial plateaus. The underlying geology is formed from the Hastings Bed Group, which being lithologically variable, today gives rise to both stagnogley (where drainage is impeded) and brown earth soils (McRae and Burnham 1975). Contained within the alluvial fills of the valleys is a thick (up to 6.5 m) laterally persistent peat deposit. Widespread peat formation began *c*. 4500 cal. yr BC and had ceased by *c*. cal. yr AD 400 (Waller *et al*. 2006), though locally organic sedimentation began earlier and ended later (Waller 2002; Long *et al*. 2007). The bulk of the peat formed within eutrophic fen communities (particularly *Alnus glutinosa* dominated fen carr) though plant communities indicative of more acidic conditions (with *Myrica gale* often a prominent component) became more prevalent during the later stages of peat formation in lower valleys (Waller 2002; Long *et al*. 2007).

The uplands south-west of Rye are particularly rich in prehistoric flint scatters. A total of 82 such scatters are listed in the parishes of Fairlight, Guestling, Icklesham, Pett and Udimore by Tyler (2007) with 12 attributed to the Mesolithic and a further two to the Mesolithic/Neolithic. This may in part reflect the unevenness of archaeological fieldwork, particularly in the parish of Pett (which includes the Pannel valley), where 42 scatters are recorded. Excavated sites at Fairlight (Moore 1979) and Pannel Bridge (Holgate and Woodcock 1988; 1989) include material assigned to the Late Mesolithic (*c*. 7500 to 4300 cal. yr BC), a period when a new pattern of resource exploitation appears to have developed with a greater reliance on 'base camps' and coastal exploitation (Holgate 2003), though many sites probably remain hidden, submerged/buried as a result of rapidly rising sea level during the early Holocene. The Mesolithic flint scatters in the Pannel valley are associated with springs and are thought to represent short-stay temporary hunting camps. One scatter, situated 70 m from the Pannel Bridge pollen sequence, covers an area 50 m diameter and includes material buried within a thin layer of colluvium (Holgate and Woodcock 1988; 1989). Flints of a Late Neolithic/Early Bronze Age date, which were also recovered from this site, were similarly thought to be associated with transitory activity. The most notable evidence for settlement in the region during later prehistory is a ploughed-out round barrow and a rectangular enclosure near Playden, north of Rye. A date of 2460 to 1770 cal. yr BC (3690±115 BP; BM-450) is associated with the first phase of barrow construction (Cleal 1982). Aside from the flint scatters there are few other signs of later prehistoric occupation, though Bronze Age metal work and a stone axe have been found near Icklesham and Iron Age pottery has been recorded from the Pannel valley and the edge of Pett Level (Tyler 2007).

In contrast to the later prehistoric periods, Roman sites are common on uplands adjacent to the Brede and Pannel valleys. They include iron-working sites

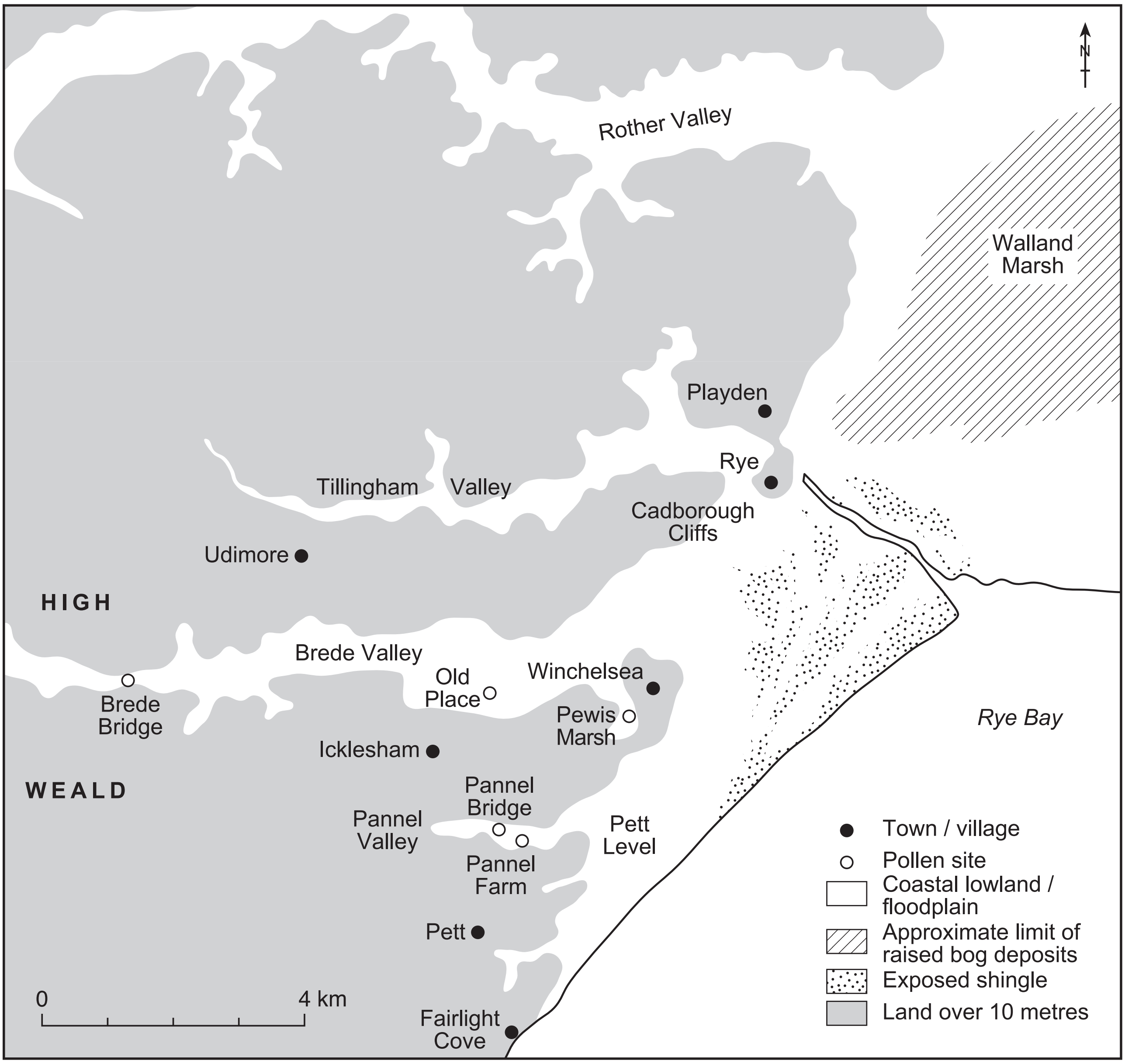


*Fig. 3.1. Locations of the pollen sites from which charcoal records have been obtained and the places referred to in the text.*

which span the 1st to the 4th centuries AD (Cleere and Crossley 1995). Roman bloomeries occur at Icklesham, overlooking the Pannel valley (*c*. 600 m south of the site of the Pannel Farm pollen diagram), and on the edge of Pett Level (Tyler 2007). It has been suggested that the iron-working sites of the East Weald formed part of an imperial estate from which non-iron-working activity was excluded (Cleere and Crossley 1995), though indicators of arable activity (cereal pollen grains and colluvial (slope wash) deposits dating to the Roman period) from sites in the Brede and Pannel valleys suggest any such estate did not entirely encompass the study area (Waller and Schofield 2007).

## Methods

### *The Sites Selected*

The five pollen sites selected for this study (listed below) occur in close proximity within the Pannel and Brede valleys (Fig. 3.1) and are located near to the edge (approximately 100 m or less) of the modern floodplain. The distance between a site and dryland influences the size of the area sensed in a pollen record, with sites close to this edge having an enhanced (extra local) input of pollen from the nearby dryland vegetation (Jacobson and Bradshaw 1981; Waller 1998). The same may be the case for records of microscopic

*Table 3.1. The radiocarbon determinations used in this study. For the calibrated age, the end points of the two sigma range (95.4%) have been rounded outwards to the nearest 10 years (Bayliss* et al. *2008). See Fig. 3.2 for age-depth models.*

| Site | Lab. code | Depth below surface (cm) | Conventional date BP | Calibrated range (cal. yr AD/ BC, at 2σ, 95.4%) |
|---|---|---|---|---|
| Pannel Bridge | SRR-2885 | 142–150 | 2670±80 | 1020–540 BC |
| | SRR-2886 | 240–248 | 2980±80 | 1420–970 BC |
| | SRR-2887 | 356–359 | 3700±90 | 2500–1750 BC |
| | SRR-2888 | 620–628 | 5040±80 | 3980–3650 BC |
| | SRR-2889 | 700–708 | 5540±80 | 4550–4230 BC |
| | SRR-2890 | 892–900 | 7000±90 | 6040–5710 BC |
| | SRR-2891 | 1036–1050 | 9380±100 | 9150–8300 BC |
| | SRR-2892 | 1116–1132 | 9960±110 | 10,050–9200 BC |
| Pannel Farm | GrA-25291<br>OxA-13227<br>Mean | 137–142 | 395±35<br>356±36<br>376±25 | AD 1440–1640 |
| | GrN-28586<br>GrN-28587<br>Mean | 143–148 | 1640±50<br>1710±100<br>1654±45 | AD 250–540 |
| | GrN-28585 | 165–170 | 2220±60 | 400–110 BC |
| | GrN-28098 | 178–182 | 2880±60 | 1270–900 BC |
| | GrN-28099 | 206–210 | 3030±50 | 1420–1120 BC |
| | GrN-28100 | 220–224 | 3510±50 | 1960–1690 BC |
| Brede Bridge | SRR-2645 | 142–150 | 3690±70 | 2290–1890 BC |
| | SRR-2646 | 720–727 | 5970±150 | 5300–4450 BC |
| Old Place (80) | SRR-2893 | 364–367 | 1830±80 | AD 20–400 |
| Pewis Marsh | GrN-27875<br>GrN-27910<br>Mean | 200–205 | 1870±35<br>1760±60<br>1842±30 | AD 80–250 |
| | GrN-28060<br>GrN-28061<br>Mean | 225–230 | 2140±50<br>2140±50<br>2140±35 | 360–50 BC |
| | GrN-27876<br>GrN-27913<br>GrN-28059<br>Mean | 230–235 | 3500±30<br>3380±80<br>2490±90<br>3485±28 | 1900–1690 BC |
| | GrN-27877<br>GrN-27914<br>Mean | 260–265 | 3960±30<br>3860±100<br>3952±29 | 2570–2340 BC |
| | GrA-23753 | 320 | 4450±40 | 3340–2920 BC |

charcoal (Whitlock and Millspaugh 1996; Laird and Campbell 2000).

In the Pannel valley, Pannel Bridge (NGR TQ 882152) is the site of the most complete Holocene pollen record obtained from the Romney Marsh area (Waller 1993). The 11.4 m sequence is organic throughout and dates from *c.* 9700 cal. yr BC onwards. The core was collected from the centre of the valley approximately 70 m from the northern edge of the floodplain and the Mesolithic flint scatter (Holgate and Woodcock 1988; 1989). The Pannel Farm (NGR TQ 883151) site is located approximately 200 m south-east of Pannel Bridge, where marine/brackish sediments overlie peat and an organic silty-clay

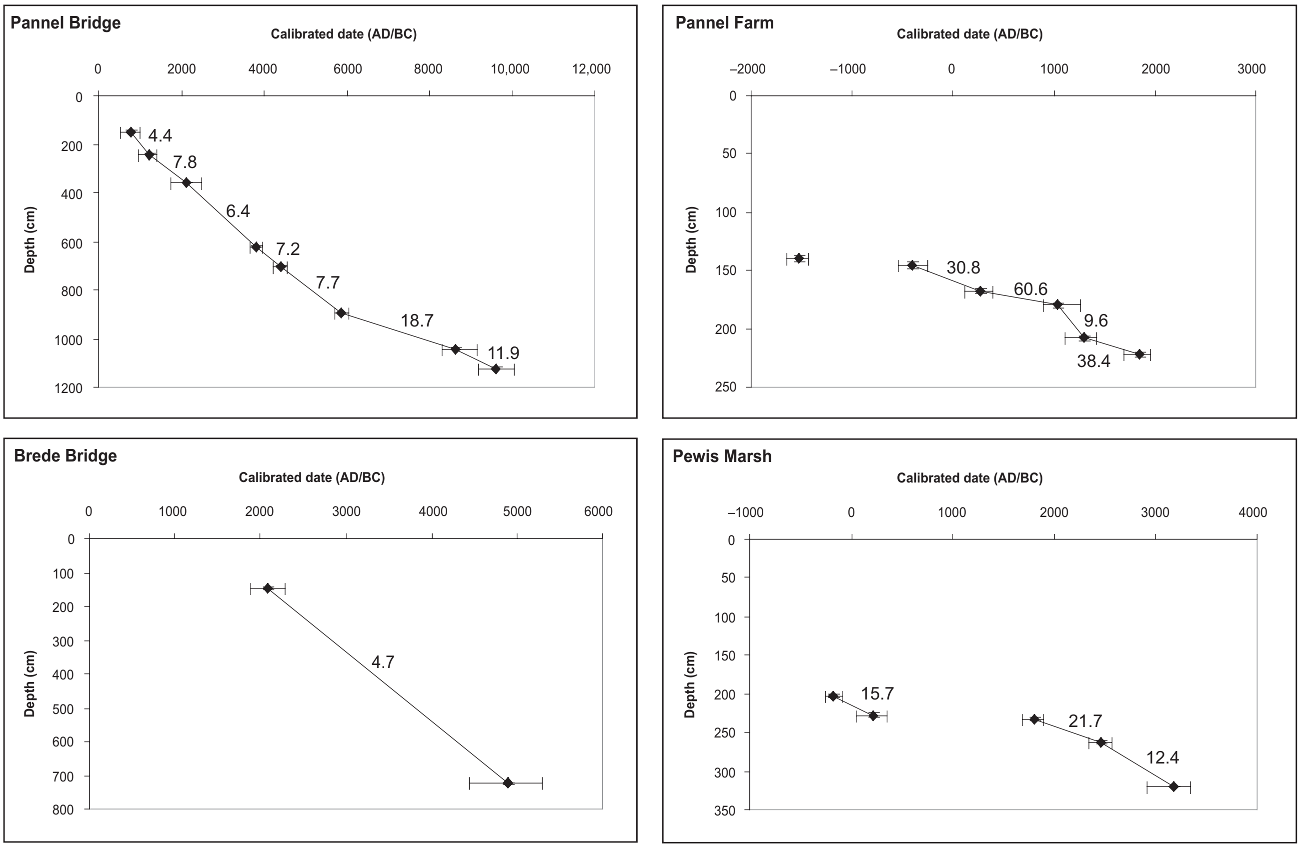


*Fig 3.2. Age-depth models for Pannel Bridge, Pannel Farm, Brede Bridge and Pewis Marsh, with the sediment accumulation rates shown above the lines (yrs cm$^{-1}$).*

(Waller and Schofield 2007). Only the upper part of the peat and the organic silty-clay were investigated here and the sequence dates to between *c.* 1800 cal. yr BC and cal. yr AD 400.

In the Brede valley, the peat sequence at Brede Bridge (NGR TQ 827175) dates to between *c.* 5000 and 2000 cal. yr BC, with the record highly temporally resolved either-side of declines in *Ulmus* and *Tilia* pollen (Waller 1994). At Old Place, four pollen diagrams constructed through the main Brede valley peat unit are detailed in Waller (1998). The core from which the microscopic charcoal record was obtained (OP80 NGR TQ 880171) was taken 80 m from the floodplain edge and dates from *c.* 4300 cal. yr BC (estimated from correlation with dated sequences nearby) to cal. yr AD 200. The Pewis Marsh site is located in a small side valley off the Brede valley, to the south-west of New Winchelsea (Long *et al*. 2007). The sequence investigated (at NGR TQ 900168) dates from *c.* 3200 cal. yr BC to cal. yr AD 140, although a break in sedimentation occurs between the top of the peat (dated to *c.* 1800 cal. yr BC) and the base of an overlying organic silty-clay (dated to *c.* 200 cal. yr BC).

## *Microscopic Charcoal Analysis*

Microscopic charcoal analysis was undertaken using the residues from the original pollen preparations (sources listed above). The method used was adapted from Clark (1982). The amount of charcoal present was quantified by counting a minimum of 200 random fields of view, applied to each slide, and the number and area of each charcoal particle recorded. A minimum of 50 *Lycopodium* spores, added as part of the original preparation procedure, were also counted enabling the calculation of charcoal area concentrations (mm$^2$ cm$^{-3}$). Charcoal accumulation rates (hereafter referred to as CHAR, mm$^2$ cm$^{-2}$ yr$^{-1}$) have been calculated from the charcoal area concentrations and sediment accumulation rates derived from the age-depth models described below. The CHAR values take account of variations in sediment accumulation rates and therefore enable more direct comparisons of the results to be made between the different study sites.

## *Age-depth Models*

To facilitate comparison between sites the age-depth models from four of the five sequences investigated have been recalculated in a consistent manner (Table 3.1 and Fig. 3.2). Old Place (80) does not contain sufficient radiocarbon dates to produce a reliable age-depth model. Radiocarbon dates (expressed in calibrated years BC/AD throughout the text) were first calibrated using the on-line Bayesian radiocarbon calibration software BCal (Buck *et al*. 1999) and the IntCal04 data set (Reimer *et al*. 2004). For Pannel Farm and Pewis Marsh, pooled means were used when two or more radiocarbon dates from the same horizon had been obtained (Long *et al.* 2007). Age-depth models have been created using Psimpoll v.4.25 (Bennett 1992), incorporating the output from BCal, and applying the weighted mean of each calibrated radiocarbon date. Linear interpolation between radiocarbon dates has been used to produce the age-depth model and sediment accumulation rates.

## Results

The results of the microscopic charcoal analyses are shown in Figs. 3.3–3.9 alongside the main taxa from the pollen records, with the pollen zonation schemes taken from the original publications.

### *Pannel Bridge*

The patterns of stratigraphic change in the charcoal values at Pannel Bridge are broadly consistent between the two methods of representation (Fig. 3.3). Although fluctuating, relatively high charcoal values are recorded from *c*. 9700 to 5000 cal. yr BC (PB-1 to PB-3b) during which the dryland vegetation of the Pannel valley underwent a series of compositional changes (Waller 1993). In PB-1, high *Pinus sylvestris*, *Betula*, Cyperaceae and Poaceae pollen values are accompanied by CHAR between 0.2 and 1.8 $mm^2\ cm^{-2}\ yr^{-1}$. The increase in CHAR (above 1084 cm) coincides with the regular occurrence of *Pteridium aquilinum* spores indicating some open areas on dryland. However, the PB-1 assemblage coincides with the deposition of an organic clayey silt and the charcoal values may be enhanced as a result of sediment inwash. Thereafter the sediment matrix consists largely of peat until the upper 37 cm. PB-2 is distinguished by high *Corylus avellana*-type values and there are also rises in *Quercus, Ulmus* and *Alnus glutinosa* pollen. CHAR are low in PB-2a, between 0.07 and 0.58 $mm^2\ cm^{-2}\ yr^{-1}$. Higher values are recorded during PB-2b, initially accompanied by a peak in *Alnus* pollen. At the top of the zone particularly high CHAR of 1.61 $mm^2\ cm^{-2}\ yr^{-1}$ are recorded along with lower *Corylus avellana*-type values and peaks in Cyperaceae and Poaceae pollen. After a phase of low CHAR during PB-3a and -3b, CHAR rise in the upper part of PB-3b. Peaks at 820 cm of 0.83 $mm^2\ cm^{-2}\ yr^{-1}$ and at 788 cm of 1.02 $mm^2\ cm^{-2}\ yr^{-1}$ are accompanied by high Cyperaceae pollen values and the occurrence of *Rumex acetosella/acetosa* pollen.

From *c*. 5000 to 2200 cal. yr BC (PB-3c to PB-3e) charcoal values at Pannel Bridge are generally reduced. The pollen record suggests this was a period of relative vegetation stability with woodland composed of *Tilia*, *Quercus* and *Corylus avellana* occupying the slopes adjacent to the site. Poaceae values are uniformly low prior to an increase during PB-3e. While remaining relatively low, CHAR are consistently higher between 606–590 cm, reaching a maximum of 0.51 $mm^2\ cm^{-2}\ yr^{-1}$. The base of this increase coincides with a decline in *Ulmus* pollen dated here to *c*. 3800 cal. yr BC. The *Tilia* decline at the PB-3e/PB-4a (*c*. 2100 cal. yr BC) is preceded by a peak in CHAR of 0.91 $mm^2\ cm^{-2}\ yr^{-1}$. In contrast to the pre *c*. 4000 cal. yr BC peaks, Cyperaceae and Poaceae pollen values are reduced, the major beneficiary of the disappearance of *Tilia* being *Betula*, with *Pteridium aquilinum* values showing a slight but consistent increase.

After a period of low values immediately after the *Tilia* decline, CHAR at Pannel Bridge increase above 256 cm (*c*. 1200 cal. yr BC), peaking at maximum of 2.69 $mm^2\ cm^{-2}\ yr^{-1}$ at the PB-4b/c boundary (*c*. 1000 cal. yr BC). These increases are associated with falling tree pollen values (*Quercus* and *Betula*) and higher values for Cyperaceae and Poaceae. Extrapolation of the radiocarbon chronology above the top date has not been attempted and the CHAR record therefore ceases at 144 cm. Above 144 cm (PB-4c and PB-4d) values for charcoal are consistently low, while tree and shrub (*Quercus*, *Betula*, *Alnus glutinosa*, *Corylus avellana*-type) pollen values are notably higher. The top of the Pannel Bridge sequence (PB-4e) is marked by declining tree and shrub pollen, a major rise in Poaceae and by a peak in charcoal particles. The latter may be enhanced by reworked charcoal given that it coincides with the deposition of organic clay.

### *Pannel Farm*

At Pannel Farm charcoal values (Fig. 3.4), low during PF-1 and PF-2 (0.02–0.07 $mm^2\ cm^{-2}\ yr^{-1}$), are consistently higher (fluctuating between 0.13–0.88 $mm^2\ cm^{-2}\ yr^{-1}$) during PF-3 and PF-4 (from *c*. 1100 cal. yr BC to cal. yr AD 400). The lower half of the sequence (PF-1 and PF-2) is notably more organic (largely peat) while PF-3 largely corresponds with the deposition of an organic silt/clay, the clastic component of which appears largely derived (on lithostratigraphic evidence) from the adjacent slopes (Waller and Schofield 2007). Above 179 cm the charcoal values are likely therefore to reflect the inclusion of inwashed particles. In the pollen sequence PF-1 is characterised by high *Alnus glutinosa* values, PF-2 by high Cyperaceae and *Pteridium aquilinum* values and PF-3 by higher *Betula* and to a lesser extent Poaceae pollen values. The fluctuations seen in the charcoal values in PF-3 are not mirrored in the pollen sequence, with representation of the major taxa showing little variation during this zone. The material used for the uppermost radiocarbon date (rootlets in a marine/brackish clay) is likely to be intrusive and CHAR have not therefore been calculated above 148 cm. However charcoal area values are similar to the previous zone, varying between 8.4–12.2 mm$^2$ cm$^{-3}$. The two methods of charcoal representation are again broadly consistent although the CHAR are notably higher from the beginning of PF-3 (in the peat).

## *Brede Bridge*

There are two dates for this site, above and below which there are changes in sediment type and probably in the accumulation rate. The chronology from the peat (*c.* 5000 to 2000 cal. yr BC) has not been extrapolated to the top and base of the pollen sequence and CHAR are therefore only available from beginning of BB-1b through into BB-3a (Fig. 3.5). Charcoal values are high in the basal sediment (BB-1a), a marine/brackish silt/clay (Waller 1994). High charcoal area concentration values are also found in the same lithostratigraphic unit at Old Place (80) and in the upper silty clay at Brede Bridge (BB-3b). For the basal silty-clay this is unlikely to be the result of a slow sediment accumulation rate (Waller and Long 2003) but rather the inwash and reworking of charcoal. CHAR are variable throughout BB-1b, fluctuating between 0.01–0.84 mm$^2$ cm$^{-2}$ yr$^{-1}$. CHAR are consistently lower towards the end of the zone and at the base of BB-2a. The BB-1/2 zone boundary has been placed on the *Ulmus* decline. The higher temporal resolution obtained for this part of the pollen sequence (Waller 1994) has been matched in the charcoal investigations (Fig. 3.6). This shows that over the period when *Ulmus* pollen values fall (519 to 503 cm) CHAR continue to be low. Accompanying changes in the pollen record over this period (which include a decline in *Tilia*, peaks in Cyperaceae and Poaceae, higher *Pteridium aquilinum* values, and the occurrence of cereal-type pollen) are strongly indicative of a Neolithic clearance phase. However, as at Pannel Bridge, CHAR rise after the *Ulmus* decline, increasing between 488 and 472 cm to 0.54–1.01 mm$^2$ cm$^{-2}$ yr$^{-1}$. There are no changes in pollen stratigraphy apparent, though a lens of organic silt occurs between 486 and 478 cm. Above 472 cm CHAR remain low until immediately prior to the *Tilia* decline at the BB-2/3 boundary (149 cm). The higher resolution obtained for this part of the sequence (Fig. 3.7) shows a peak in CHAR (0.74 mm$^2$ cm$^{-2}$ yr$^{-1}$) at 158 cm which coincides with a minor peak in *Pteridium*. Despite major changes in the pollen record above 150 cm (notably increases in Poaceae, Cyperaceae, *Pteridium* and the consistent occurrence of cereal pollen), CHAR are low in the immediate post-*Tilia* decline period (as at Pannel Bridge).

## *Old Place (80)*

Only one date (1830±80; SRR-2893) is available for the peat sequence at Old Place (80) (Fig. 3.8), although the basal silty/peat contact has been dated to *c.* 4430 cal. yr BC (5590±70; Beta-75451) within 1.5 km (Borehole 11; Long *et al.* 1996). The pollen record is therefore likely to date from *c.* 4430 cal. yr BC to cal. yr AD 200. However, the peat accumulation rate is known to have declined considerably in the lower Brede valley after *c.* 1200 cal. yr BC (Waller *et al.* 2006) and the *Tilia* decline is not a reliable chronostratigraphic marker in this area (Waller and Schofield 2007). An age-depth model (and CHARs) has not therefore been developed from this site. As noted for Brede Bridge, the high charcoal area concentrations in the basal clay at Old Place (80) are likely to be the product of the presence of inwashed material. Values are particularly low during the early stages of peat formation (559–514 cm). Above 514 cm charcoal concentrations are generally higher. This corresponds with changes in the pollen record, notably a major fall in *Quercus* values and increases in wetland taxa (*Alnus glutinosa*, *Filipendula* and *Osmunda reglis*) and *Corylus avellana*-type. Charcoal area concentrations are consistently high after the *Ulmus* decline (at OP-1/2 boundary). Particularly high values are recorded after the *Tilia* decline (in OP-3), although this is likely to be an artefact of a decline in the sediment accumulation rate.

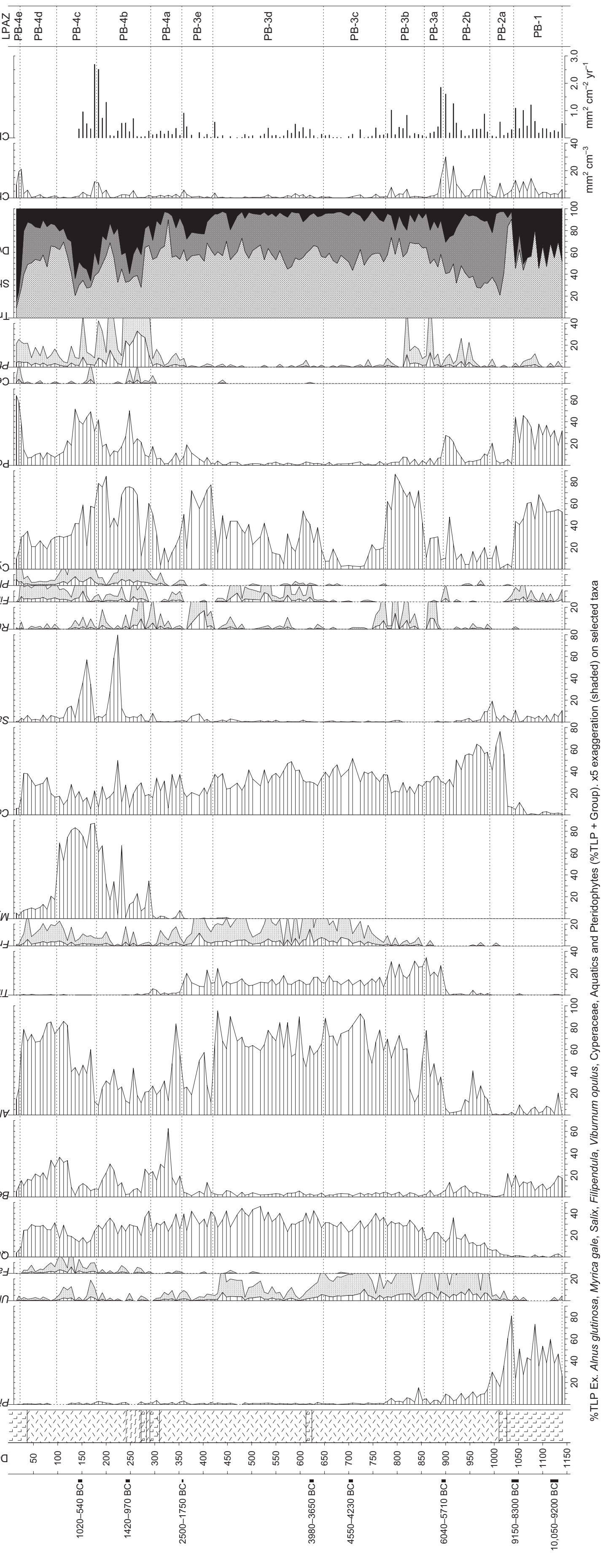


*Fig. 3.3. Summary pollen data and the microscopic charcoal record from Pannel Bridge. See Fig. 3.4 for key to the lithological components.*

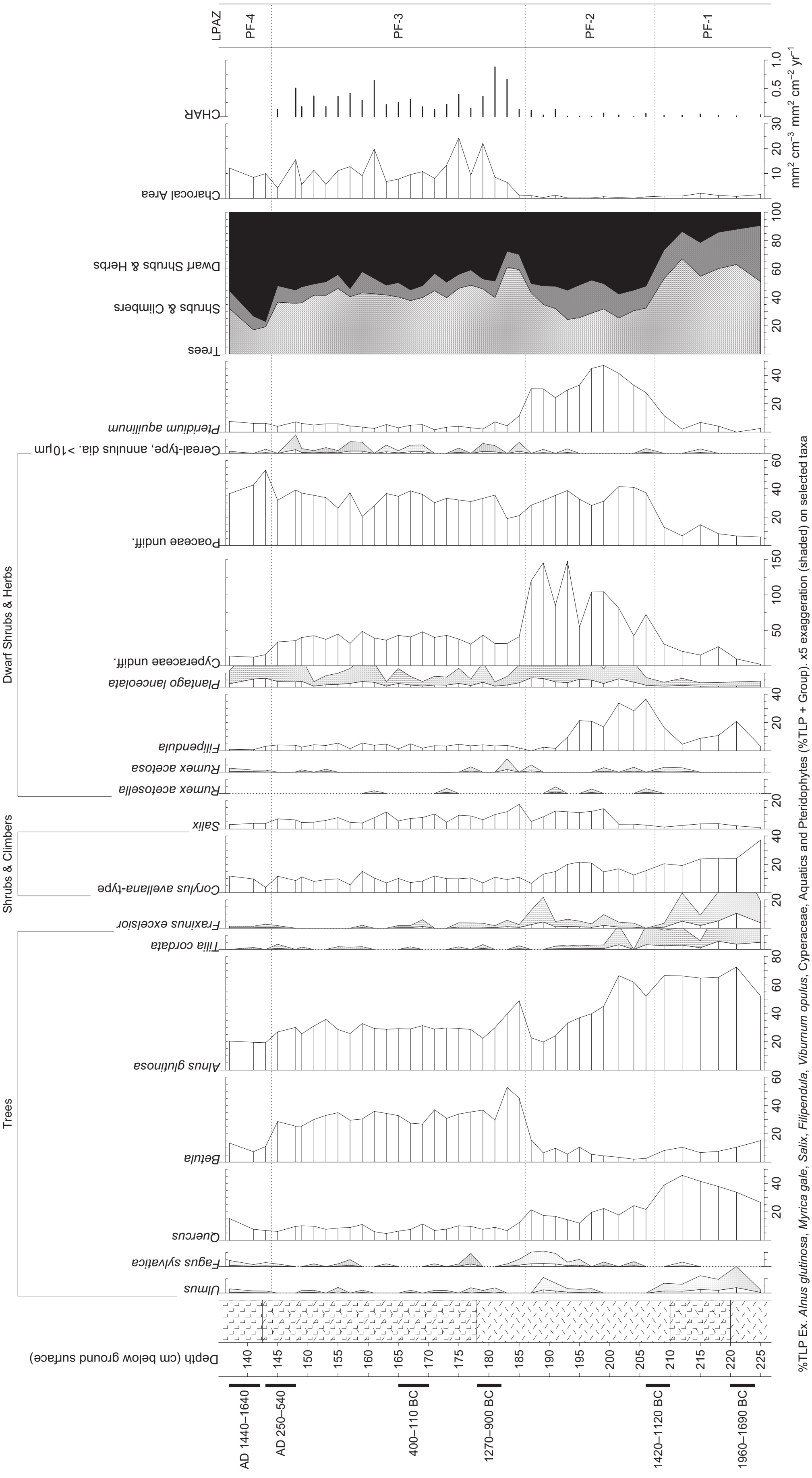


*Fig. 3.4. Summary pollen data and the microscopic charcoal record from Pannel Farm.*

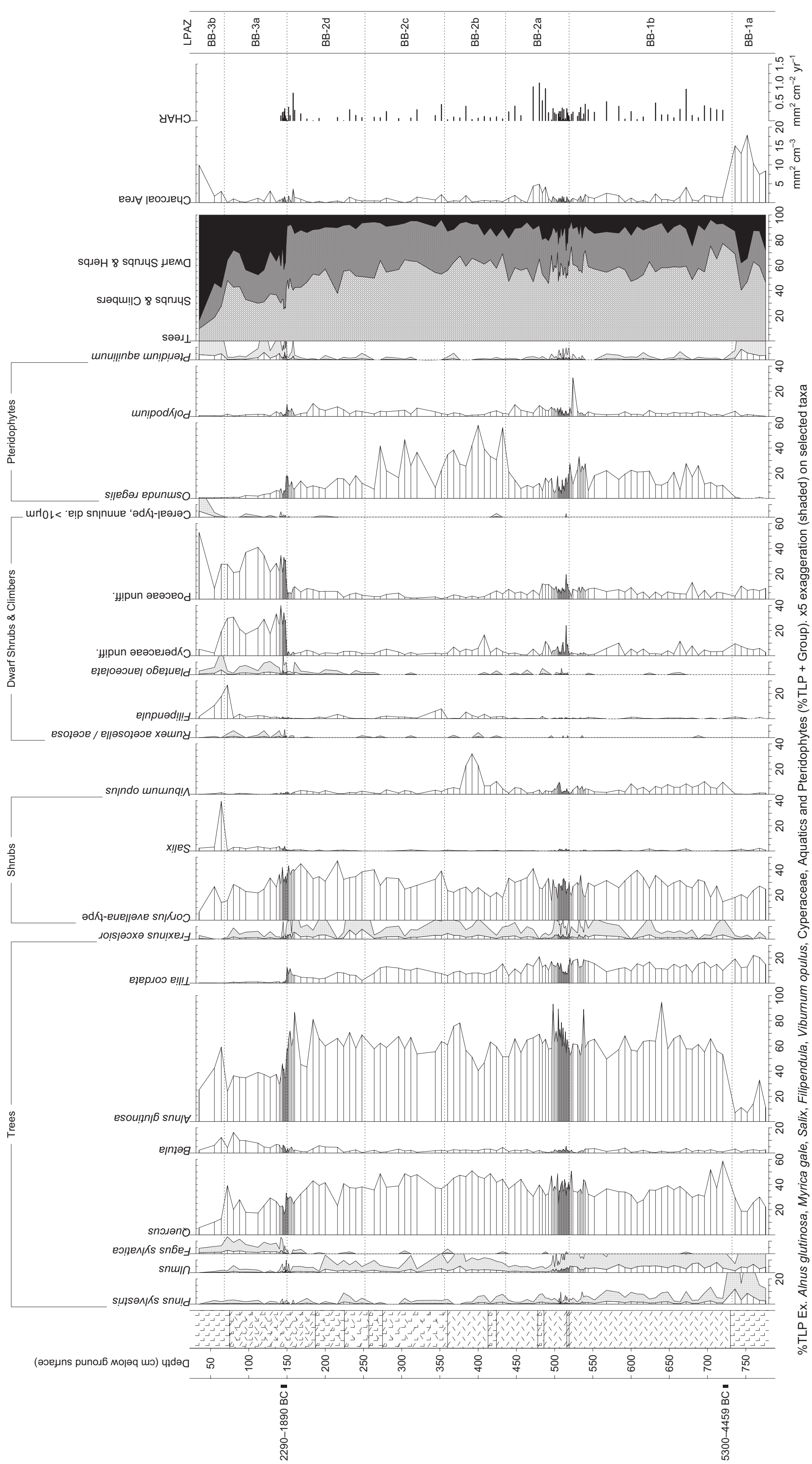


*Fig. 3.5. Summary pollen data and the microscopic charcoal record from Brede Bridge. See Fig. 3.4 for key to the lithological components.*

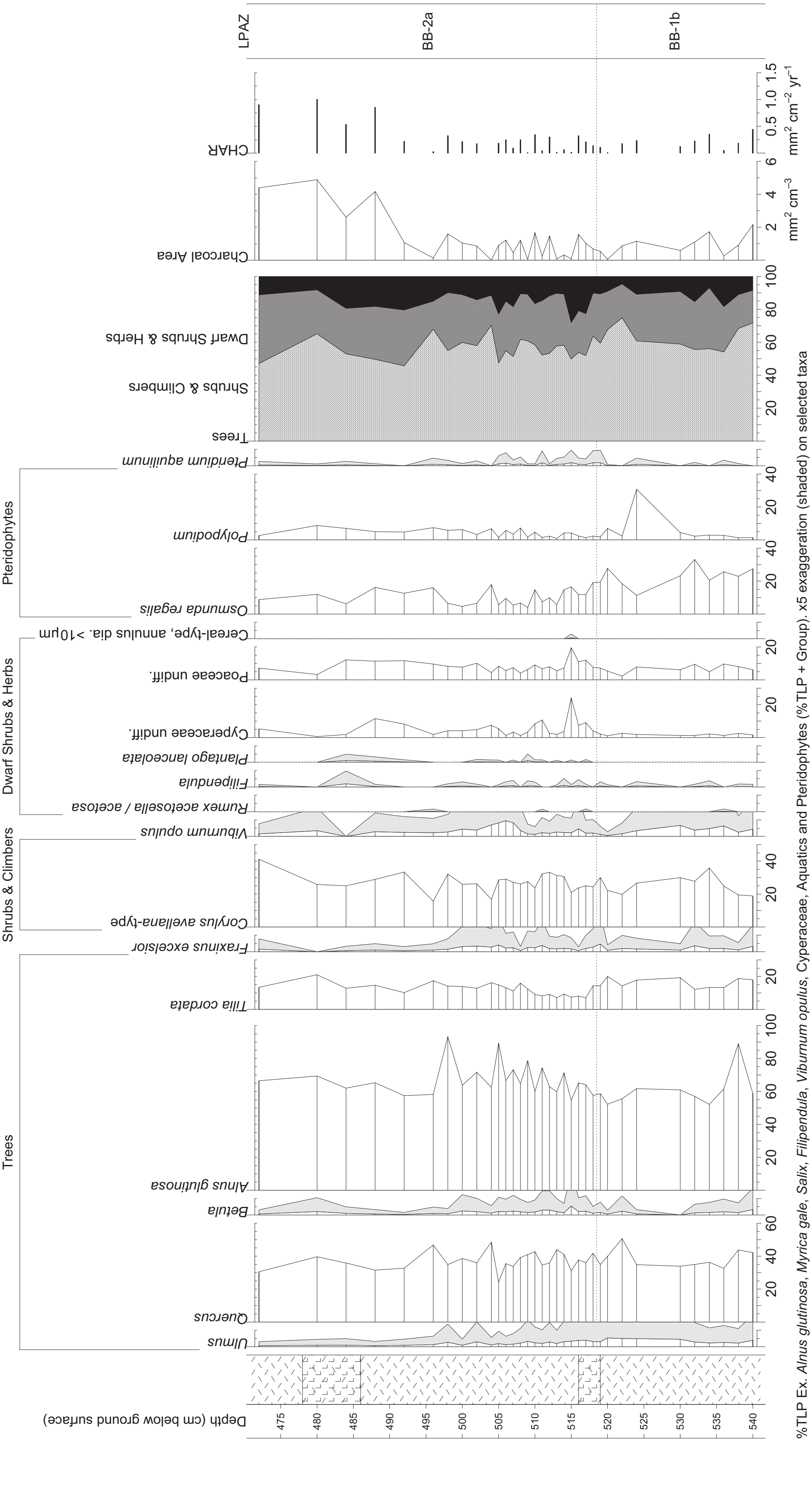


*Fig. 3.6. Summary pollen data and the microscopic charcoal record from the* Ulmus *decline at Brede Bridge. See Fig. 3.4 for key to the lithological components.*

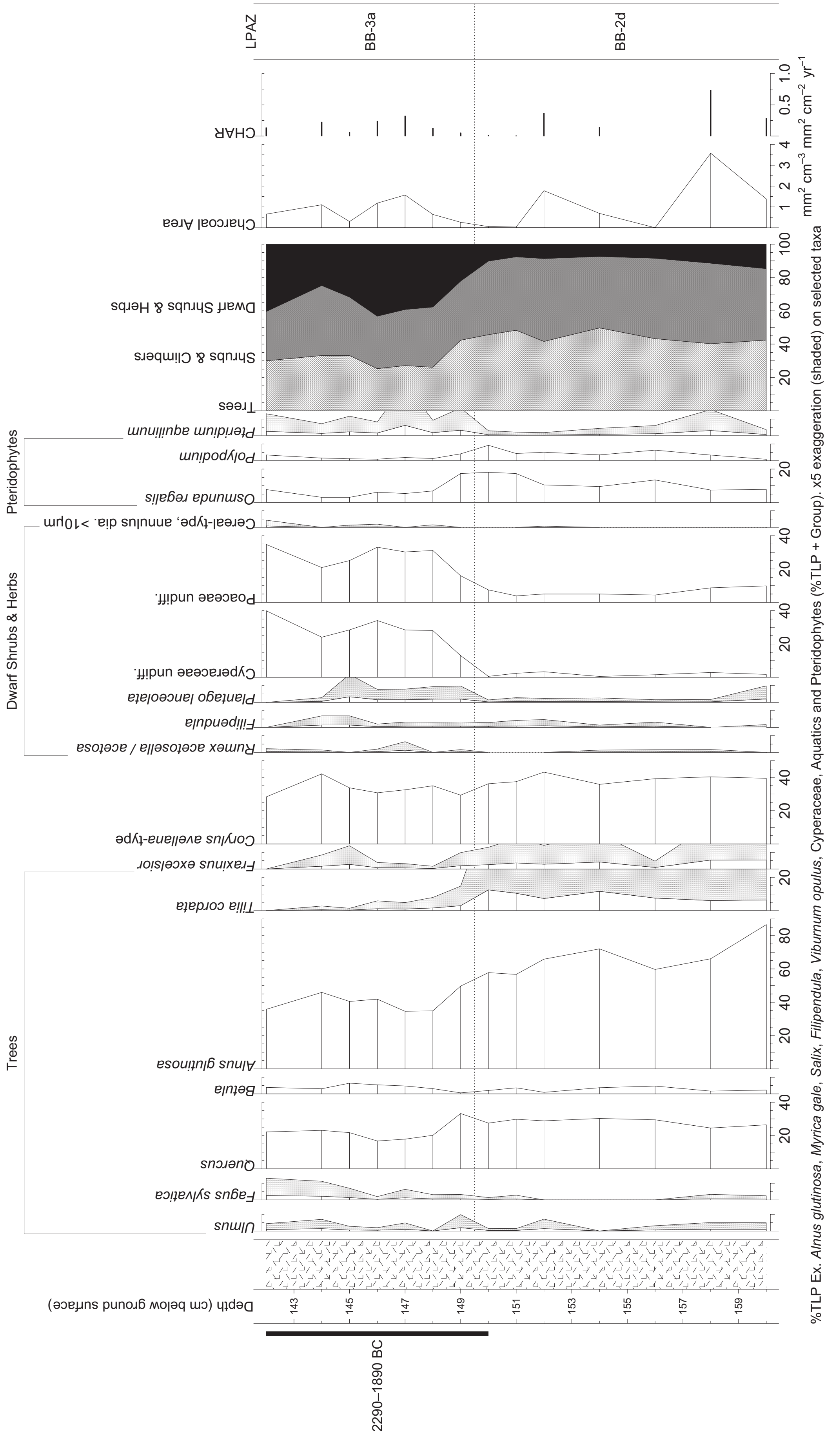


*Fig. 3.7. Summary pollen data and the microscopic charcoal diagram from the* Tilia *decline at Brede Bridge. See Fig. 3.4 for key to the lithological components.*

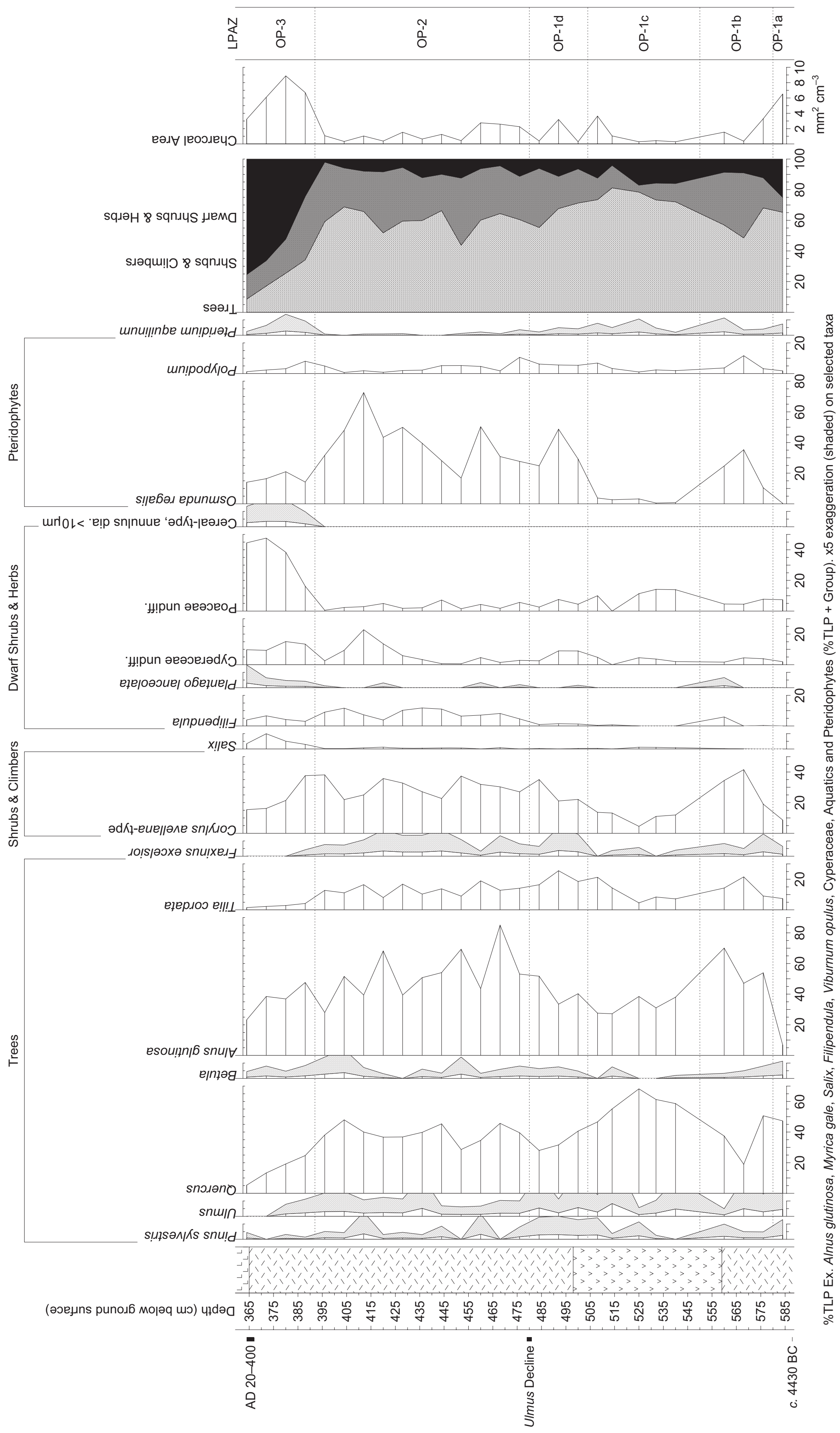


*Fig. 3.8. Summary pollen data and microscopic charcoal diagram from Old Place (80). See Fig. 3.4 for key to the lithological components.*

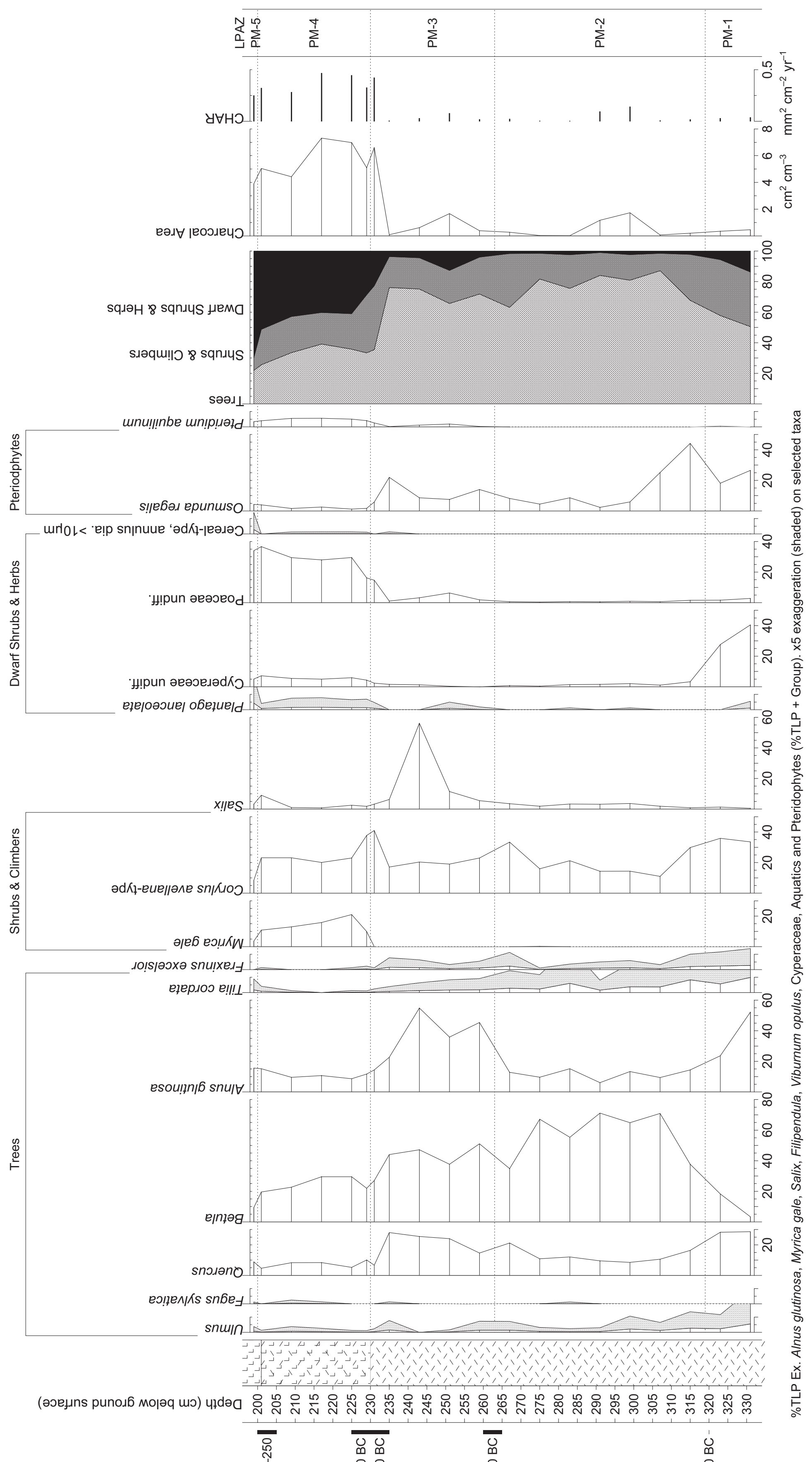


*Fig. 3.9. Summary pollen data and microscopic charcoal diagram from Pewis Marsh. See Fig. 3.4 for key to the lithological components.*

### *Pewis Marsh*

Only the upper part of the peat unit, spanning the period *c*. 3200 to 1800 cal. yr BC, was investigated at this site. The pollen record from the peat (Fig. 3.9) is dominated by *Betula* and *Alnus glutinosa* (PM-1, PM-2 and PM3). After a break in sedimentation (indicated by radiocarbon dates either side of the PM-3/4 zone boundary) an organic silt/clay accumulated (between *c*. 200 cal. yr BC and cal. yr AD 140). The pollen content of the organic silt/clay (PM-4) is relatively homogeneous (with high Poaceae and *Myrica gale* values) and, as at Pannel Farm, the clastic component is thought largely to have been derived from the slopes nearby (Long *et al*. 2007). The uppermost silt/clay was deposited in a marine/brackish environment probably again after a break sedimentation. Charcoal values (irrespective of the method of representation) are low during peat formation (CHAR for PM-1, PM-2 and PM-3 are generally < 0.1 $mm^2\ cm^{-2}\ yr^{-1}$) aside for an increase in CHAR to 0.14 $mm^2\ cm^{-2}\ yr^{-1}$ between 299–291 cm. CHAR increases at the PM-3/4 boundary (the contact between the peat and organic silt/clay) and thereafter remain high (> 0.3 $mm^2\ cm^{-2}\ yr^{-1}$). As at Pannel Farm, the organic silt/clay at Pewis Marsh probably contains reworked charcoal.

## Discussion

For the early Holocene at Pannel Bridge (PB1–PB3b) the charcoal record potentially reflects both changing climatic conditions and human activity. In addition, in a period of vegetation change, burning may both have been influenced by the combustibility of the vegetation and have impacted upon vegetation development.

Of particular note at Pannel Bridge are the peaks in charcoal frequency which occur from *c*. 9250 cal. yr BC through to *c*. 5000 cal. yr BC. Although, in the absence of contiguous samples, these give no indication as to reoccurrence interval, they do suggest, relative to the subsequent mid-Holocene, a greater frequency of fires. A similar trend in the charcoal record has been found in the sequence from Cranes Moor, Hampshire (Grant *et al.* 2009a). At Pannel Bridge two of the peaks, *c*. 9250 cal. yr BC (PB-1) and *c*. 6250 cal. yr BC (PB-2b/3a), coincide with climatic oscillations (Björck *et al.* 1996; Alley *et al.* 1997). In the UK these events are associated with drier conditions which may have been a sufficient stimulant to promote the *in situ* burning of vegetation.

Given the archaeological record (the Late Mesolithic flint scatter adjacent to Pannel Bridge and other springs within the Pannel valley), the possibility of the source of ignition for the peaks in charcoal in the early Holocene at this site being anthropogenic must also be considered. It is unlikely that they are simply the product of domestic fires (though the collection and burning of wood for this purpose could be a contributory factor) as the peaks coincide with increases in the pollen of taxa associated with open vegetation communities (e.g. Poaceae, Cyperaceae, *Rumex acetosella/acetosa* and *Pteridium aquilinum*). *Pteridium* in particular is likely to have been promoted by the *in situ* burning of vegetation. During the Mesolithic the intention of any anthropogenic burning is likely to have been the creation of openings for the purpose of increasing game or facilitating hunting (Waller 1993; Waller 2002). Unfortunately, with only the Pannel Bridge sequence in the eastern Weald extending back beyond *c*. 5000 cal. yr BC, it is currently not possible to determine whether the relatively high charcoal frequencies prior to this date are a regional phenomena (and therefore potentially indicative of burning at the landscape scale) or largely confined to areas likely to have been favoured by Late Mesolithic communities (e.g. the coastal fringe).

There are a number of additional potential influences on the high charcoal values at Pannel Bridge during PB-1. They may reflect the local presence of *Pinus sylvestris*, which is tolerant of a range of fire regimes (Agee 1998). The relatively open vegetation, which could be expected to result from frequent fires, appears to be indicated by the high Poaceae and Cyperaceae pollen values. However, it is likely that much of this pollen is locally derived (from the wetland vegetation). This zone also coincides with the deposition of an organic clayey silt and it is therefore possible that much of the pollen and charcoal was inwashed and potentially reworked from older sediment stores.

The decline in charcoal at the start of PB-2a (*c*. 8200 cal. yr BC) coincides with a rise in *Corylus avellana*-type pollen. The spread and increase in *Corylus avellana* during the early Holocene appears to be associated with relatively cold winters and cool summers (Huntley 1993), which alongside a change in fuel source, could have decreased the potential for natural burning events to occur. It had been conjectured that the expansion *Corylus* in this period was aided by the use of fire (e.g. Smith 1970; Iversen 1973; Huntley 1993). However, the absence of an increase in microscopic charcoal abundance at Pannel Bridge is in agreement with a number of other studies (e.g. Edwards 1990; 1998). It has been observed that

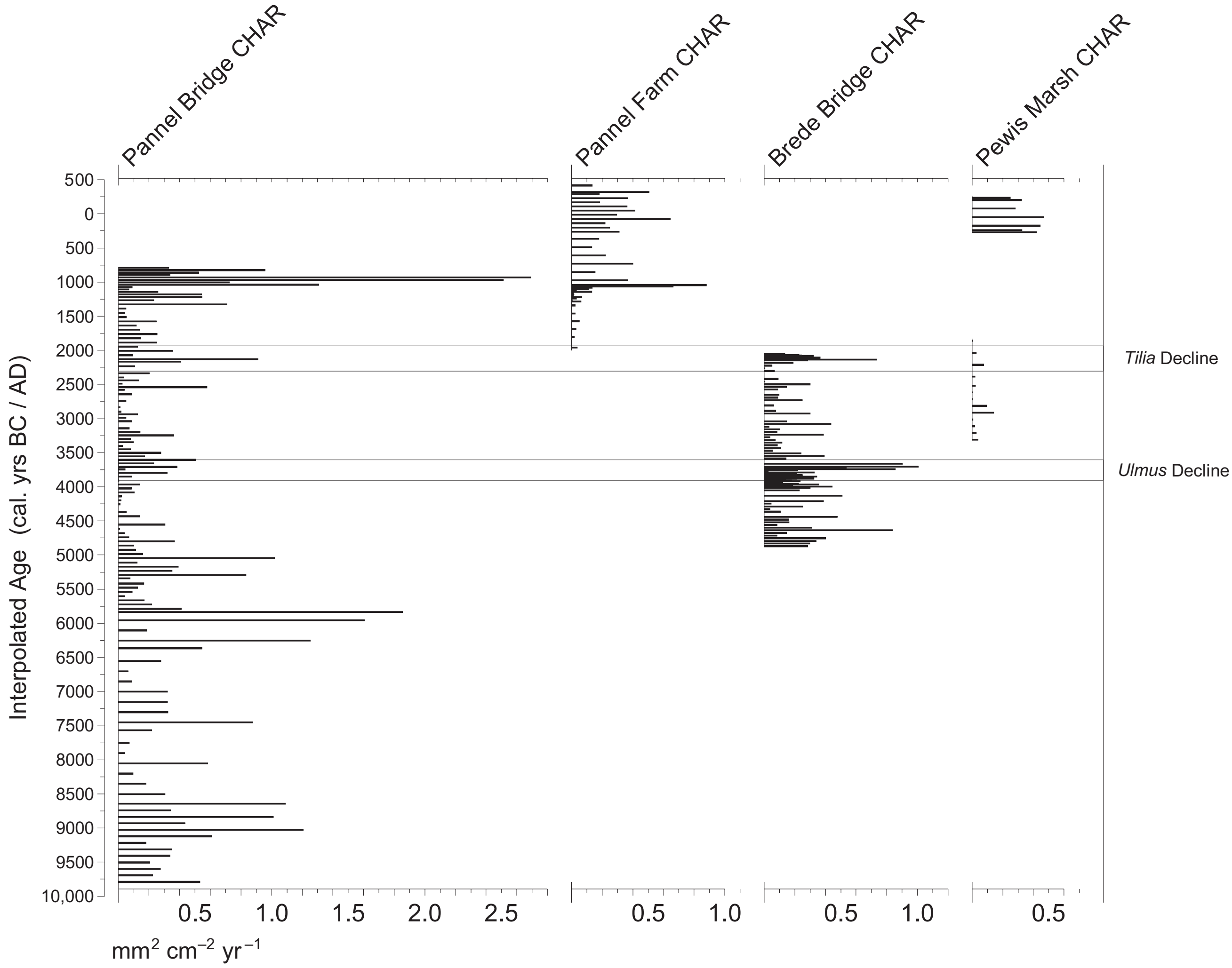


*Fig. 3.10. Comparison of CHAR values derived from sites in the Brede and Pannel valleys.*

*Corylus* may be encouraged after fire but is impeded by severe burning (Ahlgren 1974), so the reduction in fire frequency or intensity, as indicated at Pannel Bridge, may have indirectly assisted its expansion.

The *c*. 7600 cal. yr BC (the base of PB-2b) charcoal peak at Pannel Bridge corresponds with the initial expansion of *Alnus glutinosa* and declines in *Pinus sylvestris* and *Salix* pollen. An association between peaks in charcoal and the expansion of *Alnus* have been noted at a number of sites across Britain (e.g. Bennett *et al.* 1990; Edwards 1990; Edwards and MacDonald 1991; Grant *et al.* 2009a; 2009b) suggesting a causal relationship. However, the expansion in *Alnus* was not synchronous and the most likely explanation is that burning was one of a number of processes operating at a local scale which favoured the establishment of this species (Bennett and Birks 1990). At Pannel Bridge, where *Alnus* is likely to have replaced *Pinus* in the valley bottom, burning might preferentially have destroyed *Pinus* woodland while providing conditions (high light intensity and reduced competition from the ground and field layers) which would promote the germination and onward growth of *Alnus* (McVean 1956). Although, according to Smith (1984), the expansion of *Alnus* is generally associated with anthropogenic burning, this need not be the case and the *c*. 6250 cal. yr BC peak in charcoal, which may be linked to climate, is associated with a second rise in *Alnus* pollen (at the PB-2b/3a boundary).

Lower charcoal frequencies are recorded at Pannel Bridge after *c*. 5000 cal. yr BC. This does not appear to coincide with climate change, the onset of a period of relatively high summer and low winter temperatures in northwest Europe commenced *c*. 6500 cal. yr BC (Lamb 1977; Davis *et al*. 2003; Charman 2009), or vegetation change, with the rise in *Tilia* occurring *c*. 5850 cal. yr BC. It is, however, consistent with the reduction in human activity around the site implied in the archaeological record, though the decline in the number of sites must be treated with caution, given that many of the flint scatters are not dated. In the Brede Bridge record charcoal frequencies are higher than at Pannel Bridge (see Fig. 3.10) suggesting that some burning was taking place within the region, but that its occurrence within the wider landscape was patchy in nature. A change in economy and/or location of communities at this time is likely as peat-forming vegetation became widespread in the valleys and adjacent marshlands and the coastline receded (Long *et al*. 2007).

The first evidence of an increase in CHAR that can be recognised at a regional scale occurs immediately after the mid-Holocene *Ulmus* decline (dated at Pannel Bridge to *c*. 3800 cal. yr BC). CHAR increase at Pannel Bridge and Brede Bridge and there is a consistent rise in the charcoal recorded at Old Place (80). The *Ulmus* decline probably resulted from a combination of disease and human activity (Parker *et al.* 2002; Waller 2002). Silt lenses are recorded at both the Pannel Bridge and Brede Bridge sites which probably reflect an increase in sediment supply following vegetation disturbance, though they could simply be the product of channel avulsion. The increased charcoal values do not seem simply to be the result of an additional inwashed element. At Pannel Bridge they extend above the silt lens and at Brede Bridge they occur above and below as well as within the upper silt lens, with the charcoal rise after the clearance phase. If disease is contributory factor to the *Ulmus* decline, an increase in quantity of combustible material (dead wood) available might provide an explanation for higher charcoal values occurring after the pollen stratigraphic changes associated with the *Ulmus* decline. However, with the CHAR rises occurring some *c*. 200 cal. yrs later at Pannel Bridge and *c*. 100 cal. yrs later at Brede Bridge, human attempts to maintain and/or expand open areas seems more likely. Few pollen studies from lowland England have included analysis of microscopic charcoal and the potential influence of fire on the landscape at and around the *Ulmus* decline is not considered in the review of Parker *et al*. (2002). Nevertheless, charcoal increases have been recorded around the *Ulmus* decline at sites in East Anglia (Bennett *et al*. 1990; Peglar 1993) and other Wealden sites (Groves 2008) suggesting further combined pollen/charcoal investigations of the *Ulmus* decline in lowland England might throw new light on this much debated event.

For the post-*Ulmus* decline period, charcoal frequencies at Pannel Bridge and the Brede valley sites are lower until *c*. 2100 cal. yr BC, suggesting that the human activities which required the use of fire immediately after the *Ulmus* decline were no longer commonly practised. Clearance phases are not evident in the pollen records, though may be difficult to detect if occurring at distance from the sites or over a short time period. The lack of temporal resolution also restricts the interpretation of the charcoal record, which nevertheless serves to demonstrate that conditions were not conducive to widespread or regular burning. Similarly, low charcoal values were recorded after the *Ulmus* decline at sites in East Anglia by Bennett *et al*. (1990). It is possible that hunter-gatherer economies persisted in these regions with the clearances associated with the adoption of farming systems occurring later in the Holocene.

The first major clearances in the Pannel and Brede valleys are associated with the destruction of *Tilia*-dominated woodland *c*. 2100 cal. yr BC (Late Neolithic/Early Bronze Age). At Brede Bridge, *Tilia* pollen values fall from >5% TLP to <1% at the BB2d/3a boundary and subsequently remain at these low values (Waller 1994). Accompanying changes in the pollen record suggest an open landscape with a mixed pastoral/arable economy. At Pannel Bridge a decline in *Tilia* values also occurs *c*. 2100 cal. yr BC (PB-3e/4a boundary), though here rather than indicators of open vegetation, *Betula* values increase and *Tilia* pollen values slowly recover over a *c*. 500 cal. yrs period. At both sites charcoal frequencies peak prior to the major fall in *Tilia* values. Given that *Tilia* pollen is very poorly dispersed, this may simply be a reflection of a different (larger) source area for microscopic charcoal compared to *Tilia* pollen, though it does suggest that burning was more prevalent immediately before or during the destruction/clearance of the *Tilia* woodland than in the subsequent land-management regime. At Pewis Marsh there is no noticeable increase in charcoal values at this time (PM-3). Here, however, *Tilia* values are notably lower, suggesting clearance activity during the Late Neolithic/Early Bronze Age may have focussed on areas where *Tilia* was a major constituent of the woodland. The absence of a charcoal peak at Pewis Marsh suggests that the charcoal records from these sites only reflect local burning though the sampling resolution and the absence of contiguous samples should again be noted. The record at Old Place (80) appears to show an increase in charcoal after a *Tilia* decline (at the OP-2/3 boundary) though this pattern probably reflects a decline in the sediment accumulation rate.

A second *Tilia* decline at Pannel Bridge is dated *c.* 1400 cal. yr BC (LPAZ PB-4a/4b) and vegetation disturbance is indicated by declines in *Betula* and increases in *Plantago lanceolata*, Poaceae, cereal-type pollen and *Pteridium aquilinum* spores and the deposition of an organic silt layer. A decline in *Tilia* pollen at Pannel Farm is dated *c*. 1300 cal. yr BC (LPAZ PF-1/2) and appears therefore to be broadly contemporary. Charcoal values are low at both sites prior this phase of clearance and subsequently decline further at Pannel Bridge (at the beginning of PB-4b). Burning, therefore, does not appear to have been a major feature of the mid-Bronze Age land-management regimes at these sites.

Charcoal values peak *c*. 1000 cal. yr BC (at the PB-4b/4c boundary) at Pannel Bridge. Tree pollen declines simultaneously, though a major change in the wetland vegetation (the local development of a mire with *Myrica gale*) poses difficulties for reconstructing dryland vegetation at this time (Waller 1993). This peak is replicated at Pannel Farm where charcoal values remain high throughout the deposition of the organic silty-clay (from *c*. 1000 cal. yr BC), though the comparative homogeneity of the record may indicate a substantial inwashed component. Both the high charcoal values and the inwash of sediment are likely to reflected increased human activity in the Late Bronze Age. They broadly coincide with more intensive phases in the exploitation of dry land areas (including cultivation) at Pannel Farm and Peasmarsh and with a regional increase in agricultural activity recorded (from *c*. 1200 cal. yr BC) in the raised bog sequence at East Guldeford (Waller and Schofield 2007). The removal of the existing vegetation prior to cultivation, with burning used to supply an initial flush of nutrients to soil might provide an explanation, though much of the charcoal may simply have been derived from the domestic fires associated with increased settlement activity.

Potentially the charcoal records from the Pannel and Brede valleys should be able to provide new information on the history of Roman iron working in the eastern Weald. In the pollen records *Corylus avellana*-type declines during the Roman period, suggesting hazel may have been used as a source of fuel, though there is no evidence for widespread woodland clearance at this time. Unfortunately, the interpretation of the Pannel Bridge sequence is hampered by the absence of a radiocarbon chronology after *c*. 750 cal. yr BC (above 150 cm) and while both the Pannel Farm and Pewis Marsh sequences extend into the 3rd century AD, the high inorganic content of the sediment suggests the likely presence of reworked charcoal. Therefore, while the higher charcoal values at Pannel Farm (above 160 cm) and at Pewis Marsh (in PM-4) are contemporary with the period of Roman iron working in the Weald, detailed interpretation (in particularly concerning the start and demise of the industry) is not possible.

## Conclusions

The microscopic charcoal data allows the Holocene fire history of the Brede and Pannel valleys to be divided into three phases. For the early Holocene around Pannel Bridge there is evidence for the *in situ* burning of vegetation. Fewer burning and disturbance events (aside from the *Ulmus* decline) occurred during the mid-Holocene. An increase in the use of fire is evident in the late Holocene, though this may not simply reflect *in situ* burning.

The vegetation around Pannel Bridge seems to have been influenced by *in situ* burning events during the early Holocene. However, it is difficult to separate out the factors which potentially underlie these episodes. Was incidence of burning primarily controlled by climatic conditions, or was the climatic influence indirect via the changing vegetation composition and structure? The presence of hunter-gatherer communities within the landscape also needs to be considered in the context of these factors. If burning was used as a tool to manipulate woodland this would have been easier to accomplish under favourable climatic conditions (e.g. increased continentally) or if combustible sources of fuel were available (such as a dry litter layer, particularly associated with boreal woodland taxa such as *Pinus sylvestris*).

Charcoal frequencies are consistently lower in the Pannel and Brede valleys during the mid-Holocene (*c*. 5000 to 2100 cal. yr BC). Rather than climate or vegetation this appears to relate to a change in economy and/or the location of communities, as from *c*. 5000 cal. yr BC the coastline rapidly receded. At both Pannel Bridge and Brede Bridge, charcoal frequencies peak immediately after the *Ulmus* decline, suggesting attempts were made to the maintain open areas which are indicated in pollen record at this time.

Human activity intensified during the Late Neolithic/Early Bronze Age with a change in the composition of woodland (the loss of *Tilia*) and the introduction of pastoral and arable activity. While initial clearance may have been accompanied by burning, correspondence between vegetation change and fire, as inferred from the pollen and charcoal records, is not as evident during the late Holocene. Burning may have been less important in landscapes in which large areas were no longer wooded or where vegetation boundaries were proscribed (land division had occurred). In addition, it is likely that not all fluctuations in charcoal in the late Holocene relate to land-use change, some are likely to have resulted from the use of fire in domestic and industrial settings.

This study has demonstrated the potential of using microscopic charcoal in conjunction with pollen analysis in the Romney Marsh area. There are a number of further investigations that could be undertaken:

1) The only complete record of the early Holocene available for the Romney Marsh area is from Pannel Bridge. However, it is difficult to draw general conclusions from this site given the complex stratigraphy (it is at the inland limits of two phases of marine sedimentation) and its closeness to Mesolithic occupation sites. Further early Holocene records from the region would aid the separation of local and regional pollen and charcoal signals.
2) This work focused on one area marginal to Romney Marsh. Analysis of sites at distances further away from the upland edge, specifically from the raised bog deposits on Walland Marsh (Fig. 3.1, Waller *et al*. 1999; Long *et al*. 2007), would allow better understanding of regional fluctuations in charcoal production during the mid/late Holocene.
3) The increases in charcoal values at Pannel Farm and Pewis Marsh during the Late Iron Age/Roman period may be linked to the development of the iron industry. Additional investigations could be undertaken to identify this industry in the stratigraphic record; either using mineral magnetics (Mighall *et al*. 2009) or geochemical analysis (Hughes *et al*. 2008). Such methods have the potential to provide a better understanding of the timing and scale of this industry and its influence on the vegetation.

*Acknowledgements*
The authors are grateful to the Romney Marsh Research Trust for providing financial assistance to Michael Grant to support this study. Pollen analysis at Pewis Marsh was undertaken by Dr Ed Schofield of the University of Aberdeen. Dr Ed Schofield is also thanked for comments and suggestions that led to the improvement of this manuscript.

## *References*

Agee, J.K. 1998. Fire and pine ecosystems. In D.M. Richardson (ed.) *Ecology and Biogeography of* Pinus, 193–218. Cambridge University Press, Cambridge.

Ahlgren, C.E. 1974. The effects of fires on temperate forests: north central United States. In S.K. Kozlowski and C.E. Ahlgren (eds) *Fire and Ecosystems*, 196–223. Academic Press, London.

Alley, R.B., Meese, D.A., Shuman, C.A., Sowers, T., Stuiver, M., Taylor, K.C. and Clarke, P.U. 1997. Holocene climatic instability: a prominent, widespread event 8200 yrs ago. *Geology* **25**, 483–6.

Barnett, C. 2009. The chronology of Early Mesolithic occupation and environmental impact at Thatcham Reedbeds, southern England, In P. Crombé, M. van Strydonck, M. Boudin and M. Bats (eds) *Chronology and Evolution within the Mesolithic of North-west Europe*, 57–76. Cambridge Scholars Publishing, Cambridge.

Bayliss, A., Cook, G., Bronk Ramsey, C., van der Plicht, J. and McCormac, G. 2008. *Radiocarbon Dates – from Samples Funded by English Heritage under the Aggregates Levy Sustainability Fund 2004–7*. English Heritage, Swindon.

Bell, M.G. 2000. Intertidal peats and the archaeology of coastal change in the Severn Estuary, Bristol Channel and Pembrokeshire. In K. Pye and J.R.L. Allen (eds) *Coastal and Estuarine Environments: Sedimentology, Geomorphology and Geoarchaeology* (Geological Society Special Publication **175**), 377–92. Geological Society, London.

Bell, M.G., Caseldine, A. and Neumann, H. 2000. *Prehistoric Intertidal Archaeology in the Welsh Severn Estuary* (Council for British Archaeology Research Report **126**). CBA, York.

Bell, M.G., Allen, J.R.L., Buckley, S., Dark, P. and Haslett, S.K. 2002. Mesolithic to Neolithic coastal environmental change: excavations at Goldcliff East, 2002. *Archaeology in the Severn Estuary* **13**, 1–29.

Bennett, K.D. 1992. PSIMPOLL – a QuickBASIC program that generates PostScript page description files of pollen diagrams. *INQUA Commission for the Study of the Holocene: Working Group on Data-handling Methods, Newsletter* **8**, 11–12.

Bennett, K.D. and Birks, H.J.B. 1990. Postglacial history of alder (*Alnus glutinosa* (L.) Gaertn.) in the British Isles. *Journal of Quaternary Science* **5**, 123–33.

Bennett, K.D., Simonson, W.D. and Peglar, S.M. 1990. Fire and man in postglacial woodlands of eastern England. *Journal of Archaeological Science* **17**, 635–42.

Björck, S., Kromer, B., Johnsen, S., Bennike, O., Hammarlund, D., Lemdahl, G., Possnert, G., Rasmussen, T.L., Wohlfarth, B., Hammer, C.U. and Spurk, M. 1996. Synchronised terrestrial-atmospheric deglacial records around the North Atlantic. *Science* **274**, 1155–60.

Buck, C.E., Christen, J.A. and James, G.N. 1999. BCal: an on-line Bayesian radiocarbon calibration tool. *Internet Archaeology* **7**.

Charman, D.J. 2009. Centennial climate variability in the British Isles during the mid–late Holocene. *Quaternary Science Reviews* (2009), doi:10.1016/j.quascirev.2009.02.017.

Clark, R.L. 1982. Point count estimation of charcoal in pollen preparations and thin sections of sediments. *Pollen et Spores* **24**, 523–35.

Cleal, R.M.J. 1982. A re-analysis of the ring-ditch site at Playden, East Sussex. *Sussex Archaeological Collections* **120**, 1–17.

Cleere, H.F. and Crossley, D. 1995. *The Iron Industry of the Weald*. 2nd edition. Merton Priory Press, Cardiff.

Davis, B.A.S., Brewer, S., Stevenson, A.C., Guiot, J. and data contributors. 2003. The temperature of Europe during the Holocene reconstructed from pollen data. *Quaternary Science Reviews* **22**, 1701–16.

Edwards, K.J. 1990. Fire and the Scottish Mesolithic: evidence from microscopic charcoal. In P. Vermeesch and P. van Peer (eds) *Contributions to the Mesolithic in Europe*, 71–9. University Press, Leuven.

Edwards, K.J. 1998. Detection of human impact on the natural environment: palynological views. In J. Bayley (ed) *Science in Archaeology: an Agenda for the Future*, 69–88. English Heritage, London.

Edwards, K.J. and Macdonald, G.M. 1991. Holocene palynology: II. Human influence and vegetation change. *Progress in Physical Geography* **15**, 364–417.

Grant, M.J., Hughes, P.D.M. and Barber, K.E. 2009a. Early to mid-Holocene vegetation-fire interactions and responses to climatic change at Cranes Moor, New Forest. In B. Brian, M. Bates, R.T. Hosfield and F.F. Wenban-Smith (eds) *The Quaternary of the Solent Basin and West Sussex Raised Beaches*, 198–214. Quaternary Research Association, London.

Grant, M.J., Barber, K.E. and Hughes, P.D.M. 2009b. True ancient woodland? 10,000 years of continuous woodland cover at Mark Ash Wood, New Forest. In B. Briant, M. Bates, R.T. Hosfield and F.F. Wenban-Smith (eds) *The Quaternary of the Solent Basin and West Sussex Raised Beaches*, 215–33. Quaternary Research Association, London.

Groves, J. 2008. *Late Quaternary Vegetation History of the Acidic Lithologies of South East England*. Unpublished PhD Thesis, Kingston University.

Holgate, R. 2003. Late glacial and post-glacial hunter-gatherers in Sussex. In D. Rudling (ed) *The Archaeology of Sussex to AD 2000*, 29–38. Heritage Marketing, Norfolk.

Holgate, R. and Woodcock, A. 1988. Archaeological and palaeoenvironmental investigations at Pannel Bridge, near Pett Level, East Sussex. In J. Eddison and C. Green (eds) *Romney Marsh: Evolution, Occupation, Reclamation* (Oxford University Committee for Archaeology Monograph **24**), 72–6. Oxford.

Holgate, R. and Woodcock, A. 1989. A later Mesolithic site at Pannel Bridge, near Pett Level, East Sussex. *Sussex Archaeological Collections* **127**, 1–10.

Hughes, P.D.M., Lomas-Clarke, S.H., Schulz, J. and. Barber, K.E. 2008. Decline and localized extinction of a major raised bog species across the British Isles: evidence for associated land-use intensification. *The Holocene* **18**, 1033–43.

Huntley, B. 1993. Rapid early-Holocene migration and high abundance of hazel (*Corylus avellana* L.): alternative hypotheses. In F.M. Chambers (ed) *Climate Change and Human Impact on the Landscape*, 205–15. Chapman and Hall, London.

Iversen, J. 1941. Landnam I Danmarks stenalder. *Danmarks Geologiske Undersøgelse*, *Series II* **66**, 1–67.

Iversen, J. 1973. The development of Denmark's nature since the last glacial. *Danmarks Geologiske Undersøgelse, V Raekke* **7-C**, 1–126.

Jacobson, G.L. and Bradshaw, R.H.W. 1981. The selection of sites for palaeovegetational studies. *Quaternary Research* **16**, 80–96.

Laird, L.D. and Campbell, I.D. 2000. High resolution palaeofire signals from Christina Lake, Alberta: a comparison of the charcoal signals extracted by two different methods. *Palaeogeography, Palaeoclimatology, Palaeoecology* **164**, 111–23.

Lamb, H.H. 1977. *Climate: Past Present and Future*, vol. 2. Methuen, London.

Long, A.J., Plater, A.J., Waller, M.P. and Innes, J.B. 1996. Holocene coastal evolution in the eastern English Channel: new evidence from the Rye area. *Marine Geology* **136**, 97–120.

Long, A.J., Waller, M.P. and Plater, A.J. 2007. *Dungeness and Romney Marsh: Barrier Dynamics and Marshland Evolution.* Oxbow Books, Oxford.

Mason, S.L.R. 2000. Fire and Mesolithic subsistence – managing oaks for acorns in northwest Europe? *Palaeogeography, Palaeoclimatology, Palaeoecology* **164**, 139–50.

McRae, S.G. and Burnham, C.P. 1975. The soils of the Weald. *Proceedings of the Geologists' Association* **86**, 593–610.

McVean, D.N. 1956. Ecology of *Alnus glutinosa* (L.) Gaertn: III. Seedling establishment. *Journal of Ecology* **44**, 195–218.

Mellars, P. 1976. Fire, ecology, animal populations and man: a study of some ecological relationships in prehistory. *Proceedings of the Prehistoric Society* **42**, 15–45.

Mellars, P. and Dark, P. 1998. *Star Carr in Context* (McDonald Institute Monographs). McDonald Institute for Archaeological Research, Cambridge.

Mighall, T.M., Foster, I.D.L., Crew, P., Chapman, A.S. and Finn, A. 2009. Using mineral magnetism to characterise ironworking and detect its evidence in peat bogs. *Journal of Archaeological Science* **36**, 130–39.

Moore, J.W. 1979. A Mesolithic site at Fairlight, East Sussex. *Sussex Archeological Collections* **117**, 1–10.

Moore, J. 2000. Forest fire and human interaction in the early Holocene woodlands of Britain. *Palaeogeography, Palaeoclimatology, Palaeoecology* **164**, 125–37.

Parker, A.G., Goudie, A.S., Anderson, D.E., Robinson, M.A. and Bonsall, C. 2002. A review of the mid-Holocene elm decline in the British Isles. *Progress in Physical Geography* **26**, 1–45.

Patterson, W.A., Edwards, K.J. and Maguire, D.J. 1987. Microscope charcoal as a fossil indicator of fire. *Quaternary Science Reviews* **6**, 3–23.

Peglar, S.M. 1993. The mid-Holocene *Ulmus* decline at Diss Mere, Norfolk, UK: a year-by- pollen stratigraphy from annual laminations. *The Holocene* **3**, 1–13.

Rackham, O. 2003. *Ancient Woodland*. 2nd edition. Castlepoint Press, Colvend.

Reimer, P.J., Baillie, M.G.L, Bard, E., Bayliss, A., Beck, J.W., Bertrand, C.J.H., Blackwell, P.G., Buck, C.E., Burr, G.S., Cutler, K.B., Damon, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., McCormac, G., Manning, S., Ramsey, C.B., Reimer, R.W., Remmele, S., Southon, J.R., Stuiver, M., Talamo, S., Taylor, F.W., van der Plicht, J. and Weyhenmeyer, C.E. 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* **46**, 1029–58.

Smith, A.G. 1970. The influence of Mesolithic and Neolithic man on British vegetation: a discussion. In D. Walker and R.G. West (eds) *Studies in the Vegetational History of the British Isles*, 81–96. Cambridge University Press, Cambridge.

Smith, A.G. 1984. Newferry and the Boreal-Atlantic transition. *New Phytologist* **98**, 35–55.

Tooley, M.J. 1978. The history of Hartlepool Bay. *International Journal of Nautical Archaeology* **7**, 71–87.

Tyler, A. 2007. *Romney Marsh and the Western River Valleys: an Archaeological Gazetteer*. Romney Marsh Research Trust. www.rmrt.org.uk.

Waller, M.P. 1993. Flandrian vegetational history of south-eastern England: pollen data from Pannel Bridge, East Sussex. *New Phytologist* **124**, 345–69.

Waller, M.P. 1994. Flandrian vegetational history of south-eastern England: stratigraphy of the Brede Valley and pollen data from Brede Bridge. *New Phytologist* **126**, 369–92.

Waller, M.P. 1998. An investigation into the palynological properties of fen peat through multiple pollen profiles from southeastern England. *Journal of Archaeological Science* **25**, 631–42.

Waller, M.P. 2002. The Holocene vegetation history of the Romney Marsh Region. In A. Long, S. Hipkin and H. Clarke (eds) *Romney Marsh: Coastal and Landscape Change through the Ages* (Oxford University Committee for Archaeology Monograph **56**), 1–21. Oxford.

Waller, M.P. and Long, A.J. 2003. Holocene coastal evolution and sea-level change on the southern coast of England: a review. *Journal of Quaternary Science* **18**, 351–9.

Waller, M.P. and Schofield, J.E. 2007. Mid to late Holocene vegetation and land use history in the Weald of south-eastern England: multiple pollen profiles from the Rye area. *Vegetation History and Archaeobotany* **16**, 367–84.

Waller, M.P., Long, A.J., Long, D. and Innes, J.B. 1999. Patterns and processes in the development of coastal mire vegetation: multi-site investigations from Walland Marsh, southeast England. *Quaternary Science Reviews* **18**, 1419–44.

Waller, M.P., Long, A.J. and Schofield, J.E. 2006. The interpretation of radiocarbon dates from the upper surface of late Holocene peat layers in coastal lowlands. *The Holocene* **16**, 51–61.

Whitehouse, N.J. 2000. Forest fires and insects: palaeoentomological research from a subfossil burnt forest. *Palaeogeography, Palaeoclimatology, Palaeoecology* **164**, 231–46.

Whitlock, C. and Millspaugh, S.H. 1996. Testing the assumptions of fire history studies: an examination of modern charcoal accumulation in Yellowstone National Park, USA. *The Holocene* **6**, 7–15.