Somerset's Peatland Archaeology

Managing and Investigating a Fragile Resource

Richard Brunning

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The results of the Monuments at Risk in Somerset Peatlands (MARISP) project

Richard Brunning

with contributions by

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Contents

List of Figures

Appendix 3

Appendix 4

List of Tables

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Summary

Waterlogged archaeological remains provide our most complete evidence for past society but in rural peatlands they are being destroyed at a rapid rate. This volume presents the results of a project examining the *in situ* preservation of nine of the most significant wetland archaeological monuments in the Somerset peat moors. The project was undertaken by Somerset County Council with partnership funding from English Heritage, Somerset County Council and the Environment Agency. All the sites were located on private land. Techniques involved hydrological analysis and condition assessment of wooden remains and palaeoenvironmental evidence. New condition assessment techniques were developed for pollen and plant remains. Excavations to obtain samples also allowed important research questions to be answered about some of the monuments. The project provides a good case study for a cost effective methodology for researching and managing sites in rural wetlands.

The nine sites chosen for assessment included four groups of Neolithic and Bronze Age wooden trackways, a Bronze Age wooden platform, a late Bronze Age ritual pile alignment, two Iron Age wetland settlements and an early medieval stone and wood causeway. The sites of three other late prehistoric wooden trackways were investigated but no structures were located. In one case radiocarbon dating of the peat suggests that the monument had been destroyed by ploughing and consequent peat wastage. This may also be the case with the other two sites, although this was not proven.

Hydrological monitoring demonstrated that all the sites are threatened with seasonal desiccation and consequent monument damage in the summer months when the water table lowers significantly. The most extreme case was the Iron Age Meare Lake Village where the water table was so low throughout the year that wood survival was exceptionally poor. Many of the other monuments were found to be so close to the ground surface that it would be impossible to improve their hydrological setting and also retain them in a farmed regime.

Condition assessments demonstrated great variability between the wood, pollen, plant macrofossil and beetle remains. This was partly due to variations in the original burial environment and partly determined by variable responses to recent changes in that environment.

Small scale excavations to recover samples for assessment were also used to enhance knowledge about the sites. This was especially the case for four sites where detailed palaeoenvironmental analysis took place. These have added considerably to our understanding of changes in the Brue valley floodplain during later prehistory. The causeway between Street and Glastonbury was scientifically dated for the first time to the middle Anglo-Saxon period and its place in wider reclamation and river canalisation at that time is discussed. The excavations of the Harding Alignment at Harter's Hill showed how that late Bronze Age ritual pile alignment developed over time. Comparisons with discoveries of similar structures from the same period and comparable environments suggest the existence of a particular class of ritual monument in the UK which shared the same fundamental characteristics.

Recommendations are made for research and management priorities for each of the sites studied. Only a proportion of the sites are likely to survive over the longer term. Climate change over the next century is predicted to make the situation even worse. A landscape scale approach is suggested as the main management objective with the aim to slow down, and ideally stop, peat wastage. Alongside this, site specific measures can be developed to preserve some of the wetland monuments *in situ*. For other monuments long term preservation is not realistic. The knowledge contained within the waterlogged components of those sites should be extracted to answer research questions

Résumé

Ce sont les vestiges archéologiques gorgés d'eau qui nous fournissent les témoignages les plus complets des sociétés du passé mais, dans les tourbières rurales, ils sont détruits à grande vitesse. Ce volume présente les résultats d'un projet qui a étudié la préservation in situ de neuf des plus importants monuments archéologiques en terrain marécageux des landes à tourbe du Somerset. Le projet fut entrepris par le Conseil Général du Somerset dans le cadre d'un partenariat financier entre English Heritage, le Conseil Général du Somerset et l'Agence pour l'Environnement.Tous les sites se trouvaient sur des terrains privés. Les techniques comportaient une analyse hydrologique et une évaluation de l'état des restes de bois et des indices paléo-environnementaux. On a développé de nouvelles techniques pour évaluer les restes de pollen et de plantes. Des fouilles pour obtenir des échantillons ont aussi permis de répondre à d'importantes questions de recherches pour certains des monuments. Le projet représente une bonne étude de cas pour une méthodologie rentable pour l'étude et la gestion des sites de zones humides rurales.

Les neuf sites choisis pour l'évaluation comprenaient quatre groupes de voies en bois du néolithique et de l'âge du bronze, une plateforme en bois de l'âge du bronze, un alignement d'amoncellements rituels de la fin de l'âge du bronze, deux occupations lacustres de l'âge du fer et une chaussée en pierre et en bois du début du moyen-âge. Les sites de trois autres voies en bois de la fin de la préhistoire ont été examinés mais aucune structure n'a pu être localisée. Dans un des cas, la datation de la tourbe au C14 donne à penser que le monument avait été détruit par les labours et la disparition de la tourbe qui s'en était suivie. Il se peut que ce soit aussi le cas pour les deux autres sites, bien que cela n'ait pu être prouvé.

La surveillance hydrologique a démontré que tous les sites étaient sous la menace d'un assèchement saisonnier résultant en des dégâts aux monuments en été quand le niveau de la nappe phréatique baisse considérablement. Le cas le plus extrème était le village lacustre de l'âge du fer de Meare où la nappe phréatique était si basse durant toute l'année que la survivance du bois était extrèmement médiocre. On a trouvé que beaucoup des autres monuments étaient si près de la surface du sol qu'il serait impossible d'améliorer leur situation hydrologique et aussi de les conserver sous un régime agricole.

Les évaluations de l'état de conservation ont fait apparaître d'importantes variations entre les restes de bois, de pollen, de macrofossiles de plantes et de coléoptères. C'était en partie dû aux divers environnements dans lesquels ils avaient été inhumés à l'origine et en partie déterminé par la variété des réactions aux récents changements dans cet environnement.

Des excavations de petite échelle pour récupérer des échantillons pour l'évaluation ont aussi été utilisées pour consolider notre connaissance de ces sites. Ce fut le cas en particulier pour quatre sites sur lesquels on mena une analyse paléo-environnementale détaillée. Ils ont été un apport considérable à notre compréhension des changements dans la plaine inondable de la vallée de la Brue pendant la préhistoire finale. La chaussée entre Street et Glastonbury a été datée scientifiquement pour la première fois de la période anglo-saxonne moyenne et on discute de sa place dans la plus étendue mise en valeur et canalisation de la rivière à cette époque. Les excavations de l'alignement de Harding à Harter's Hill ont montré comment cet alignement d'amoncellements rituels de la fin de l'âge du bronze s'est développé au cours du temps. Des comparaisons avec des découvertes de structures similaires de la même période et d'environnements comparables donnent à penser qu'il existait une classe particulière de monuments rituels au Royaume-Uni qui partageaient les mêmes caractéristiques fondamentales.

Nous faisons des recommandations pour les priorités en matière de recherche et de gestion pour chacun des sites étudiés. Seule une proportion des sites est susceptible de survivre sur le long terme. On prédit que les changements climatiques au cours du prochain siècle aggraveront encore la situation. Nous proposons une approche à l'échelle du paysage comme principal objectif de la gestion dans le but de ralentir, et idéalement d'arrêter, la disparition de la tourbe. A côté de cela, des mesures spécifiques à chaque site peuvent être développées pour préserver in situ certains des monuments de terres marécageuses. Pour d'autres monuments, la préservation à long terme n'est pas réaliste. Les informations contenues à l'intérieur des composants gorgés d'eau de ces sites devraient être extraites pour répondre aux questions des recherches avant qu'elles ne disparaissent à jamais.

Zusammenfassung

Unter Sauerstoffabschluß erhaltene organische Materialien gehören zu den am besten erhaltenen archäologischen Hinterlassenschaften vergangener Gesellschaften, in ländlichen Torfmooren unterliegen sie jedoch einer rasanten Zerstörungsrate. In diesem Band werden die Ergebnisse eines Forschungsprojekts zur in situ-Erhaltung von neun der wichtigsten Feuchtboden-Denkmale in den Torfmooren der Grafschaft Somerset vorgelegt. Das Projekt wurde von der Grafschaftsverwaltung von Somerset durchgeführt und gemeinschaftlich von English Heritage, der Grafschaftsverwaltung und der Nationalen Umwelt Agentur gefördert. Alle Fundplätze sind in Privatbesitz. Die für die Untersuchungn angewandten Methoden schließen hydrologische Analysen sowie Gutachten zur Ermittlung der Erhaltungszustände hölzerner und paläoökologischer Bodenfunde ein. Es wurden neue Techniken zur Ermittlung der Erhaltungszustände von Pollen und Pflanzenresten entwickelt. Die Ausgrabungen im Zuge der Probenentnahme ermöglichten die Klärung wichtiger Forschungsfragen zu einer Reihe der Bodendenkmale. Das Projekt bietet eine gute Fallstudie für eine kosteneffiziente Methodologie zur Erforschung und Bewirtschaftung von Fundplätzen in ländlichen Feuchtgebieten.

Unter den neun für die Zustandsbestimmung ausgewählten Fundplätze finden sich vier Gruppen neolitischer und bronzezeitlicher Bohlenwege, eine bronzezeitliche Holzplatform, eine spätbronzezeitliche Pfostenreihung, zwei eisenzeitliche Feuchtbodensiedlungen und ein frühmittelalterlicher, mit Steinen und Hölzern errichteter Damm. Bei Untersuchungen an den Fundplätzen von drei weiteren spätbronze-/eisenzeitlichen Bohlenwegen konnten keine Strukturen gefunden werden. In einem Fall legen die Ergebnisse von Radiokarbondatierungen des Torfs nahe, dass das Denkmal durch Rigolen und darauf folgende Torfschrumpfung zerstört wurde. Dies mag auch für die beiden anderen Fundplätze zutreffen, ließ sich jedoch nicht bestätigen.

Hydrologische Untersuchungen ergaben, dass alle Fundplätze während der Sommermonate, wenn der Grundwasserspiegel deutich absinkt, von saisonaler Austrocknung und dadurch bedingter Schädigung des Denkmalbestands bedroht sind. Im extremsten Fall, der eisenzeitlichen Feuchtbodensiedlung Meare, lag der Grundwasserspiegel ganzjährig so niedrig, dass die Holzerhaltung außergewöhnlich schlecht war. Mehrere andere Denkmale lagen so dicht unter der Oberfläche, dass eine Verbesserung ihrer jeweiligen hydrologischen Bedingungen unter gleichzeitiger Fortführung ihrer landwirtschaftlichen Nutzung unmöglich wäre.

Die Untersuchungen der Erhaltungzustände ergaben große Unterschiede zwischen Holz, Pollen, pflanzlichen Makroresten und Insekten. Dies war zum Teil auf unterschiedliche Lagerungsmilieus zurückzuführen und teilweise durch unterschiedliche Reaktionen auf rezente Änderungen dieser Milieus bedingt.

Kleinmaßstäbige Ausgrabungen, die der Probenentnahme für Voruntersuchungen dienten, ermöglichten darüber hinaus, die vorhandenen Kenntnisse zu den jeweiligen Fundstellen zu erweitern. Dies trifft in besonderem Maße auf vier Fundstellen zu, an denen detaillierte paläoökologische Untersuchungen durchgeführt wurden. Anhand dieser Untersuchungen konnten unsere Kenntnisse der Entwicklung im Auenbereich des Brue-Tals während der jüngeren vorgeschichtlichen Perioden wesentlich erweitert werden. Der Bohlenweg zwischen Street und Glastonbury wurde mit Hilfe naturwissenschaftlicher Datierungsmethoden erstmals in die mittel-angelsächsische Periode datiert, und in der anschließenden Diskussion wird sein Stellenwert im Umfeld der gleichzeitigen Landgewinnung und Flußkanalisation erörtert. Anhand der Ausgrabung des Harding Alignment bei Harter's Hill konnte die Entwicklungsgeschichte dieser spätbronzezeitlichen Pfostenreihung aufgezeigt werden. Vergleiche mit Funden ähnlicher Strukuturen der selben Periode und aus vergleichbaren Umgebungen legen nahe, dass es in Großbritannien eine bestimmte Klasse ritueller Monumente gab, die die selben wesentlichen Charakteristika teilten.

Empfehlungen zu Forschungs- und Bewirtschaftungsprioritäten werden für jeden untersuchten Fundplatz gegeben. Nur einem Teil der Fundplätze werden längerfristige Erhaltungschancen eingeräumt. Angesichts klimatischer Veränderungen im Laufe des nächsten Jahrhunderts wird eine Verschlimmerung der Situation vorhergesagt. Als wesentlichstes Managementziel wird eine landschaftsumfaßende Herangehensweise vorgeschlagen, deren Ziel eine Verlangsamung, wenn nicht gar ein Stopp, der Torfschrumpfung ist. Daneben können fundstellenspezifische Maßnahmen entwickelt werden, die den in situ-Erhalt einer Reihe der Feuchtboden-Denkmale ermöglichen. Für andere Denkmale ist hingegen eine langfristige Erhaltung unrealistisch. Der Erkenntnisgewinn, den die unter Luftabschluß erhaltenen Komponenten dieser Fundstellen bieten, sollte zur Beantwortung wissenschaftlicher Fragestellungen herangezogen werden bevor sie für immer verloren sind.

1. Introduction to the Project

Richard Brunning

The Somerset Levels and Moors

The Somerset Levels and Moors are part of a series of coastal floodplains that fringe both sides of the Severn Estuary. These areas have similar Holocene environmental histories and contain a wealth of waterlogged archaeological landscapes and discrete monuments. This project forms a small part of the ongoing archaeological research into the area, which is coordinated by the Severn Estuary and Levels Research Committee (www.selrc.org.uk).

The Somerset Levels and Moors consist of extensive floodplain deposits in central Somerset in the valleys of the present rivers Axe, Brue, Parrett and Tone (Figure 1). In total they cover an area of 160,000 acres ($650km^2$) and can be broadly divided into the coastal clay belt or 'Levels' and the inland, peat dominated, 'moors' (Figure 1). The extent of the lowland peat deposits has been mapped by the peat survey of Cope and Colborne (1981), which identified $202km^2$ of peat deposits 1–8.5m deep, covered in places by surface

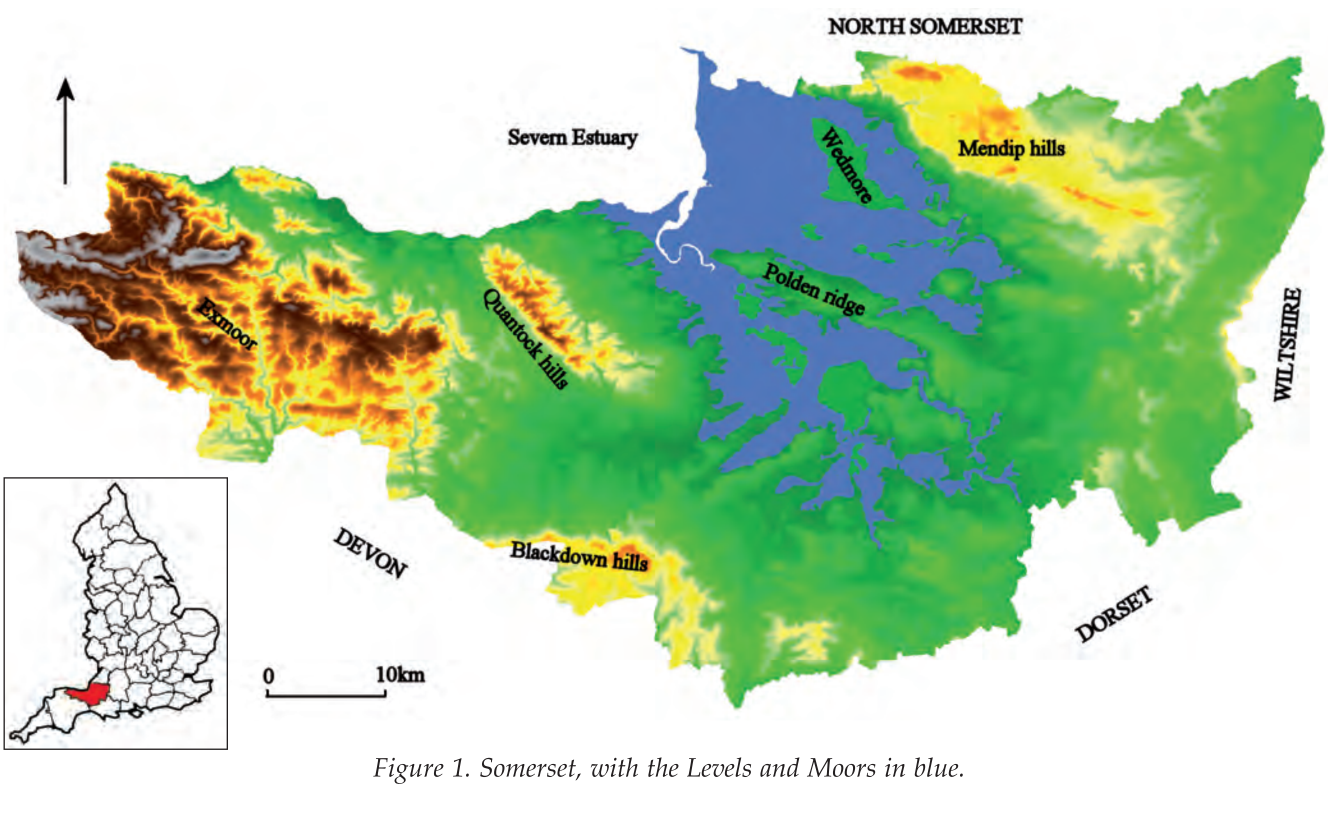


Figure 1. Somerset, with the Levels and Moors in blue.

Figure 2. Southlake moor in winter flood.

alluvium of varying thickness. This underestimates the extent of the peatlands because the survey did not cover the floodplain upstream of Langport or the middle Brue valley.

A circle of high ground surrounds these floodplains, with the Mendip Hills to the north, the Quantock Hills to the west and the Blackdown Hills to the south. This large catchment area produces extensive flooding of the lowland every winter (Figure 2). A long finger of hard geology, the Polden Hills, effectively divides the area into a northern and southern zone.

Scattered throughout the valleys are over a hundred 'islands' of hard geology that rise above the floodplain deposits and have been the foci for human activity throughout the Holocene period, right up to the present day. Some of the islands, such as the Isle of Wedmore, are several kilometres across and rise up over 100 metres. The smallest islands are just tens of metres across and are almost completely masked by Holocene clay or peat.

The Holocene palaeoenvironmental background

Considerable evidence for Holocene palaeoenvironmental change has been obtained from the Somerset Levels and Moors, especially from the central Brue valley, where over 60 years of research has been carried out. The Holocene sequence in the area has a broad tripartite lithostratigraphic division, corresponding to similar evidence from southern Britain and north-west Europe. The division distinguishes early Holocene silt dominated sequences, formed in mudflats and saltmarshes, from mid-Holocene intercalated silts and peats (formed in high inter-tidal to supra-tidal marshes) and then a return to silt dominance in the late Holocene (Allen 2006). In the Somerset area this division has been formalised into the Lower, Middle and Upper Somerset Levels Formation (Haslett *et al.* 2001) corresponding to the Wentlooge Formation on the Welsh coast. This broad tripartite division masks a more complicated sequence as shown by the existence of intercalated peat deposits in the earlier Holocene sequence (e.g. Kidson and Heyworth 1976; Hill *et al*. 2006 and Wilkinson 2007).

Climatic amelioration at the end of the Devensian glaciation appears to have occurred rapidly with temperatures broadly comparable to those of today being reached within a few hundred years between *c*. 7850 and *c*. 7550 cal BC (Atkinson *et al.* 1987 and Cope and Lemdahl 1995). The retreat of the glaciers led to eustatic global sea level rise from around -55m OD at the beginning of the Holocene to present day levels by *c*. 4900 cal BC (Tooley and Shennan 1987). This led to the submergence of the present Severn Estuary, the

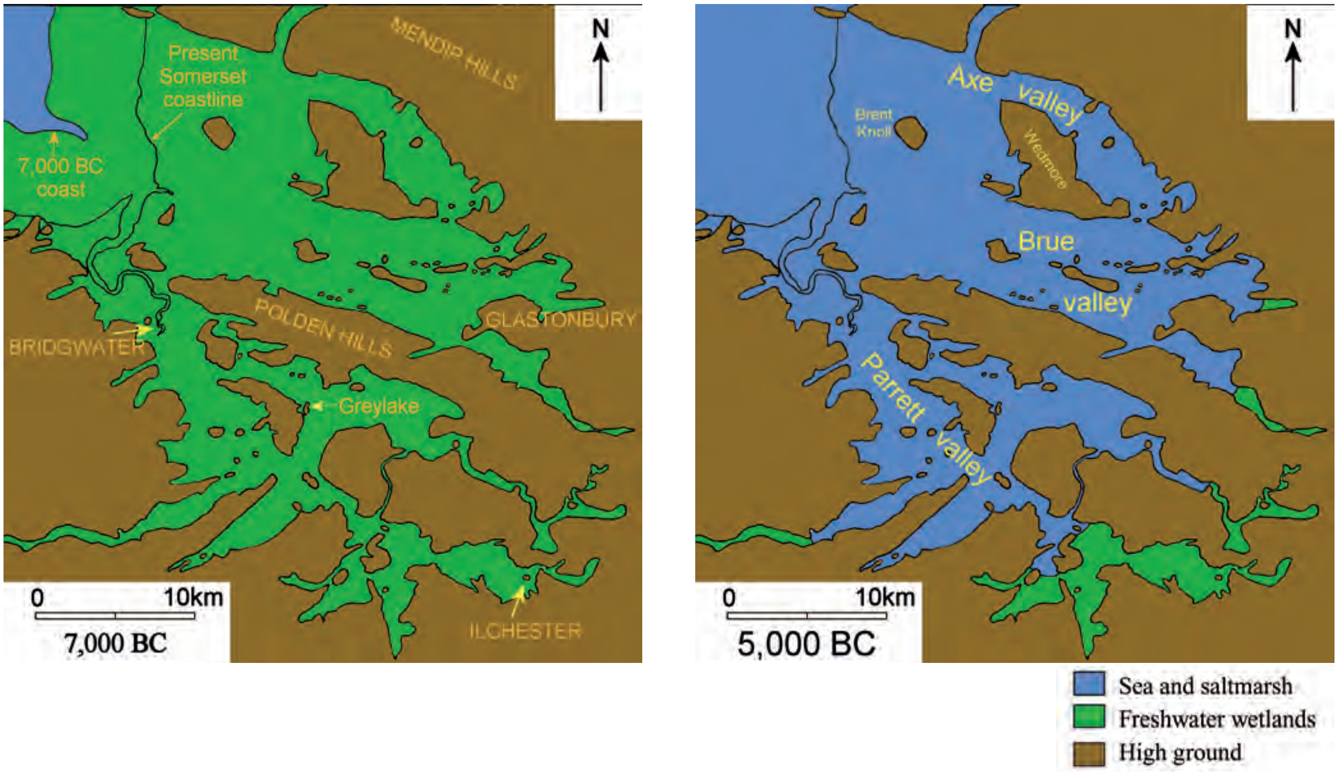


Figure 3. The Somerset coast between c. *7,000 BC and* c. *5,000 BC, representing the maximum extent of the Holocene transgression.*

Somerset Levels and Moors, and the North Somerset and Avon Levels by *c*. 4500 BC (Figures 3 and 4).

Thin peat layers are known from deep cores along the Somerset coastline and the M5 route (Kidson and Heyworth 1976; Long *et al.* 2001). These represent possible fluctuations in sea level rise giving rise to the formation of upper saltmarsh or supra-tidal marsh conditions. They exist between -21.3m OD up to *c*. -2m OD just below the beginning of the peat dominated Middle Somerset Levels Formation. Their existence suggests that the difference between the Lower and Middle Somerset Formations are not as strong as has previously been suggested.

Scientific dates for the Lower Somerset Levels (Severn) Formation, dated to before *c*. 5000 cal BC, have been very limited and focus on work in the inter-tidal area at Minehead (Jones *et al.* 2005) Woolaston (Brown *et al.* 2006) Burnham-on-Sea (Druce 1998) and Porlock (Jennings *et al*. 1998). The dates available before 1998 were used as sea level index points to suggest Mean Sea Levels, with a MSL of -25 to -26m OD at *c*. 7500 cal BC (Jennings *et al*. 1998). By *c*. 5900 to 6200 cal BC MSL had risen rapidly to between *c*. -12.5m to -14m OD and by *c*. 5000 cal BC MSL was *c*. -8m OD (Jennings *et al.* 1998, tab. 1, 166).

The implications of this rapid sea level rise on the changing coastline have been modelled in detail for the central Axe valley (Haslett *et al.* 2001) where the marine sediments of the Lower Somerset Levels Formation were studied in detail. Between *c*. 8000 and 5000 cal BC the sea level rise was *c*. 5–6mm yr^{-1} (Haslett *et al.* 2001, or 7.5mm according to Long *et al.* 2001). During this time the estuarine surface, which penetrated far inland of the modern coastline, would have been dominated by mudflats/low marsh environments (Figure 3). Mid- to high marsh would only occupy a narrow, relatively steeply inclined, fringe along the coastline (Haslett *et al.* 2001).

From *c*. 5000 cal BC the rate of sea level rise began to decrease from the previous very rapid rate of *c*. 5–6mm yr^{-1} to *c*. 2mm yr^{-1} between *c*. 5000 and 3000 cal BC (Haslett *et al.* 2001). This had major effects on the development of the coastline as organic sedimentation began to outpace sea level rise (Figure 4). This allowed the development of the Middle Somerset Levels Formation and Middle Wentlooge peat-dominated environments to develop. The deceleration in sea level rise would also have allowed the mid-marsh environments to expand and dominate a larger part of the estuary (Haslett *et al.* 2001). Eventually the higher marsh environments would squeeze out the middle marsh and would dominate the estuarine environment with small tidal creeks and a reduction in tidal flooding frequency (Haslett *et al.* 2001).

The timing of the change from silt to peat environments and the character of the peat environments varied from place to place. In general the peat deposits are thicker inland while towards the coast they become increasingly intercalated with silt layers, as at Minehead, Stolford, Burnham-on-Sea, Huntspill and East Brent.

Three periods of peat deposition were identified on the present foreshore at Minehead, forming between *c.* 5400 and 4500 cal BC (Jones *et al.* 2005). Very little dating and analysis has been carried out in the Parrett and Tone valleys. Around the mouth of the Parrett between Stolford and the Poldens Kidson and Heyworth (1976) recorded the Middle Somerset Levels Formation as intercalated peat and clay along the coast and as a thick peat layer further inland, deposition beginning around 4000 cal BC. The Middle Somerset Levels Formation exists as a thick peat layer in the central Parrett valley and has been briefly characterised by Alderton (1983) and has been dated on its base at Sutton Hams to *c.* 3900 cal BC (Coles and Dobson 1989). Further inland near Langport, recent evidence has dated the base of the Formation to 4840–4520 cal BC (Wilkinson 2006). This limited evidence suggests that the organic deposits of the Formation developed seawards over a period of several hundred years in the 5th millennium cal BC.

Much more information exists for the Brue and Axe valleys. Intercalated peat and silt deposits are known from Burnham-on-Sea (Druce 1999), the Huntspill River (Brunning and Farr Cox 2006), Walpole (Hollinrake and Hollinrake 2001) and East Brent (Haslett *et al.* 2001a). The M5 boreholes also show similar deposits (Long *et al.* 2001) although the accuracy of the interpretation may be open to question and they are undated. The intercalated peat deposits have been dated between 5440 and 3370 cal BC at Burnham-on-Sea (Druce 1999), between *c.* 4780 and 1320 cal BC at Walpole (Hollinrake and Hollinrake 2001). Godwin (1960) recorded intercalated peat and silt on the River Huntspill between Puriton Bridge and Withy Bridge. At Withy Bridge two peat layers (not noted by Godwin) formed in short lived higher saltmarsh conditions in the later Bronze Age and early Iron Age sandwiched between clays created in lower saltmarsh ecosystems (Vickery 1999).

A transect between Brean and Wedmore (Haslett *et al.* 2001a) showed the main peat deposit dividing into intercalated peat and clays at Brean and to the south in the area north of Brent Knoll. The beginning of the peat formation is dated to 4200–3200 cal BC and its surviving end to between *c.* 2000 and 1500 cal BC (Haslett *et al.* 2001a).

In the Axe valley the beginning of the main peat layer has been dated to between 4905 and 4540 cal BC, continuing until sometime between 1775 and 1425 cal BC (Haslett *et al.* 2001). In the central Brue valley peat formation began between 4500 and 4000 cal BC (Coles and Dobson 1989) with an earlier thin peat in places forming possibly as early as *c.* 4700 cal BC (Wilkinson 1999).

Most of the analysis of the main peat sequence has taken place in the central Brue valley, with only limited work elsewhere. The earliest peat layers were formed in *Phragmites* reedswamps. These gradually gave way to fen woodland, which was in turn replaced by raised bog peats in the middle Brue valley. At the eastern end of the valley around Glastonbury more diverse fen habitats persisted because of the influence of the River Brue as it flowed northwards into the Axe valley. A more detailed examination of the environmental sequence of the central Brue valley is presented in Chapter 7.

In the 2nd millennium cal BC there is a significant shift from the Middle to the Upper Somerset Levels Formation and their equivalents over a large part of the Somerset Levels and Moors. This represents a shift from freshwater and upper saltmarsh habitats to lower to mid-marsh environments. Analysis of sediments in the Axe valley showed a positive sea level tendency throughout the Upper Somerset Levels Formation (Haslett *et al.* 1998).

At several locations along the coast peat formation ceases at similar dates in the 2nd millennium cal BC. At Walpole, in Somerset the last peat was formed sometime between 1603 and 1320 cal BC after which silts and clays dominated (Hollinrake and Hollinrake 2001). Further north at the lower end of the Axe valley silt deposition occurs from sometime around 2000–1600 cal BC (Haslett *et al.* 2001a). Further up the Axe valley near Nyland the change from peat to silt happened sometime between 1775 and 1510 cal BC (Haslett *et al.* 1998).

Clay of the Upper Somerset Levels Formation also extends from the head of the Axe valley through the Panborough Gap into the Brue valley around Godney Moor and southwards through the Godney Gap into East Backwear (Godwin 1955; Housley *et al.* 2000). The transgressive change has been dated to between 1120 and 950 cal BC at Long Run farm south of Godney. This represents the furthest extent of the transgression in Somerset and appears to have occurred at least several hundred years after the change in the Axe valley and at Walpole (Figure 4).

Rising sea level increased base levels further inland and led to flooding of the raised bog in the central Brue valley with calcareous water and the establishment of sedge fen (Godwin 1960) associated with the Meare Heath (Bulleid 1933; Godwin 1960; Coles and Orme 1976; Coles and Orme 1978a; Coles *et al.* 1988) and Tinney's Tracks (Coles and Orme 1978b; Beckett 1978; Girling 1978; Coles and Orme 1980). These two trackways have dated tree-ring chronologies, tying

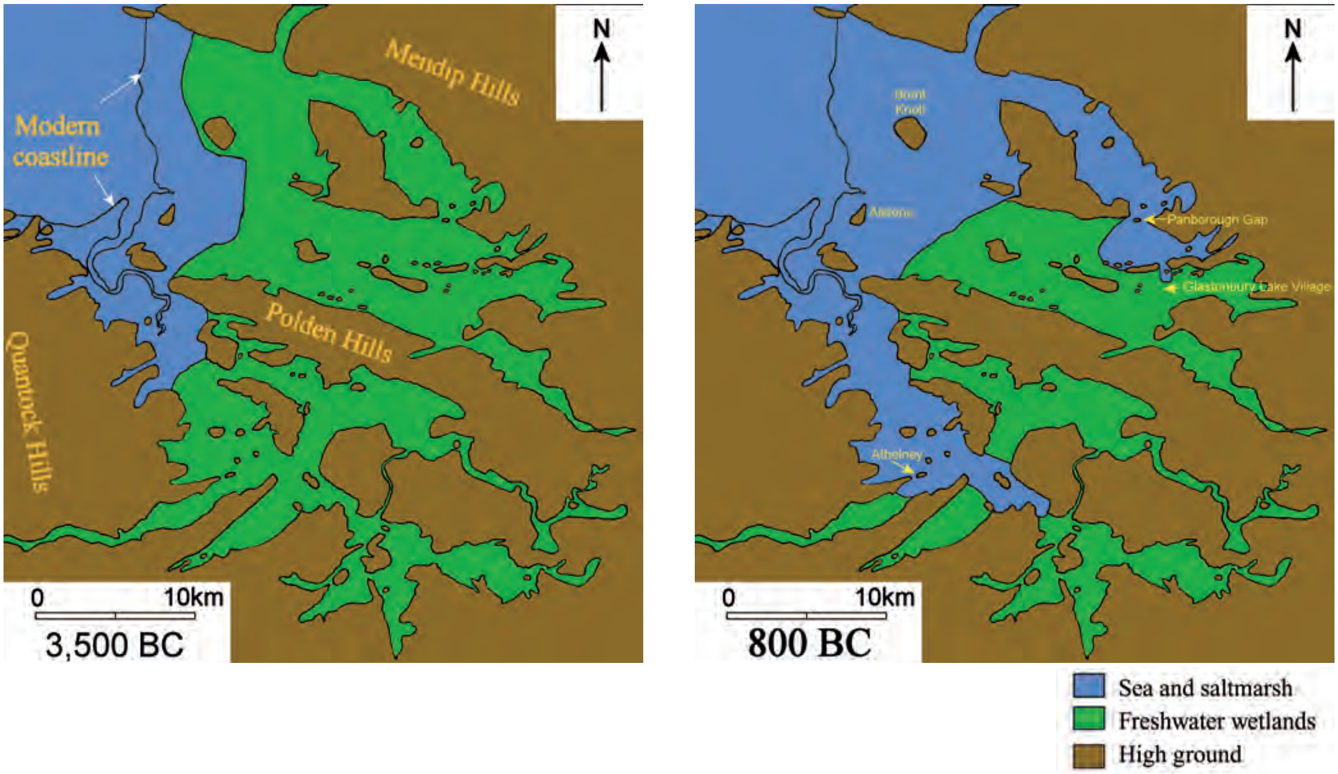


Figure 4. The Somerset coast c. 3,500 BC and c. 800 BC.

down their construction to sometime between 1550 and 1450 BC (Tyers 2004). As they appear to have been built in response to the increasing wetness on the bog surface they provide probably the most precise date for the transgression and associated rise in base levels in this area.

In the Parrett valley near Langport the transition form the Middle Somerset Formation peat to a silt-depositing environment has been dated to 1130–840 cal BC (Wilkinson 2006). This corresponds well to the dates for a similar change south of Godney (above) suggesting that the transgression lasted for several hundred years and penetrated inland gradually.

It is difficult to identify the exact position of the coastline during this period because of the absence of peat forming upper saltmarsh/brackish environments. This may be because such deposits were largely eroded by the coastal transgression and/or because they were of very limited spatial extent. The inland extent of the upper saltmarsh is limited by the presence of the main central Somerset Levels peat formation that still dominated the central Brue and Parrett valleys during these periods, with raised bog growing at least as far seawards as Woolavington Bridge on the River Huntspill (Jones 2003; Smith 2003; Tinsley 2003).

Fluctuations in sea level rise and coastal change in the later Bronze Age and early Iron Age are well illustrated at Withy Bridge on the Huntspill River in Somerset. There inter-digitated peat and clay deposits have been dated to the late Bronze Age and early Iron Age (Vickery 1999). By the middle of the 1st millennium cal BC there is evidence of regressive tendencies in some places, most notably on Godney Moor and the area south of Godney in the Brue valley where freshwater environments began forming peat on top of the estuarine clays between *c*. 840–450 cal BC (Housley *et al*. 2000).

In the last few centuries of the 1st millennium cal BC rising sea level may have helped to cause the rising base levels that may have been responsible for the clay filled channel that cut the raised bog at Skinner's Wood in the Brue valley (Horner 1996) and the freshwater conditions in which the nearby Shapwick canoe was deposited (Godwin 1967). Late Iron Age salterns are also known from the Axe valley and the area immediately west of Wedmore (Leech 1997). Around the end of the 1st millennium cal BC the raised bog at Woolavington Bridge on the River Huntspill stops growing and begins to be eroded by saltmarsh creeks (Brunning and Farr-Cox 2006).

Extensive reclamation of much of the coastal wetlands in Somerset appears to have taken place during the Romano-British period (Figure 5). To the north of the Poldens, settlement is known along the finger of

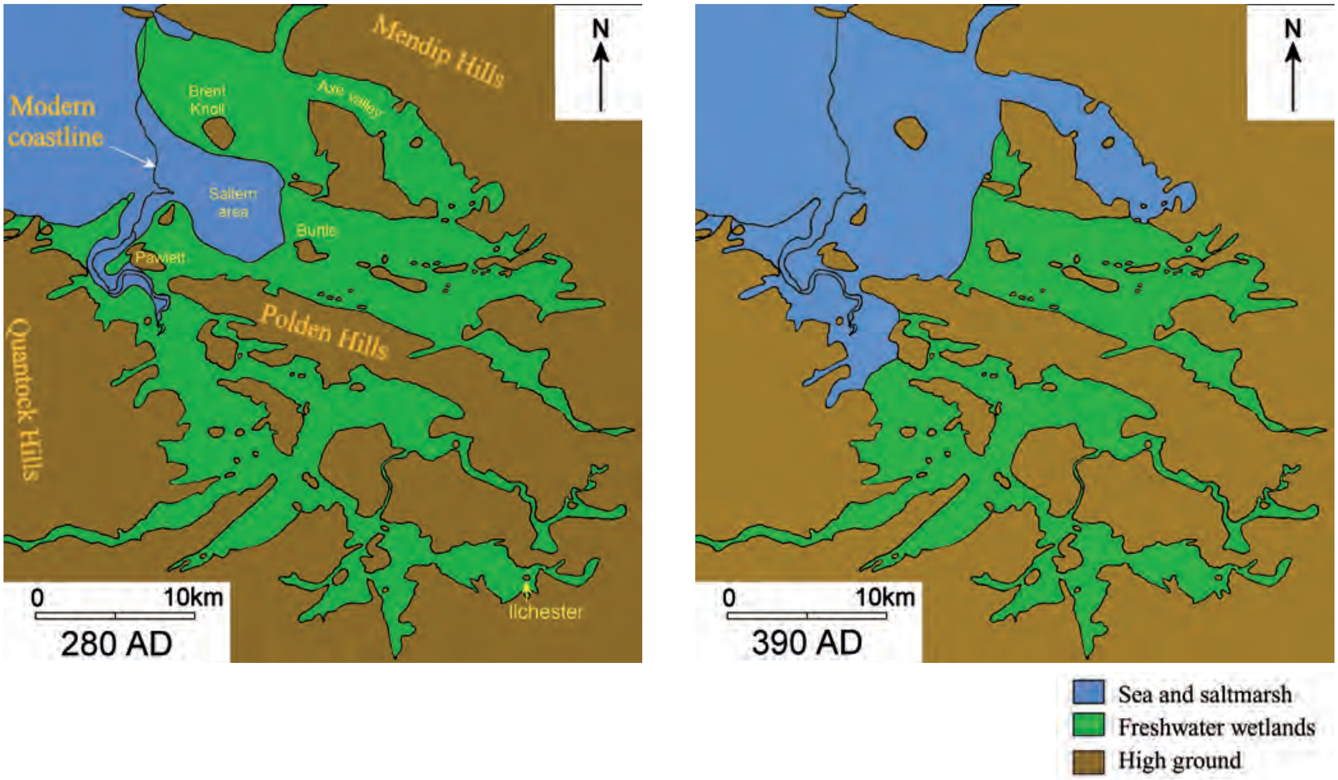


Figure 5. The early and late Roman coastline in Somerset.

hard geology from Pawlett to Highbridge, around Brent Knoll and the area northwards to Brean Down and the River Axe and within the Axe valley itself (Rippon 1997; Grove 2003). This settlement seems to have taken place from the 1st or 2nd centuries AD but environmental analyses of deposits of this period are very rare in the area. Most of the evidence takes the form of artefact scatters or poorly recorded excavations. In the Axe valley extensive remains of a reclaimed landscape are visible as slight earthworks, representing fields, settlements, droveways and a possible canal (Grove 2003). Reclamation in the Axe valley has been dated chemostratigraphically to AD 130–221 (Haslett *et al*. 1988). Recent work to the south of Brean Down shows a marginal saltmarsh/terrestrial environmental environment in the present inter-tidal area that was cut by a ditch indicating freshwater grassland environment seasonally subject to coastal flooding (Allen and Ritchie 2000).

The mapping of an extensive river system south of Brent Knoll, and its association with Romano-British salt-making sites of 3rd to early 4th century date (Figure 6), suggests that an extensive saltmarsh existed in the area (Brunning and Farr-Cox 2006). The presence of salterns north and south of Burtle island suggests that tidal creaks must have penetrated this far inland. Slight earthworks orientated roughly north-west to south-east have been noted over an extensive area west of Burtle underlying the present field pattern. They are too closely spaced for relic field boundaries and may represent turbaries supplying fuel to the saltern industry (Brunning and Farr-Cox 2006). Such extraction would have increased the vulnerability of that landscape to coastal flooding.

There is widespread evidence for a transgressive phase in the study area beginning in the late Roman period (Figure 5). The most southerly evidence comes from the Huntspill Cut where a saltern site of 3rd–4th century AD date was covered by silt deposited in an intertidal environment. The base of the silt has been dated by Optically Stimulated Luminescence (Figure 7) to AD 110±290 (Oxl-1268) (Rhodes 2003).

In the Axe valley the date of the end of the reclamation and the return of marine influence is hard to determine. The only available estimate is a date between AD 207 and 411 (Haslett *et al*. 2001). The villa at Lakehouse Farm continued in use into the 4th century AD (Rippon 1997) suggesting a similar date of transgression to that evidenced from the salterns south of Brent Knoll. The evidence from the North Somerset Levels, Avon Levels, Oldbury and Berkeley Levels and the inner estuary indicates extensive settlement along the coast until the mid-4th century AD (Rippon 1997, 84–97).

The gradual reclamation of the English side of

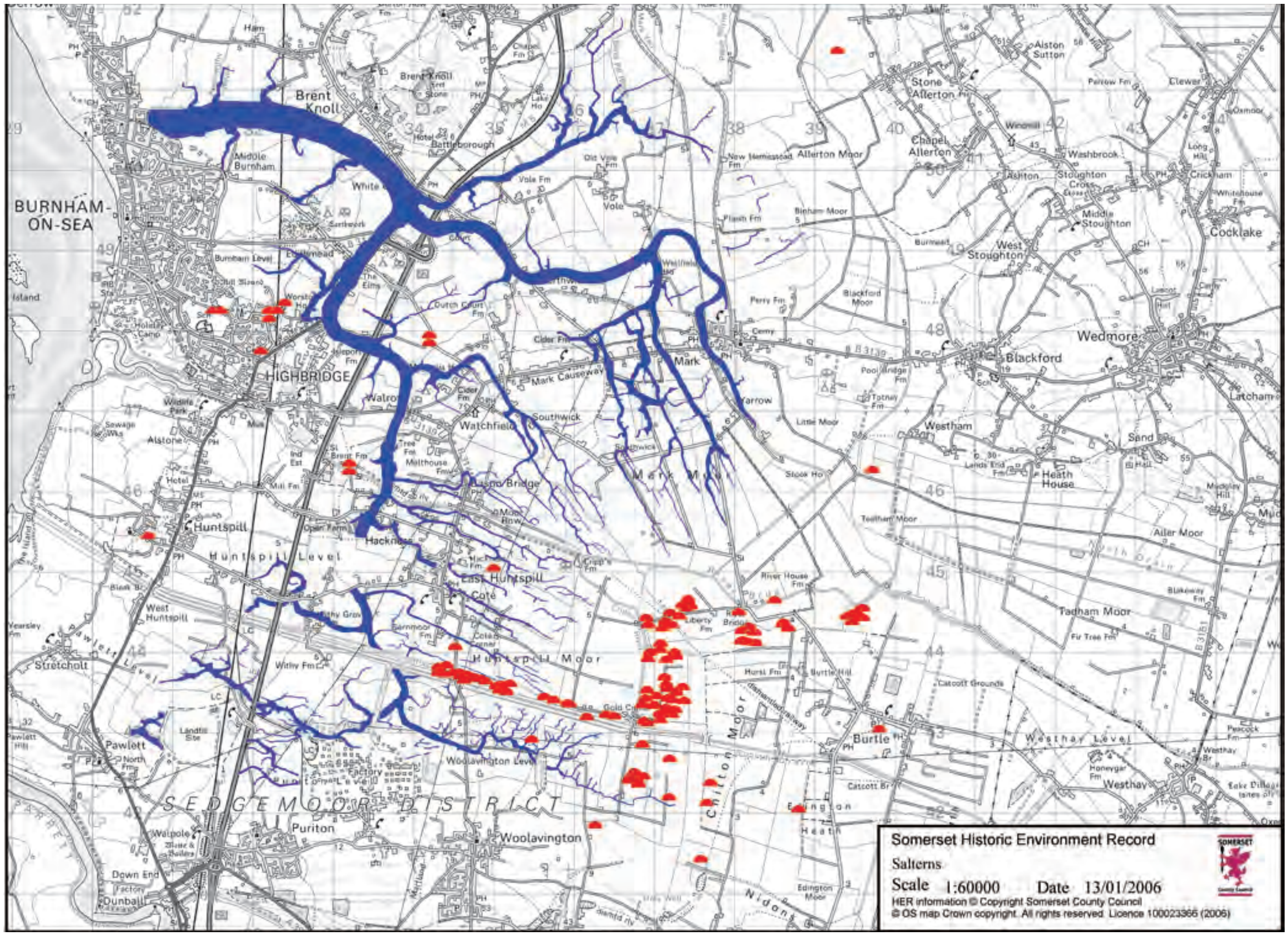


Figure 6. Roman saltern distribution and relic river systems in the Brue valley.

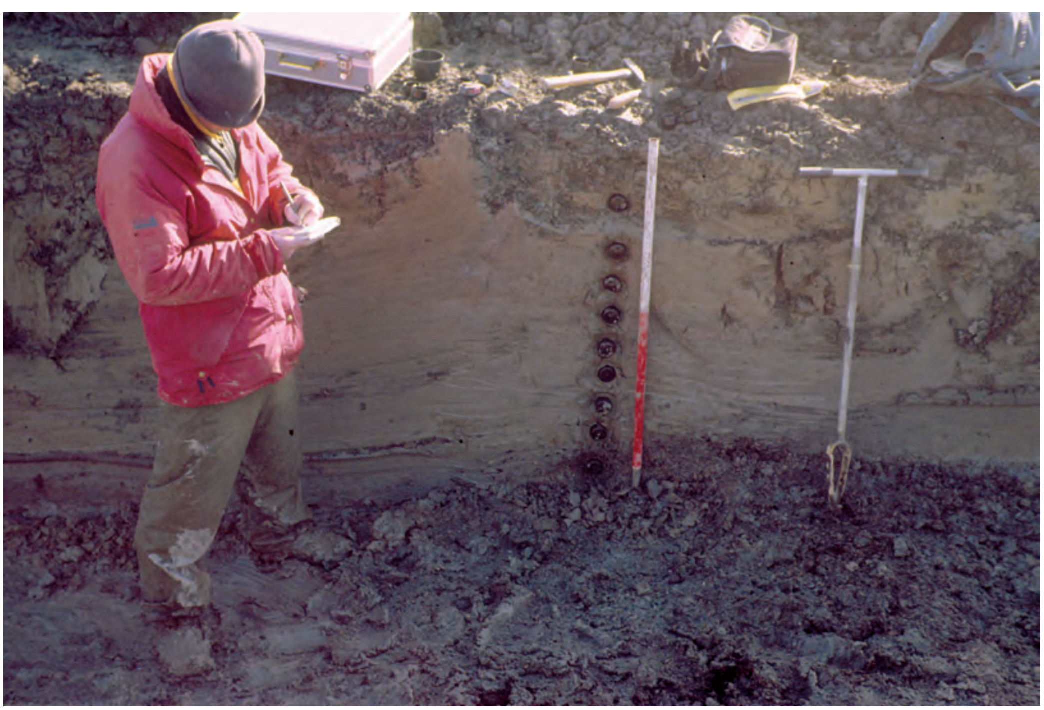


Figure 7. OSL sample column on the River Huntspill.

Figure 8. Aerial photograph of the landscape around Brent Knoll (B) showing regular (R) and irregular (I) field systems formed by large scale and piecemeal saltmarsh reclamation.

the Severn Estuary coastline in the early medieval period has mainly been studied through landscape characterisation and place name analysis (e.g. Rippon 1997; 2000a) with few detailed excavations (eg. Rippon 1998; 1999; 2000b; 2007). Saxon habitative place names suggest occupation along the Severn Levels was very extensive by the late Saxon period although the back fen areas were only colonised much later.

The irregular field patterns noted along the coastal clay levels suggest that this reclamation took place in a gradual piecemeal fashion (Figure 8). This is supported by the most detailed local study of this process at Puxton (Rippon 2007). The date of reclamation of the coastal marsh is therefore not likely to be consistent across the study area although Saxon charters suggest that it could have started by the end of the 7th century AD (Sawyer 1968; Edwards 1998) and was largely complete by Domesday.

Reclamation of the inland moors began in the medieval period alongside the extensive canalisation of the major river systems (Williams 1970; Rippon 1997; 2007; Housley *et al*. 2007). Large parts of the floodplain were protected by floodbanks by AD 1300, most notably on the moors south of Middlezoy/Westonzoyland (Figure 9). Inherent problems with the drainage of other areas meant that much of the wetland heath and moor was only finally drained after the parliamentary enclosure acts of the late 18th and early 19th centuries (see Williams 1970 and Rippon 2007 for the detail of this process).

The Levels and Moors area is inherently prone to seasonal flooding from the rivers and the possibility of severe coastal inundation. Many of the inland moors are often covered by water for many months in winter. In some of the worked out peat extraction pits reedbeds are once again forming new peat layers (Figure 10).

The history of archaeological research

The Reverend W. Stradling, a local antiquary, made the earliest records of archaeological remains in the mid-19th century. He provides us with the first and only record of many of the early discoveries including bog oaks, a box containing a bronze hoard, prehistoric bows and paddles, and a dug out canoe 'formed from an immense oak ... (and) long known as 'Squire Phippen's Big Ship'' (Stradling 1849, 52).

None of these early discoveries exist today. Many finds did not survive the day of their discovery, like the maple box containing the Edington hoard (Figures 11

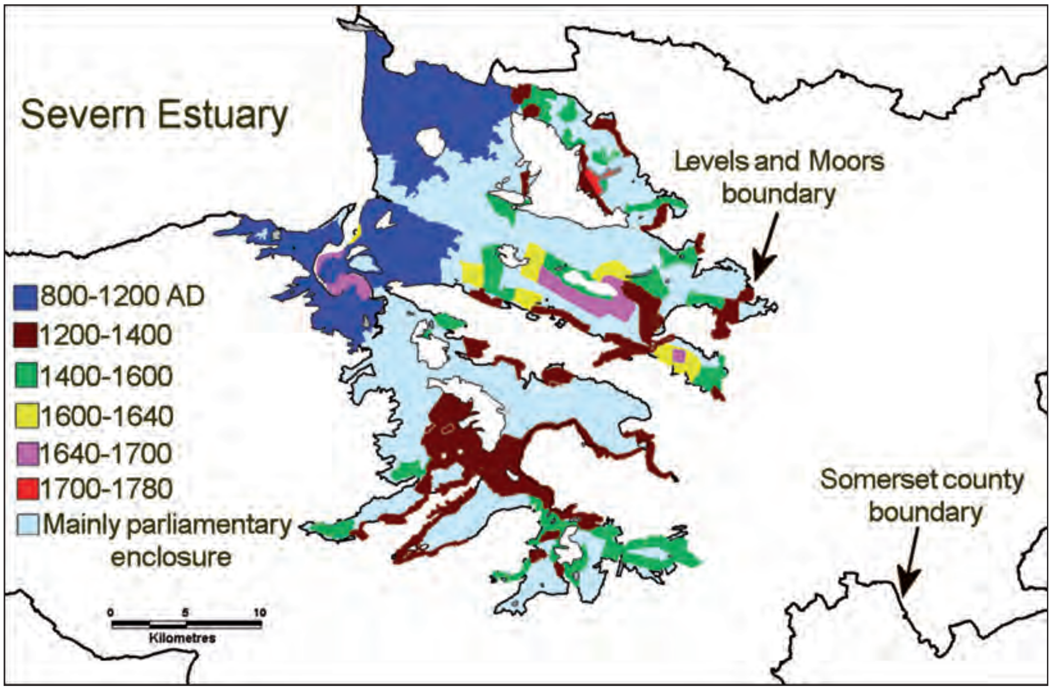


Figure 9. Map showing dates of wetland enclosure in the Somerset Levels and Moors.

Figure 10. Reedbeds on Ham Wall.

and 12), which 'soon fell to dust' (Stradling 1854, 92). 'Squire Phippen's Big Ship' suffered a more prolonged and practical fate. It 'made its appearance partially in very dry seasons' and Stradling recounted that 'I one day had a piece of the poor old 'Ship' brought me, and was told she had been broken up in the dry weather, and used by the cottagers for fuel' (Stradling 1849).

In 1880 the first excavation to record a wooden structure was carried out by John Morland of the Glastonbury Antiquarian Society, on part of a causeway that ran across the narrow valley that separates Street and Glastonbury (Morland 1881). The causeway was investigated as part of this project, finally revealing its true date of construction.

Figure 11. The Edington hoard.

Figure 12. The discovery of the Edington hoard (David Bennett).

The year 1880 also saw the publication of investigations on a Neolithic trackway known as the 'Abbot's Way', so called because when it was first discovered, it was thought to have been a creation of one of the medieval Abbots of Glastonbury. The published article concerned the detailed observations and measurements of the trackway made by C. W. Dymond, a Fellow of the Society of Antiquaries, on a stretch freshly uncovered by peat cutting in 1873 (Dymond 1880). A section of this trackway was examined by this project but was found to be in much worse condition than when Dymond recorded it.

The most important contribution to early wetland research in the area was made by Arthur Bulleid (Figure 13), who became inspired by Ferdinand Keller's book *The Lake Dwellings of Switzerland* (Keller 1878) while studying for a medical career. Determined to find similar sites in the moors of Somerset, Bulleid searched for four years until in 1892 he noticed 'a field covered with small mounds, an unusual feature in a neighbourhood where the conformation of the land is for miles at a dead level' (Coles *et al.* 1992, 8). Subsequent excavations by Bulleid revealed an Iron Age settlement site, the internationally famous 'Glastonbury Lake Village' (Figures 14 and 15).

The landowner, Mr Edward Bath, donated the field containing the site to the Glastonbury Antiquarian Society who set up a fund to finance Bulleid's excavations. These continued from 1893 to 1898 and then again from 1904 to 1907. For the second period of fieldwork Bulleid was joined as co-director by Harold St George Gray, the Curator of the Somerset Archaeology and Natural History Society. The recording of the work in terms of plans, sections and descriptions was very good for its day, as was the analysis of the plant material, metal artefacts and the bird and animal bones which was carried out by four Fellows of the Royal Society (Bulleid and Gray 1911; 1917).

Bulleid discovered another Iron Age wetland settlement, near Meare, in 1895 after being sent some pottery found by a farmer in a mound where he stored his winter hay. The eastern and western 'Meare Lake villages' were excavated by Bulleid and Gray between 1910 and 1956 (Bulleid and Gray 1948; Gray and Bulleid 1953; Gray 1966). The work between 1933 and 1956 concentrated on the eastern settlement and suffered from that all too common archaeological disaster, non-publication of results. It was not until 1987 that the Somerset Levels Project retrospectively published their findings (Coles 1987).

As well as excavating at Glastonbury and Meare and continuing in his medical practice, Bulleid also recorded the archaeological remains being uncovered in the peat workings (Figure 16). This work was published in 1933, including reports on many of prehistoric trackways, such as the Meare Heath Track (Bulleid 1933). It was this paper that inspired the succeeding archaeological work in the peatlands.

Several of the sites excavated and recorded by Bulleid were assessed by this project, including the Meare and Glastonbury Lake Villages and the Meare Heath Track. The results were mixed, quite positive for one, more worrying for another and disastrous for the third.

From 1937 the central Brue valley became the focus of activity for Sir Harry Godwin, then Professor of Botany at Cambridge, who became interested in the area after hearing of Bulleid's discoveries. He made numerous borings through the peat into the underlying clay and established the basic sequence of environmental change for the valley (Godwin 1941; 1948; 1981). For the first time this allowed a reconstruction of the landscape against which to set the archaeological discoveries. Godwin was also determined to record the structures that were being uncovered in the peat diggings. He was ably assisted by Stephen Dewar, a local amateur archaeologist who maintained very close links with the peat-cutters, a relationship lubricated by occasional gifts of an alcoholic variety.

Figure 13. Arthur Bulleid.

Godwin and Dewar recorded, excavated and reported on many small finds and structures such as the prehistoric Shapwick Heath, Blakeway, and Honeygore trackways (Godwin 1960; Dewar and Godwin 1963). As well as pioneering environmental analysis Godwin also made great use of the new radiocarbon dating methods that were being developed at the Cambridge laboratory. Several of the sites discovered by Godwin and Dewar were investigated by the current project, some of which have been totally destroyed.

Professors Harry Godwin and Grahame Clark introduced John Coles, an assistant lecturer in Cambridge University, to the area. He carried out some small excavations of the Viper's and Platform trackways in 1962 and was one of the team from Cambridge that investigated the Abbot's Way, the Chilton Tracks, the Bell Tracks and the Baker Platform over the next six

Figure 14. Bulleid's excavation at Glastonbury Lake Village (1897).

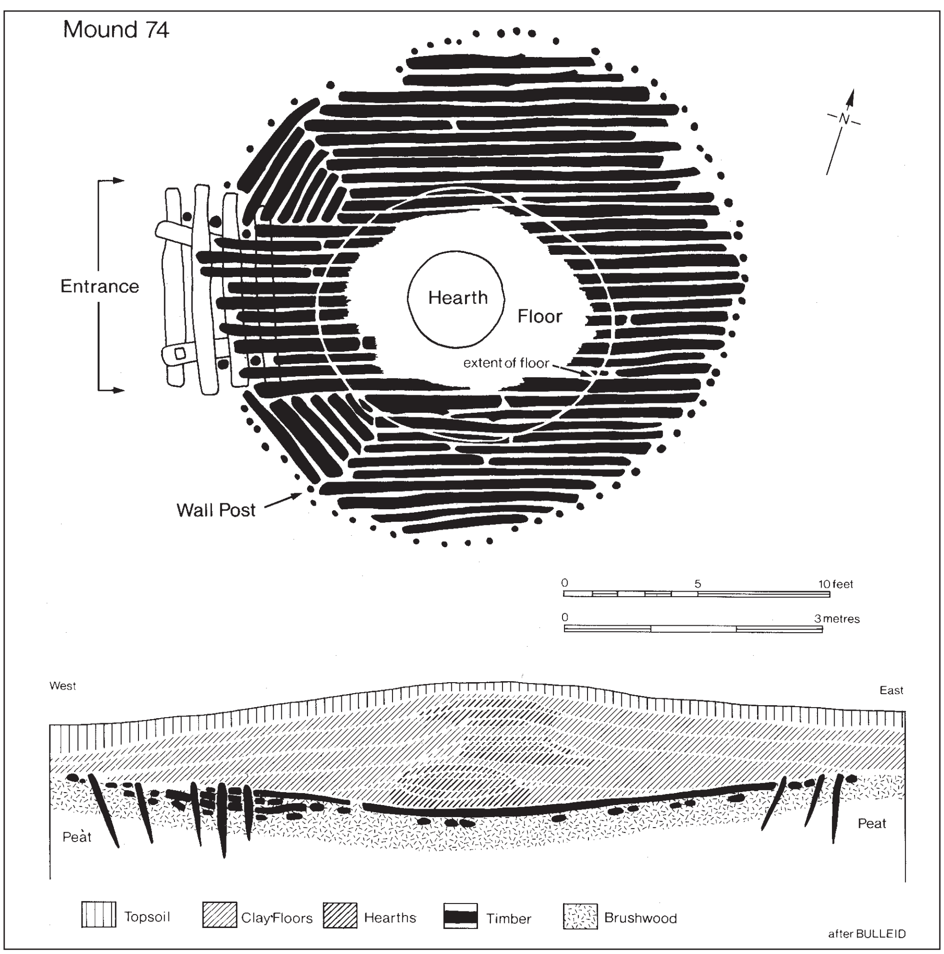


Figure 15. Section and plan of a mound from Bulleid's excavation at Glastonbury lake Village.

years (Coles 1972). This work was aided by a local archaeologist, Colin Clements, who rediscovered the Chilton Tracks (first mentioned by Bulleid), and later worked with another local man, Christopher Norman, recording the wooden trackways around Chedzoy in Sedgemoor (Figure 17; Norman and Clements 1979; Norman 1980).

Figure 16. Hand dug peat in the Brue valley piled up to dry c. 1905.

In 1970 E. J. Godwins peat company sent a package to John Coles containing part of a plank from what turned out to be the Sweet Track, still the oldest known wooden trackway in the UK. The discovery led to a large scale excavation of the trackway in 1973 funded by a grant from the Department of the Environment (Figure 18). The local inspector, Dr Geoffrey Wainwright, was so impressed by the excavations continuing in the pouring rain that support from central government continued for many years. In that same year, 1973, the Somerset Levels Project was officially born.

The Somerset Levels Project ran for an unbroken 15-year period until 1989, dedicated to the recording of the wetland archaeology that was being uncovered in the peat cuttings of the Brue valley (Figures 19–21). The joint directors were John Coles and Bryony Orme, based at Cambridge and Exeter Universities. Financial support came from a large number of sources but chiefly from English Heritage.

Throughout its life the project employed an archaeologist to observe the peat cuttings and to maintain contact with the local peat cutters. Large numbers of prehistoric artefacts and wooden trackways were discovered and excavated by the project, often with associated palaeoenvironmental investigations. The area covered by the Project extended south of the

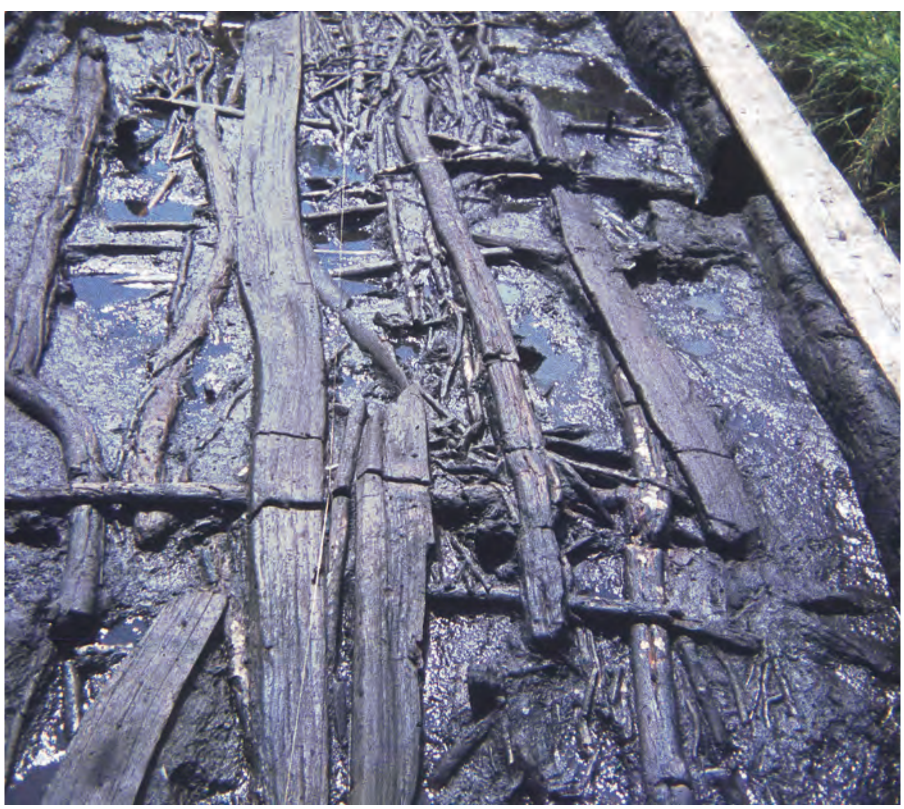


Figure 17. Neolithic trackway excavated by Colin Clements south of Chedzoy.

Figure 18. Excavation of the Sweet Track by the Somerset Levels Project (Somerset Levels Project).

Figure 19. Reconstruction of the Sweet Track (E. Mortlemans).

Figure 20. Excavation of the Bronze Age Eclipse trackway (Somerset Levels Project).

Polden hills, where the discovery of artefacts, trackways and worked wood suggested that the character of the archaeological resource was also duplicated on the southern moors. Many previously known sites such at the Abbot's Way and Glastonbury and Meare 'Lake Villages' were also revisited to assess their condition and gain more information.

The project results were published in 15 annual reports (the *Somerset Levels Papers*) and a popular summary (Coles and Coles 1986). The techniques of excavation, analysis and conservation pioneered by the project helped to significantly advance wetland archaeology as a discipline and led to the founding of the Wetland Archaeology Research Project (WARP), which was instrumental in bringing together wetland archaeologists from around the world.

The Somerset Levels Project assessed the condition of the lake-villages and the Sweet Track and was a lead partner in a management scheme designed to conserve a 500m stretch of the Sweet Track in a nature reserve (Coles and Orme 1981; 1984). The 1990s saw an increased emphasis on the preservation of archaeological deposits *in situ* wherever possible. Small scale excavations were undertaken to assess the condition of two known trackways, the Abbot's Way

Figure 21. Excavation of the Neolithic Walton Heath trackways (Somerset Levels Project).

and the Sweet Track (Figure 22), and to determine if any steps needed to be taken to improve their chances of future *in situ* preservation (Cox *et al.* 1992; Brunning *et al.* 2000). The latter project, financed by English Heritage, directly informed the methodology for the current project.

The English Heritage Monuments Protection Programme conducted a survey of waterlogged prehistoric trackways and settlements in England, which led to many more sites receiving Scheduled Monument designation (Brunning 1995a and b). New sites were also discovered away from the peat extraction areas. These included the late Bronze Age ritual pile alignment at Harter's Hill on Queen's Sedgemoor (Figure 23) at the eastern end of the valley (Brunning 1998). That site, together with several others discovered by the Somerset Levels Project and Colin Clements, were examined by the current project, with mixed results.

The future for wetland archaeological research in the project area and in the wider Somerset Levels and Moors will be guided by the results of this project. New work will also be driven by the numerous threats to the continued existence of the internationally important wetland archaeological resource in the area.

Figure 22. Excavations of the Sweet Track for condition assessment.

Figure 23. Bronze Age piles of the Harding Alignment, discovered beside Harter's Hill on Queen's Sedgemoor.

The waterlogged archaeological resource in Somerset's peatlands

The Somerset Levels and Moors is one of England's most extensive lowland wetland areas and has largely escaped the wholesale destruction that has affected other areas such as the Fens. The importance of Somerset's prehistoric wetland heritage can be shown by a few basic facts:

- 25% of all the prehistoric waterlogged sites thought still to exist in England are from the Somerset moors.
- With one exception, all the wetland prehistoric trackways and settlements deemed worthy of Scheduled Monument status in England occur in Somerset.
- The County Museum in Taunton Castle holds the largest collection of conserved prehistoric worked wood in the UK, possibly in the whole of Europe.
- The Sweet Track and Glastonbury Lake Village have produced the most complete record of Neolithic and Iron Age material culture in the UK.
- Glastonbury Lake Village was the best preserved prehistoric settlement ever discovered in the UK.
- West Sedgemoor contains probably the longest lowland peat sequence in England.

The density of archaeological sites in the Somerset peatlands has been estimated at 3.4 sites per km^2, using information from the peat extraction areas of the Brue valley where intensive archaeological survey work has been carried out (Van De Noort *et al.* 2001). Even this is probably an underestimate of the resource because much peat was extracted from that area before systematic archaeological recording began.

The extent of the peat deposits in the Somerset Levels and Moors can be roughly equated with the soils of the Middleney and Downholland soil series. The gradations within these soil series reflect varying depths of clay overlying the peat. In the area of these soils in Somerset there are a total of 1066 entries on the County Historic Environment Record (HER) of which 115 relate to archaeological sites known to contain waterlogged archaeological remains. Many of the others may also contain such remains but detailed information is insufficient to from a judgement. A total of 62 of the 115 waterlogged sites have been totally excavated or destroyed. Some of these were isolated finds of artefacts while others were structures such as trackways, which were destroyed or excavated during peat extraction.

For the purpose of the MARISP project, the most relevant part of the archaeological resource are the sites containing waterlogged remains, which are thought to survive wholly or partially *in situ*. There are 54 such sites, composed of 33 groups of prehistoric trackways and ritual pile alignments, four prehistoric wetland settlements, 16 prehistoric stray finds and a medieval causeway. The causeway, three of the wetland settlements and 11 of the trackways are wholly or partially designated as Scheduled Monuments. Only 21 of these sites have been subject to any significant form of archaeological excavation. Some of the excavations were carried out very early in the 20th century or even in the late 19th century. Many of the excavations were also small in scale and did not reveal the whole extent of the sites.

The nature and significance of the unexcavated sites are poorly understood. In some cases it has been possible to identify them as prehistoric wooden trackways, and in one case as a possible prehistoric wetland settlement site.

The condition of most of the waterlogged sites is not known. Many were discovered several decades ago and could have been suffering from desiccation for a prolonged period. Some may no longer exist. The Somerset Levels Project assessed the condition of some of the monuments they discovered (e.g. Coles and Orme 1981; 1984), but hydrological monitoring was only undertaken on part of the Sweet Track in Shapwick Heath (Coles and Orme 1984).

Until 2004 there was only recent information on the condition of a 500m length of the Sweet Track (Brunning *et al.* 2000), a short stretch of the Neolithic Abbots Way (Cox *et al.* 1992) and two recently investigated Bronze Age ritual sites at Greylake and Harter's Hill (Brunning 1998; Cheetham 1998; Dinnin 1999). The only site that appears secure from the threat of desiccation is the section of the Sweet Track that benefits from a pumping system in Shapwick Heath National Nature Reserve (Brunning *et al.* 2000).

Threats to the waterlogged resource

There are several factors that threaten the survival of the waterlogged archaeological resource in the Somerset Levels and Moors. Some of these have a degree of control through the planning system, while others have no restraint and no dedicated source of funding to mitigate their effects.

The threats to Somerset's wetland archaeological resource reflect the wider national situation. The Monuments at Risk in England's Wetlands (MAREW) project, commissioned by English Heritage, aimed to produce a broad assessment of the wetland archaeological resource across the country. The project results suggested that 2020 wetland monuments, and over half of the original extent of lowland peatland, have been destroyed in England during the last 50 years (Van de Noort *et al.* 2001). Within the wetlands an estimated 10,450 monuments had been damaged or destroyed over that period. This national catastrophe is part of a wider international problem for wetlands. Across Europe over 100,000km^2 of peatlands have been lost in the last 50 years, representing one-fifth of the total resource (Clarke and Joosten 2002).

Development and infrastructure projects

In general there is very little development on the peat moors in Somerset. Local planning seeks to prevent any development within the Somerset Levels and Moors Environmentally Sensitive Area (ESA) unless it is beneficial to the natural or cultural interest of the area. No significant development has therefore taken place in recent decades in the peat areas with the exception of new relief road and house construction on the edge of the floodplain around Glastonbury (Brunning *et al.* 1995).

Peat extraction

Peat has been extracted for fuel from the Brue valley since at least the Roman period (Leech *et al.* 1983). The 19th century peat diggings were made by rapidly excavating a square pit down to the base of the peat (Stradling 1854). Early maps clearly show the extent of extraction (Figure 24). Several metres of peat had been extracted in parts of the valley by 1950. The mechanisation of peat extraction in the late 1950s increased the rate of destruction, which peaked in the 1970s and 1980s (Figure 25). Since then the largest peat company has left the area and the amount of extraction has significantly reduced. The quantity of peat extracted in Somerset between 1999 and 2008 has been estimated at 900,000m^3, providing *c.* 9% of the peat consumed in the UK (Brown 2009, 9). Current peat extraction covers *c.* 275ha with a further 30ha having valid planning permission but currently remaining unworked.

Government targets for reducing the use of peat in the UK suggest that the industry has a very limited life but the 2010 reduction targets were not met. New voluntary targets have been proposed by the UK government in a Defra consultation at the end of 2010. These include an end to the use of peat in domestic compost by 2020 and the end of peat in professional horticultural products by 2030. A new minerals plan for the county is in the process of development and it is not currently certain how much longer peat will be extracted from the area. Draft planning guidance, currently under consultation, has suggested that no new or extended peat extraction permissions should be granted.

Peat extraction is now subject to archaeological planning legislation (DCLG 2012). This means that the peat extraction companies have to avoid extraction in areas known to contain nationally important archaeological remains and are normally required to carry out evaluations before being granted permission. The problems and limitations of evaluating deep

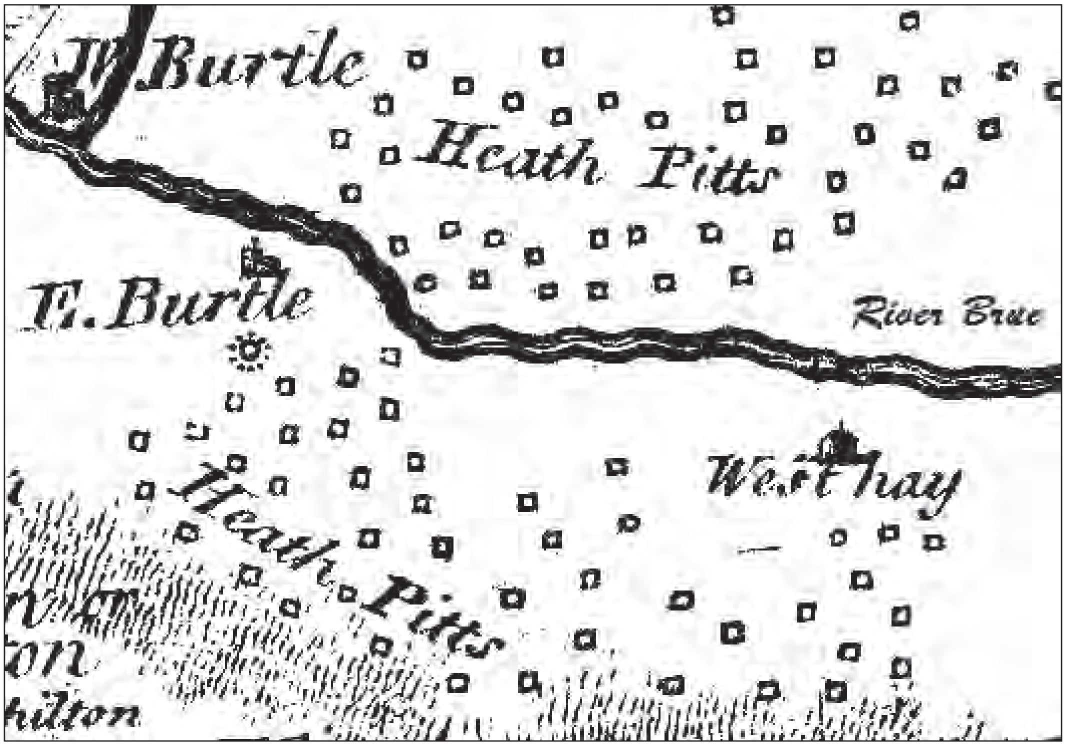


Figure 24. Detail of Bowen's map of Somerset 1750 showing peat extraction pits in the central Brue valley.

Figure 25. Aerial view of peat extraction in the Brue valley.

Figure 26. Bank erosion on the River Huntspill eroding the site of a Romano-British saltern.

peat mean that even if the evaluation fails to identify significant archaeological remains, a 'programme of archaeological works' condition is normally attached to any permission granted. This is normally used to secure archaeological monitoring of extraction and excavation of any archaeological remains encountered.

Coastal and river erosion

Most of the water channels in the project area are well managed and little or no significant erosion occurs. The main exceptions are the lower reaches of the River Parrett, which are tidal, and the Huntspill Cut. The Huntspill Cut is a man made drainage channel at the western end of the Brue valley. It is relatively wide and very straight, which allows significant wave generation to occur, driven by the prevailing westerly winds. This has caused undercutting and erosion of both sides of the channel. Many metres of both banks have been lost since its creation in the 1940s (Figure 26). This has resulted in the exposure and destruction of numerous Romano-British salt-making mounds (Grove and Brunning 1998). Recent bank grading and reed planting has been carried out in places and has successfully prevented erosion.

Coastal erosion is occurring in several places in the Somerset Levels and this erosion will undoubtedly quicken in response to the predicted increase in sea level and storm frequency over the next century. Most of the low lying coast beside the Somerset Levels is actively managed by the Environment Agency. A draft Shoreline Management Plan for the Severn was produced in 2010. This identified the need for managed realignment in several places over the next century, most notably around the mouth of Parrett estuary. The first realignment will take place at Steart, on the western side of the Parrett. Over the next five years this will produce the largest managed realignment in the UK. Impacts from creek and lagoon creation and flood defence formation will have a significant impact on the historic environment.

Peat wastage and agriculture

The last comprehensive assessment of English archaeology, the 'MARS' Project (Darvill and Fulton 1998), identified agriculture as the biggest destroyer of archaeological sites in England. One of the main causes of destruction in wetland areas was the desiccation and wastage of peat deposits. When peat is drained it shrinks and the ground levels lowers because of the loss of water and the oxidation and decay of organic matter. Undrained, heavily waterlogged anaerobic peat is up to 90% water, so a great deal of peat bulk is lost by drainage and evapo-transpiration. The change from anaerobic to aerobic conditions allows oxidation

Figure 27. The perils of ploughing on the Somerset Levels postcard by Louis Jordan photography.

to take place and the loss of organic matter through microbial decay. After the initial loss of water from peat it is estimated that 85% of the continued subsidence is due to oxidation and 15% due to compaction of the material above the water table (Armstrong 1996). Low ground water tables and high temperatures mean that more than 80% of peat oxidation occurs in the summer (Verhagen *et al.* 2009, 27).

The reduction of organic matter in soil is a primary factor in its susceptibility to erosion (Hodge and Arden-Clarke 1986, 13). Arable farming promotes faster oxidation because of lower water levels and aeration of soils by ploughing (Figure 27). The organic matter content of arable soils can therefore be as low as 1–2% as opposed to 5–10% in pasture soils (Johnston 1973). Soil structural stability is therefore much lower in arable soils than pasture ones. In arable areas the effect of peat wastage can be dramatically accentuated by the effect of wind erosion in the spring and early summer (Evans 1992). In intensively drained areas of arable cultivation, such as the southern Fenland, the thin deflated former peaty organic soils have lost so much organic matter that they are largely past conservation, if not already non-existent (French 2000, 5).

As peat wastage gradually lowers the ground level, buried archaeological remains are brought closer to the surface and its associated drier, oxygen rich conditions. The possibility of direct physical damage by ploughing or subsurface drainage work is also increased, as happened to the late Bronze Age Skinner's Wood tracks on Shapwick Heath. When wooden piles are revealed by peat wastage the farmer often pulls them out to prevent damage to agricultural machinery (e.g. Brunning 1998).

A large body of data on field hydrology has been generated in the Somerset peatlands. The most relevant studies to this project have been on the conservation of peat soils (Spoor *et al.* 1999). These have confirmed the mechanisms that are leading to peat wastage in pasture fields. The main problem occurs in summer when a concave water table is established in peat fields as the ditch water levels, which are penned at a high level, only affect the water table over a distance of *c.* 15–20m. In the remainder of the field the main influence on the water table is the balance between rainfall and evapo-transpiration.

The rate of peat wastage

Rates of peat wastage have been estimated for many different areas in the UK and Europe. Peat soil wastage rates are most rapid in areas where land is drained for arable cultivation. A study in Borough Fen, Cambridgeshire, comparing peat thickness recorded by the British Geological Survey in the mid-1970s and archaeological records a decade later, showed figures for peat wastage of 20–30mm yr^{-1} (French and Pryor 1993). Peat wastage following new drainage schemes is particularly rapid, up to 220mm per year, but slows to a longer term average of 10–18mm per year (Richardson and Smith 1977). Even greater rate of loss have been recorded for Chat Moss in Greater Manchester (Hall *et al.* 1995). In the Netherlands subsidence in peat areas can be up to 50mm yr^{-1} in well drained land (Verhagen *et al.* 2009, 25). The lower the summer ditch levels, the faster the rate of peat wastage. This rate varies due to ditch spacing, peat conductivity and presence and depth of clay capping. A rule of thumb measurement used in the Netherlands suggests that every 100mm lowering of the ditch water levels results in an extra 1–2mm per year of subsidence (Verhagen *et al.* 2009, 27).

Much less work has been carried out on peat soil loss in permanent grassland. Peat soil wastage by oxidation has been measured at rates of between 10–20mm yr^{-1} in Central and Western Europe and a Polish study suggested losses under grassland were about half those under arable cultivation (quoted in Armstrong 1996, 8). In pasture regimes in the Netherlands peatland subsidence has been recorded at 10mm yr^{-1} (Acreman and Miller 2007). In the same country variations in hydrology and peat type have seen variations in subsidence of 2–25mm yr^{-1}, with an average of 8mm yr^{-1} (Kuikman *et al.* 2005). The presence of a thin (25–30cm) clay layer covering the peat significantly reduces average wastage to 4mm yr^{-1} (Kuikman *et al.* 2005).

Peat wastage lowers the ground surface causing the most resistant parts of the waterlogged sites, oak timbers and piles, to break the ground surface. These often cause damage to agricultural machinery such as mowing machines. Examples includes the Stradling canoe (Stradling 1849, 52), and pile finds at Greylake (Gray 1927, 86), Ivythorne on Kings Sedgemoor (Bulleid 1945) and Harter's Hill (Brunning 1998).

The rates of peat wastage in Somerset have been examined by several recent reports (Brunning 2001; Brown 2009). Brown (2009) estimated the volume of the lowland peat in Somerset at 663.61M m^{-3} and that there was 3.33M metric tons of organic carbon in the top 1m of peat that was most at risk from wastage. The annual carbon loss due to peat wastage was estimated at 200,000 tons. The rate of carbon loss from Somerset's lowland peat resource has been estimated to be roughly 0.2% of the total carbon store per year (Brown 2009, 1).

Several sources of potential information have been used to estimate peat wastage in Somerset. Topographic information is available from a series of six permanent ground anchor points installed at various points around the Somerset moors (Environment Agency 1998). All of the six sites displayed considerable seasonal variation as well as significant differences between years. Wastage rates of 4.4–7.9mm yr^{-1} have been calculated using this source (Brunning 2001). Over a period of 100 years this rate of wastage would result in a loss of 0.44–0.79m of peat.

Peat wastage rates have also been estimated at various locations across the peat moors by taking radiocarbon dating samples from sequential depths and comparing the results to the date of enclosure, which is taken to mean the end of peat formation. This has suggested wastage rates of 0.87–8.70mm yr^{-1} (Brown *et al.* 2003). The report also assessed peat wastage using humification classification, bulk density analysis, Eh, loss on ignition, UV reflectance, and multiple radiocarbon determinations to provide age-depth profiles. The latter was used to estimate historic peat wastage rates of between 0.20mm and 0.57mm per year.

All the waterlogged archaeological sites on the levels and moors designated as Scheduled Monuments exist within 90cm of the ground surface and are therefore likely to be totally destroyed by desiccation within this period if these wastage rates are applicable across all the peat areas.

The project area

The area chosen for the project was the central Brue valley, west of Glastonbury (Figure 28). This area of floodplain is roughly 20km long east to west and 6km across north to south. It is bounded to the south by the Polden Hills and to the north by the Isle of Wedmore. At its eastern end is the promontory of hard geology where Glastonbury is located. Numerous large and small islands of hard geology exist in the valley, most notably Burtle, Westhay-Meare and Godney.

The valley is dominated by Holocene peat deposits 1–8m deep, which began forming around 4500 cal BC and continued growing into the early medieval period (Housley *et al.* 2000). At the eastern end of the valley, alluvium from the rivers Brue and Axe have formed deposits up to 3m thick on top of the peat. A detailed summary of the palaeoenvironmental history of the area is presented in the discussion at the end of Chapter 7.

Peat extraction has taken place in the valley since the Roman period, when it was used as the fuel for the local salt industry. Extraction occurred over a wide area during the 20th century, resulting in the discovery of many archaeological finds and structures.

The central Brue valley was chosen as the project area for three main reasons:

1. It has been the focus for the most intensive wetland archaeological survey in the area.
2. It contains the greatest concentration of wetland Scheduled Monuments in the UK.
3. Many of the wetland monuments in the area were known, or suspected of being, at risk from desiccation.

The selection of individual sites within the study area is discussed in the methodology section of this report.

Aims of the project

The aims and objectives of the MARISP project were informed by the resource assessment, agenda and strategy for the research and management of waterlogged archaeology in Somerset (Brunning 2000).

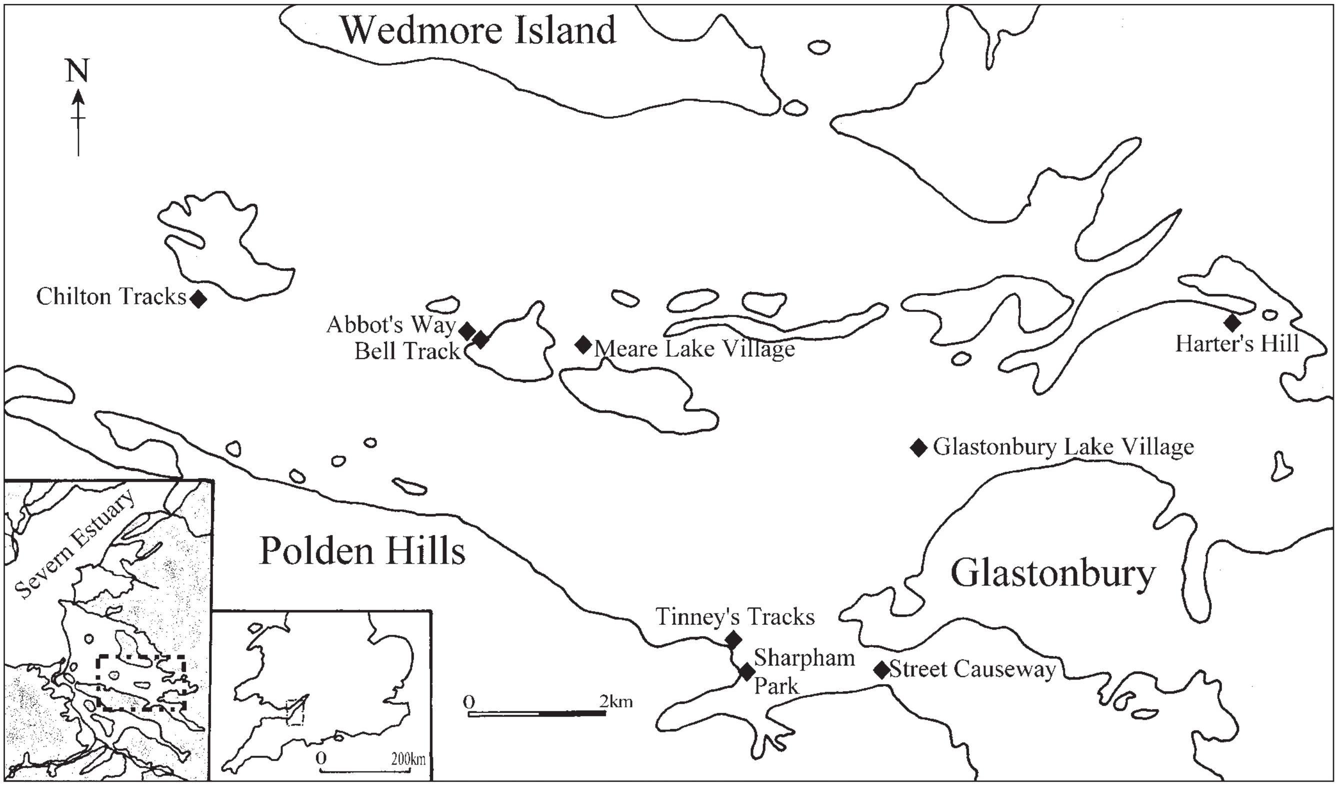


Figure 28. The MARISP project area and site location (high ground shaded).

That document helped to prioritise monuments for research and management in the area. The project was also heavily influenced by the previous monitoring work carried out on the Sweet Track (Brunning *et al.* 2000). The aims and objectives of the MARISP project have been designed to comply with the four main principles of the English Heritage Wetlands Strategy for the conservation and management of monuments at risk in England's wetlands, ie. management, outreach, policy and research. The project also aimed to deliver some of the strategic applied research objectives of the Europea Archaeologiae Consilium (EAC) for the heritage management of wetlands (Olivier 2001).

The aims of the project were as follows:

Management aims

1. To assess the condition of the most important wetland monuments in the study area;
2. to provide baseline information on their condition by techniques that are quantifiable and can be replicated in the future;
3. to monitor the burial environment of each site to assess the possibilities for preservation *in situ* of the surviving deposits;
4. to identify monuments which cannot be preserved *in situ* and to suggest appropriate mitigation measures for them;
5. to identify sites which may benefit from scheduling or land purchase; and
6. to provide reliable data upon which to develop water management policies and plans by the Environment Agency and the Internal Drainage Boards.

Research aims

7. To answer key research questions about the sites through the use of minimally invasive excavation;
8. to develop cost-effective techniques for the investigation and monitoring of wetland archaeological sites;
9. to improve understanding of the decay paths of wood and palaeoenvironmental material and the factors that affect them; and
10. to inform the development of future national and county wetland strategies.

Outreach aims

11. To increase public understanding and awareness of wetland archaeology and the factors which threaten its existence; and
12. to increase understanding of wetland archaeology among non-archaeological organisations, especially those involved in land and water management.

2. Methodology

Richard Brunning

Managing and monitoring wetland monuments

Over the last two decades much research has taken place on monitoring wetland monuments, especially in the Netherlands, England and Denmark. Despite this the numbers of monuments involved are still surprisingly small, with perhaps only a dozen rural sites in England having significant monitoring. One reason for this may be the relatively high cost of many monitoring projects that have focused on individual sites.

Although considerable numbers of wetland sites in England have been damaged or destroyed over the last 50 years (Van de Noort *et al.* 2001), the process of destruction is poorly documented. Two recurring problems have dogged the development of wet site condition assessment and monitoring. One is the short-term nature of much of the funding, which often results in just one year or less of monitoring. This means that climatic variations can play a significant part in interpreting the meaning and implications of the monitoring data.

The other problem is the lack of existing baseline data on the condition of the archaeological resource before assessment and monitoring projects begin. What information there is, is often gathered in a subjective way with little hope of replicating the analysis at a future date to produce a significant and quantifiable comparison. A condition assessment of palaeoenvironmental remains is rarely undertaken for the purpose of establishing a baseline against which to measure future decay. This problem has been recognised in the Netherlands and a comprehensive assessment methodology to tackle it has been developed as a standard (Smit *et al.* 2006).

The MARISP project used a range of monitoring techniques to characterise the burial environment at each site. In addition, a condition assessment was carried out on wood and palaeoenvironmental remains to provide a quantifiable baseline and to determine the type and extent of decay occurring.

Monitoring techniques

There are many different factors that are of relevance to preservation conditions within wetland monuments. Over the last 20 years some of these have been consistently applied in European projects while others have been used at just one or two sites. Several authors have reviewed the parameters of the burial environment that should be analysed (e.g. Caple 1992; Jordan 2001; Huisman 2009; Lillie and Smith 2009). The basic key parameters that are analysed at most sites are water table, hydrogen-ion concentration (pH) and redox potential (Eh). There is much less uniformity in how these parameters are measured and what, if any, additional factors should be analysed. The recent Dutch monitoring standard proposed recording of groundwater table, soil moisture content, redox potential, soil pH and acid buffering capacity (Smit *et al*. 2006). That analytical suite should be sufficient for most sites when combined with an assessment of hydraulic conductivity.

Improved knowledge of the complex interplay of factors that can prevent preservation *in situ*, has led to the deployment of ever more sophisticated methods of analysing the burial environment. For waterlogged sites it is little surprise that water remains the key. As a rule, if an archaeological site continues to remain permanently below the water table and there is no significant contamination of the water supply, then that site is usually ‘safe’ from rapid degradation. If a site is seasonally or permanently above the water table then there are a host of things that can lead to its destruction *in situ* over the short to medium term. It is unfortunate that most of the known wetland archaeological sites in England fall into this category.

This simplistic relationship is based on the author's (Brunning) long experience of wetland archaeological sites, the vast majority of which have never been subjected to scientific monitoring. Such observational data should be treated with caution, and some recent studies have suggested that even sites permanently below the water table may be at significant risk (Klaassen 2005; Smith and Lillie 2007; Douterlo *et al.* 2009). For each site it is also essential to understand the degree to which the site hydrology is responding to local factors or to processes occurring in the wider catchment (e.g. Lillie and Smith 2007).

The methodology for the MARISP project was developed to assess the factors thought to be most critical for the sites in the study area. The techniques chosen were limited by the need to deliver the project on a relatively restricted budget and by practical considerations, such as the difficulty of leaving above ground equipment in the fields. Since the monitoring was carried out, techniques have continued to develop. One recent study, for example, concluded that pH should be measured *in situ* because all the usual sampling methods engendered a bias in the results of up to 2 pH units (Matthiesen 2004). An enhanced monitoring project is currently looking in more detail at Glastonbury Lake Village and a section of the Sweet Track (Jones 2010). That project will hopefully help to clarify what the crucial monitoring parameters are for sites in the Brue valley.

Survival and decay processes

Wood is one of the most common and important organic materials present in waterlogged sites. The effect of desiccation on waterlogged wood is well known. After thousands of years in the ground very slow decay by erosion bacteria has normally destroyed most of the cellulose content of archaeological wood leaving only the more resistant lamella/lignin skeleton intact (Kim *et al.* 1996; Nilsson and Singh 1999; Blanchette 2000; Brunning *et al.* 2000; Björdal 2001; Huisman 2009). The shape of the wood is only maintained because of the large amount of water within the degraded cells. Desiccation therefore results in immense physical damage as the wood shrinks and cracks effectively destroying its value as a repository of archaeological information.

If an anoxic burial environment is replaced by aerobic conditions this will usually allow the recommencement of decay of organic materials by bacteria and fungi. These effects have been recorded at two Scheduled Monuments in the study area, the Neolithic 'Abbot's Way' trackway (Cox *et al.* 1992) and the Iron Age settlement at Meare (Coles *et al.* 1986).

There are uncertainties about the length of time that waterlogged archaeological wood can survive when a seasonally fluctuating water table drops below it for part of the year. The species of wood is important, as oak and yew appear to be more resistant to decay. The amount of decay that occurred before the object entered a waterlogged burial environment is also a factor (Brunning *et al.* 2000) and is probably one reason why bog oaks are so well preserved compared to wood from man-made structures. Vertical elements, such as piles, seem to be able to resist desiccation better than horizontal pieces, possibly because of capillary action drawing up water from lower waterlogged levels.

The BACPOLES project (Klaassen 2005) provides the most detailed analysis of the decay patterns of wood in waterlogged conditions over long time periods. It concluded that bacterial wood degradation occurs over a wide range of conditions and that the degrading bacteria responsible are present in all watery conditions. These bacteria can, and even need, to live in low nitrogen and oxygen conditions. Degradation appeared to be enhanced by the absence of nutrients, by an oscillating water flux inside the wood and by low lignin content in the wood cells. As the heartwood of pine and oak has a high resistance to water transport and high lignin content they are less prone to degradation than the wood of other species. Bacterial degradation appeared to be greatest where there is a water flux through the wood.

Non-organic artefacts (e.g. metal or glass) are also affected by changes in water regimes. In waterlogged environments they will normally have reached equilibrium with their burial environment but changes in water level will alter the equilibrium and therefore restart the decay process. Frequent changes between aerobic and anaerobic conditions are very damaging for such materials. Therefore if such material is brought within the zone of seasonal fluctuations in the water table it could be at great risk. Oxidation of peat soils also leads to increased acidification and more activity by sulphate reducing bacteria, which can be especially damaging to metal objects (Kelly 1995). For similar reasons, poor water quality can also increase bacterial activity and hence decay.

The palaeoenvironmental material contained within wetland soils is potentially even more vulnerable than the structures and artefacts themselves. Palaeoenvironmental data forms an important part of the archaeological resource in waterlogged sites and its assessment should be included in projects seeking to develop comprehensive baseline information on site condition. The factors affecting the survival of pollen, plant macrofossils and beetles are considered in more detail in the methodology and results sections below.

Assessment of archaeological preservation

When considering how to establish the condition of the archaeological record on a site there are several pertinent questions to ask; what part of the archaeological record to assess and how to do it? The most useful components of the archaeological record to assess are those which owe their survival to a waterlogged burial environment, and which form an important part of the archaeological importance of each site. Wood is invariably chosen because of its ubiquitous presence and its use for structures and objects. Bone is another common material that can also be radically affected by chances in the burial environment. More resistant artefact types such as pottery, stone and glass are rarely assessed. Palaeoenvironmental data is present on most waterlogged sites and is also often studied, most commonly in the form of pollen, plant macrofossils and insects. The Dutch monitoring standard includes assessment of non-carbonised wood, unburnt bone and botanical macro-remains in addition to soil micromorphology and organic content (Smit *et al.* 2006).

The MARISP project chose wooden material and palaeoenvironmental remains as the site components for condition assessment. This was because they were categories that were expected to be present at every site and because they were known to be vulnerable to changes in site hydrology.

Data collection for condition assessment should be minimally intrusive. In the Netherlands coring is most commonly used to obtain samples from cultural layers (e.g. Heeringen and Theunissen 2000). This reduces disturbance to negligible proportions while still permitting several forms of analysis to occur. An alternative is to open a small evaluation trench to briefly uncover the archaeological deposits for sampling. The drawback of this method is that the site is disturbed and the local hydrology can be adversely affected, especially if pumps are used to maintain working conditions in the trench (Matthiesen *et al.* 2001).

Site selection

A total of 54 waterlogged sites are thought to survive *in situ* in the Somerset peatlands of which 16 are stray finds, leaving a total of 38 structures or groups of structures. Eleven of these structural groups are designated as Scheduled Monuments. These were prioritised for selection along with other sites that are nationally important but not yet Scheduled.

Assessments of preservation and burial conditions have recently been carried out on three waterlogged sites in the area. Of these, the Greylake Bronze Age ritual alignment was the only one thought to be have been sufficiently studied (Brunning 1998; Cheetham 1998; Dinnin 1999). The other two monuments were the Neolithic Sweet Track and Abbot's Way track, both of which only had a proportion of their surviving length assessed (Brunning *et al.* 2001; Cox *et al.* 1992). The preservation of a 500m stretch of the Sweet Track was assessed in Shapwick Heath National Nature Reserve where a pumping system helps to ensure its survival. This represents roughly a quarter of the original length of the trackway. Of the remainder, *c.* 200m has been totally excavated and the rest survives at various depths in pasture fields.

The Abbot's Way assessment was carried out in one of four fields where it may still survive. The Abbot's Way eastern terminal was chosen for the project because little was known of its present condition. The other three fields include one where the trackway is already known to have suffered significant desiccation (Cox *et al.* 1992), one where arable cultivation may have destroyed it and one where the trackway is deeply buried and hopefully not at threat.

In addition to the Abbot's Way, the majority of the most significant prehistoric trackway groups were included in the current project (the Chilton, Tinney's, Meare Heath, Withy Bed Copse, Viper's, Nidon's and Bell tracks). Other groups of prehistoric trackways known to exist in Sedgemoor were not included because the (absentee) landowners did not give permission in time for the fieldwork. They are equally deserving of examination however, and many are Scheduled Monuments. All the known and possible wetland prehistoric settlements (Glastonbury and Meare Lake Villages and Crannel Farm) were included because of the rarity of such sites in England. The late Bronze Age Saul Platform and Harding ritual pile alignment, and the Street to Glastonbury causeway were included for the same reason.

Excavation and analysis

Evaluation trenching

The Dutch method of coring to extract samples was not a feasible option for the type of structures being assessed in the MARISP project, as most were narrow discrete wooden structures rather than general occupation layers. The sampling required to adequately assess such structures could only be obtained from trial trenching. It was also vital to know what part of the structure was sampled to understand the information that the condition assessment is producing. One aim of the project was also to answer specific research questions about the site. This was only likely to be successful by utilising evaluation trenching.

Small-scale excavations were carried out on each site to permit the removal of samples for the condition assessment. Excavation of the structures was limited to the minimum required to facilitate the sampling of representative layers for dating and decay analysis. For some sites more than one trench was opened to adequately reflect the potential differences in preservation across the site.

The fieldwork was carried out according to the *General Specification for Archaeological work in Somerset,* March 1994 (Somerset County Council).

Wood recording

The sampling and recording was undertaken according to the latest professional guidelines (Brunning 1997). For the sake of brevity the common English names are used for the wood species. After cleaning, the dimensions, morphology, and woodworking information were recorded on wood recording sheets. Cross-sections were sketched of all the converted timbers and woodworking debris. The converted material was described according to the method of splitting, such as radial, tangential, half or quarter split. The knottiness of the wood was assessed on a scale of 1–5 with 5 being very straight grained and 1 very knotty.

The recording methodology followed that used in the Somerset Levels and other prehistoric sites in Britain and Ireland (Coles and Orme 1985; Orme and Coles 1983; Brunning and O'Sullivan 1997; O'Sullivan 1997). The worked points of timbers were classified according to the number of sides they had been worked on to produce 'pencil', 'wedge' or 'chisel' shaped ends. The number, length, width and cross-sectional shape of the tool facets were noted. Where the tool blade had come to a stop in the wood leaving a small step, this curvature or 'jam curve' was traced as a record of the blade shape. Wood recording was carried out on site as far as possible.

At most of the sites disturbance of the wooden remains was limited to the taking of samples for species identification, dendrochronological analysis and decay studies. At the Street to Glastonbury causeway this sampling entailed the complete removal of the oak posts. At the Harding Alignment below Harter's Hill the upper layers of the structure were removed to allow sampling of the lower layers and a characterisation of the whole structure.

Species identifications

Rowena Gale

The wood was prepared for examination using standard methods (Gale and Cutler 2000). The wood structure was examined using a Nikon Labophot-2 compound microscope at magnifications up to x400, and matched to reference slides of modern wood. Whenever possible, the diameters and ages of the stems were recorded.

Dating

Tree-ring dating

Ian Tyers, Cathy Tyers and Christine Locatelli

The waterlogged samples were prepared by being frozen for a minimum of 48 hours before their cross-sectional surface was cleaned with a surform plane, scalpels and razor blades until the annual growth rings were clearly defined. The sequence of growth rings in each sample were measured to an accuracy of 0.01mm using a purpose-built travelling stage attached to a microcomputer-based measuring system (Tyers 1999). The ring sequences were plotted onto semi-logarithmic graph paper to enable visual comparisons to be made between them with the aid of a lightbox. In addition, cross-correlation algorithms (Baillie and Pilcher 1973; Munro 1984) were employed to search for positions where the ring sequences were highly correlated. The Student's *t*-test is then used as a significance test on the correlation coefficient. The *t*-values quoted below are derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match (Baillie 1982, 82–5), provided that high *t*-values are obtained at the same relative or absolute position with a series of independent sequences and that the visual match is satisfactory.

Dating is usually achieved by cross-correlating, or cross-matching, ring sequences within a phase or structure and combining the matching patterns to form a phase or site master curve. This master curve and any remaining unmatched ring sequences are then tested against a range of reference chronologies, using the same matching criteria as above. The position at which all the criteria are met provides the calendar dates for the ring sequence. A master curve is used for absolute dating purposes whenever possible as it usually enhances the common climatic signal and reduces the background noise resulting from the local growth conditions of individual trees.

The cross-dating process provides precise calendar dates only for the rings present in the timber. The nature of the final (youngest) rings in the sequence determines whether the date of the youngest ring also represents the year the timber was felled. Oak consists of inner inert heartwood and an outer band of active sapwood. If the sample ends in the heartwood of the original tree, a *terminus post quem* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings which may be missing. This is the date after which the timber was felled but the actual felling date may be many decades later depending on the number of outer rings removed during timber conversion.

Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimate used here is a minimum of 10 and maximum of 55 annual rings, where these figures indicate the 95% confidence limits of the range. These figures are applicable to prehistoric oaks from England and Wales. Alternatively, if bark-edge survives, then a felling date can be directly obtained from the date of the last surviving ring. In some instances it may be possible to determine the season of felling according to whether the ring immediately below the bark is complete or incomplete. However the onset of growth can vary within and between trees and this, combined with the natural variation in actual ring width, means that the determination of felling season must be treated with great caution.

The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the reuse of timbers and the repairs or modifications of structures, as well as factors such as stockpiling or seasoning, before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of phases within the structure.

Note that the BC scale used by dendrochronologists, and used here, has no year zero, the year 1 BC immediately precedes the year AD 1. The term 'bog-oak' is used in the discussion to cover all naturally deposited oaks in bogs, peats, or gravels.

Radiocarbon dating

P. D. Marshall, W. D. Hamilton, G. Cook and C. Bronk Ramsey

Thirty samples were submitted for radiocarbon analysis from five sites (Dewar's Track, Street Causeway, Harter's Hill, Saul Platform (Sharpham Park) and Glastonbury Lake Village) investigated as part of the Monuments at Risk in Somerset Peatlands (MARISP) project.

One bulk peat sample, from Dewar's Trackway and two pieces of waterlogged wood from Street Causeway submitted to the Scottish Universities Research and Reactor Centre in 2004 were measured by Liquid Scintillation Counting according to the procedures described by Stenhouse and Baxter (1983) and Noakes *et al.* (1965). These measurements are prefixed by the laboratory code GU-.

In 2006 a further 27 samples were submitted for dating; 17 to the Scottish Universities Environmental Research Centre AMS Facility (4 bulk peat and 13 plant macrofossils) and 10 to the Oxford Radiocarbon Accelerator Unit (8 bulk peat and 2 plant macrofossils). Nine of the samples, all plant macrofossils, submitted to SUERC failed to produce a result due to producing insufficient carbon. The samples measured by Accelerator Mass Spectrometry at the Scottish Universities Environmental Research Centre were prepared according to the methods outlined in Slota *et al.* (1987) and measurement as described by Xu *et al.* (2004). The samples submitted to Oxford were prepared according to methods given in Hedges *et al.* (1989) and measured by Accelerator Mass Spectrometry as described in Bronk Ramsey *et al.* (2004).

Both laboratories maintain continual programmes of quality assurance procedures, in addition to participation in international inter-comparisons (Scott 2003). These tests indicate no laboratory offsets and demonstrate the validity of the measurement quoted.

The results are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). They are conventional radiocarbon ages (Stuiver and Polach 1977).

Calibration

The radiocarbon determinations have been calibrated with data from Reimer *et al.* (2004) using OxCal (v3.10) (Bronk Ramsey 1995; 1998; 2001). The date ranges have been calculated according to the maximum intercept method (Stuiver and Reimer 1986), and are cited at two sigma (95% confidence). They are quoted in the form recommended by Mook (1986), with the end points rounded outwards to 10 years if the error term is greater than or equal to 25 radiocarbon years, or to 5 years if it is less. The ranges quoted in italics are *posterior density estimates* derived from mathematical modelling of archaeological problems (see below). The ranges in plain type in the site results tables have been calculated according to the maximum intercept method (Stuiver and Reimer 1986). All other ranges are derived from the probability method (Stuiver and Reimer 1993).

Bayesian modelling

A Bayesian approach has been adopted for the interpretation of the results from four sites; Street Causeway, Glastonbury Lake Village, Saul Platform, Sharpham Park and Harter's Hill (Buck *et al.* 1996; Blockley *et al.* 2004). Although the simple calibrated dates are accurate estimates of the dates of the samples, this is usually not what we really wish to know. It is the dates of the events (e.g. the start of peat growth), which are represented by those samples, which are of interest. The dates of such events can be estimated not only using the absolute dating information from the radiocarbon measurements on the samples, but also by using the stratigraphic relationships between samples.

Fortunately, methodology is now available that allows the combination of these different types of information explicitly, to produce realistic estimates of the dates of interest. It should be emphasised that the *posterior density estimates* produced by this modelling are not absolute. They are interpretative *estimates*, which can and will change as further data become available and as other researchers choose to model the existing data from different perspectives.

The technique used is a form of Markov Chain Monte Carlo sampling, and has been applied using the program OxCal v3.10 (http://www.c14.arch.ox.ac.uk/), which uses a mixture of the Metropolis-Hastings algorithm and the more specific Gibbs sampler (Gilks *et al.* 1996; Gelfand and Smith 1990). Details of the algorithms employed by this program are available from the on-line manual or in Bronk Ramsey (1995; 1998; 2001).

Sample selection

In order of preference the following samples for radiocarbon analysis were identified:

1. ***Terrestrial macrofossils***. Short-lived, identifiable to species, with bark edge or outer rings of large pieces of wood.

   Aquatic macrofossils (e.g. *Potamogeton*) were avoided due to the fact that dissolved CO_2 may be utilised resulting in the uptake 'old' carbon (Bowman 1990).
2. ***Bulk organic sediment samples***. Bulk radiometric measurements on the humin (acid washed, alkali insoluble) fraction and the humic (acid washed alkali soluble) fraction.

   Due to the nature of the sampling, most sediments were sampled with 0.5x0.1m steel monolith tins, the retrieval of enough sediment for 'bulk' radiometric measurement (>250g) was in most cases impractical. Thus, AMS measurement of 'bulk' samples were undertaken, although the potential of inhomegeneity (a small amount of contaminant will have a greater effect because of the size of sample (Shore *et al.* 1995)) must be acknowledged.

Palaeoenvironmental analysis

Palaeoenvironmental sampling was carried out at the MARISP sites in the summer and autumn of 2003. At the Harter's Hill site the 1997 monolith samples were collected by Vanessa Straker.

Laboratory methods

Julie Jones and Heather Tinsley

The monoliths from the four MARISP sites were sampled for initial pollen assessment (Tinsley 2006), and then stored. The tins were re-opened in 2005 for the higher resolution pollen sampling required for full analysis, and for extraction of some additional samples for radiocarbon dating. Stratigraphic descriptions of each monolith sequence were made using a modified Troels-Smith system (Aaby and Berglund 1986). The descriptions are shown in tabular form in Appendix 5. Two samples for radiocarbon dating and one additional pollen sample were taken from the monolith tins of the Harter's Hill 1997 sequence, which was previously undated.

Pollen

Heather Tinsley

The pollen samples were prepared using standard techniques (Moore *et al.* 1991). Samples of $1cm^3$ of sediment were digested in dilute potassium hydroxide; followed by sieving and acetolysis. Samples were stained with safranin and mounted in glycerol. Two tablets of *Lycopodium* spores were added to each sample at the start of the preparation to allow pollen concentration to be assessed (Stockmarr 1971). The original Harter's Hill 1997 samples were prepared in a similar way, but were mounted in glycerol jelly (V. Straker, pers. comm.). Samples were counted at a magnification of ×400 with ×1000 magnification used for critical determinations. The pollen sum was in excess of 500 grains from each sample level (excluding pollen of aquatic plants). In addition to pollen, non-pollen palynomorphs such as spores of ferns and *Sphagnum* moss, and algal spores of the family Zygnemataceae (includes the filamentous green algae *Spirogyra* and *Mougeotia*), were counted. The area of microscopic charcoal in each sample was estimated using a point count method based on that of Clark (1983).

In the assessment phase of the MARISP project, it was established that pollen preservation at the four sites later chosen for full analysis was largely good. However, the rather complex system adopted for recording comparative baseline assessment data on pollen preservation (Jones *et al.* 2007), was modified for the purposes of the full analysis undertaken in Phase 2, following discussion with David E. Robinson (English Heritage).

Phase 1 had established that comparison of pollen preservation at different sites, using a scoring system on a sample of 100 grains, was complicated by the differential susceptibility of pollen taxa to degradation. However, the number of indeterminable grains in any assemblage was a good proxy for the overall state of pollen preservation (Tinsley 2006). It was therefore decided that in this full analysis phase the state of pollen preservation would be characterised by recording the numbers of biochemically deteriorated grains for just two common taxa, Poaceae and *Corylus*-type, along with the total number of indeterminable grains in each sample. The Phase 1 study had already established that the major processes involved in pollen deterioration at the assessed sites were biochemical; evidence of mechanical deterioration was much more limited and difficult to interpret (Tinsley 2006; Jones *et al.* 2007).

Pollen taxa generally follow Bennett (1994). Cereal-type encompasses all grass pollen grains greater than 40μm in diameter; this includes the cultivated grasses (cereals) and *Glyceria fluitans, Aira caryophyllea, Ammophila arenaria, Leymus arenarius* and *Elytrigia.* Of these wild grasses, it is *Glyceria fluitans* (floating sweet grass) that is most likely to be present in fresh water wetland environments such as the Somerset Levels and therefore might potentially be a complicating factor in the interpretation of the cereal-type curve. *Corylus*-type includes *Corylus avellana* (hazel) and *Myrica gale* (bog myrtle). According to Andrew (1984) *Myrica* can be distinguished from *Corylus* by the sloping 'shoulders' to the pores. On this basis, the majority of *Corylus*-type grains in these analyses are believed to be hazel, where observations on well-preserved grains suggested the possibility of bog myrtle this has been noted in the text. *Sparganium emersum*-type includes *Sparganium* undifferentiated (bur-reeds) and *Typha angustifolia* (lesser bulrush), both of which might potentially be found in wet fen areas of the Levels.

Zygnemataceae were identified according to illustrations in van Geel and Grenfell (1996). Pollen was identified using keys from Moore *et al.* (1991) and Faegri and Iversen (1989), descriptions from Andrew (1984) and type collections.

Plant macrofossils

Julie Jones

The assessment stage of the project (Jones 2005) had shown that macrofossil abundance varied greatly between the sites and therefore for the analysis stage, samples between 500g and1000g were processed. After soaking in warm water the samples were washed through a nest of sieves to a minimum of 250μm; the resultant wet organic matter was then sorted. The extracted macrofossils were identified using the author's reference collection with the aid of Cappers *et al.* (2006) and Bertsch (1941). The habitats of different taxa are listed in Table 1.

Beetles

Harry Kenward

Following the assessment and record of preservational condition (Kenward 2006), four samples were selected for detailed analysis of their insect and other macro-invertebrate remains. No further sediment was available, so the following account is based on the remains recovered from the 1kg sub-samples examined in the assessment.

The raw sediment was processed by Palaeoecology Research Services (PRS), Shildon, Durham, who made a record of sample lithology using standard 1kg sub-samples. The sediment was sieved to 300μm, and invertebrate macrofossils recovered using the paraffin (kerosene) flotation method described by Kenward *et al*. (1980; 1986). Beetle (Coleoptera) and bug (Hemiptera) remains were generally recorded fully quantitatively, while for other invertebrates a semi-quantitative scale was used: 1, 2, 3, 'several' (translated as 6), 'many' (15), with estimates for very large numbers (Kenward 1992). Quality of preservation had been recorded during assessment using the scales of Kenward and Large (1998), but was re-assessed during the analysis stage, any significant differences being noted below.

The insect remains have been interpreted in the same general way as those from a variety of other sites in north-west Europe (methods introduced by Kenward 1978, with modifications outlined by, for example, Kenward 1982; 1988; Hall and Kenward 1990; Kenward and Hall 1995). In short, a number of 'main statistics' of whole assemblages and ecologically related groups of species of adult beetles and bugs are used and discussed in comparison with typical occupation site faunas. These statistics include species-richness (or diversity) of the whole assemblage and components of it, measured using α (alpha) of Fisher *et al*. (1943) and proportions of 'outdoor' species (OB, calculated from taxa coded oa and ob), aquatics (W, w), waterside species (D, d), phytophages (plant-feeders) (P, p), species associated with dead wood (L, l), moorland/heathland taxa (M, m), and decomposers (species associated with decomposing matter of some kind). Decomposers are subdivided into (a) species primarily associated with somewhat dry habitats (RD, rd), (b) those found mostly in rather, to very, foul habitats (RF, rf), and (c) a residuum not easily assignable to one of these (rt). The category 'RT' includes all three of these groups of decomposers (rt + rd + rf). In each case, the lower-case codes (e.g. 'rd') are those applied to species and the upper-case codes ('RD') are for the ecological group. Significant values of categories vary: thus, for example, % N OB = 30 is a high value, but % N RT = 30 is low; while % N W and % N RF are both high at 10.

An additional quantified component is the synanthropes, i.e. those species favoured by human activity, but these were effectively absent from the present group of sites. The index of diversity offers a guide to the presence or absence of remains of insects which bred in or on the developing deposit (autochthones), low values indicating breeding communities, high ones faunas of mixed origins.

Table 1. Plant taxa and habitat descriptions.

Taxa with common names	Habitat descriptions
Aethusa cynapium (Fool's parsley)	weed of ruderal sites
Alchemilla sp (Lady's-mantle)	grassland, woodland margins
Alisma plantago-aquatica (Water-plantain)	marsh vegetation in shallow freshwater
Alnus glutinosa (Alder)	swamp woodland
Atriplex sp (Orache)	disturbed and waste ground
Berula erecta (Lesser Water-parsnip)	ponds, fen, marsh
Betula pendula (Silver Birch)	light mostly acid soils in woodland
Betula pubescens (Downy Birch)	damp peaty moorlands
Betula sp (Birch)	
Callitriche spp (Water-starwort)	aquatic/semi-terrestrial. Shallow water up to 1m
Calluna vulgaris (Heather)	heaths, moors, bogs, open woodland, sandy or peaty soil
Carex paniculata (Greater Tussock-sedge)	marsh vegetation and alder carr
Carex pendula (Pendulous Sedge)	heavy soils in woods and damp copses
Carex spp (Sedge)	various habitats, often damp
Cerastium sp (Chickweed)	grassland, waste, cultivated ground
Ceratophyllum demersum (Rigid Hornwort)	aquatic, shallow still water
Chara spp (Stonewort)	shallow clear water or muddy/sandy sub-strata
Chenopodium album (Fat-hen)	fields and ruderal habitats
Chenopodium ficifolium (Fig-leaved Goosefoot)	habitats rich in nitrates
Cirsium palustre (Marsh Thistle)	wet habitats
Cladium mariscus (Great fen-sedge)	dense pure stands in reedswamp, shallow water
Eleocharis palustris/uniglumis (Spike-rush)	marsh, bankside, still shallow waters
Epilobium hirsutum/roseum (Great/Pale Willowherb)	wet or damp places
Erica sp (Heather)	bogs, heaths, moors
Eriophorum sp (Cottongrass)	raised bog
Eupatorium cannabinum (Hemp-agrimony)	marshy and moist places
Glyceria spp (Sweet-grass)	water's edge, shallow water
Hydrocotyle vulgaris (Marsh-pennywort)	bogs, fens, marshes
Hypericum sp (St. John's-wort)	grassland, woodland
Juncus spp (Rush)	damp ground such as marshes and wet meadows
Lemna spp (Duckweed)	aquatic, still fresh water
Leucanthemun vulgare (Oxeye Daisy)	grassy places, especially rich soils
Lychnis flos-cuculi (Ragged Robin)	damp meadows and wet woodland
Lycopus europaeus (Gipsywort)	banks of rivers, ditches, marsh and fen
Lythrum salicaria (Purple-loosestrife)	wet to moist freshwater habitats
Mentha aquatica (Water-mint)	marsh vegetation, wet grassland/woods
Menyanthes trifoliata (Bog-bean)	marshes and shallow lakes
Moehringia trinervia (Three-nerved Sandwort)	shady places in woods and hedges
Montia fontana (Blinks)	many kinds of damp places
Myriophyllum alterniflorum/verticulatum (Alternate/Whorled Water-milfoil)	ponds, lakes, rivers
Najas spp (Naiad)	still water lakes, waterways
Nuphar lutea (Yellow Water-lily)	aquatic, ponds, lakes, streams, up to 5m
Nymphaea alba (White Water-lily)	lakes, ponds, slow-moving streams, up to 3m depth
Oenanthe aquatica (Fine-leaved Water-dropwort)	in ditches and marshes
Poaceae indet (Grass)	grassland
Potamogeton spp (Pondweed)	mostly freshwater aquatic, varying depths
Potentilla erecta (Tormentil)	moist to dry sandy and peaty soils
Ranunculus acris/repens/bulbosus (Meadow/Creeping/Bulbous Buttercup)	grassy places, fields, ruderal habitats, can be moist
Ranunculus subg. *Batrachium* (Water Crowfoot)	aquatic/sub-aquatic, relatively shallow, still to slow moving water
Ranunculus flammula (Lesser Spearwort)	marshy places and wet grassland
Ranunculus lingua (Greater Spearwort)	marsh vegetation in shallow water
Ranunculus sceleratus (Celery-leaved Buttercup)	wet places which rich in nitrates
Rubus sect. *Glandulosus* (Bramble)	woodland edge, hedgerow, scrub
Rumex spp (Dock)	grassy and disturbed habitats
Sagina spp (Pearlwort)	various habitats
Solanum dulcamara (Bittersweet)	alder carr and shrub vegetation in moist places
Sparganium erectum (Branched Bur-reed)	along ditches and lakes, particularly in eutrophic water
Stellaria media (Common Chickweed)	fields and ruderal habitats
Typha spp (Bulrush)	along ditches and in lakes, reed-swamp
Urtica dioica (Common nettle)	common in places rich in nitrates
Viola odorata (Sweet Violet)	woodland, scrub, hedgerow, usually base–rich soils
Viola sp (Violet)	

The principal sources for information concerning beetle ecology were Friday (1988), Hansen (1987) and Koch (1989–92). For heteropteran bugs Southwood and Leston (1959) and Wagner (1996–7), and for Homoptera the Royal Entomological Society of London *Handbooks*, were used.

Snails

Paul Davies

The unprocessed samples were prepared using the hydrogen peroxide method of Evans (1972). For each sample approximately 100g of sediment was processed. The processed sediment was then sieved through a 0.5mm sieve, and all snail shells with an apex (plus operculae) picked under a 6–40× binocular microscope.

The shells from the samples were identified and counted under a binocular microscope using Kerney and Cameron (1979), Macan (1960) and Ellis (1962) as guides to identification. The reference collection held in the Quaternary Research Centre, Bath Spa University, was also consulted. Nomenclature follows Kerney (1999).

Diatoms

Nigel Cameron

Diatom preparation followed standard techniques (Battarbee 1986): the oxidation of organic sediment, removal of carbonate and clay, concentration of diatom valves and washing with distilled water. Two slides, each with two coverslips of a different concentration of the cleaned solution, were prepared from each sample and fixed in Naphrax, a mounting medium with a suitable refractive index for diatom microscopy. Slides were scanned at magnifications of ×400 and ×1000 under phase contrast illumination. Diatom floras and taxonomic publications consulted to assist with diatom identification include Hartley *et al.* (1996) and Krammer and Lange-Bertalot (1986–1991).

Assessment of preservation

Wooden remains

Mark Jones

Absence of baseline data

For all the sites there was a general description of the waterlogged remains and in many cases the detailed results of analysis for woodworking, wood species identification and tree-ring dating. There was a significant problem in determining the degree of recent degradation because of the absence of precise replicatable baseline data on condition.

Physical properties and decay of wood

Wood is structurally and chemically complex and is based upon the controlled use of two biopolymers, cellulose and lignin. Whilst cellulose has a high tensile strength, the presence of lignin in the wood cell wall increases its resistance to compression. The third major component is the polyoses, polymers of sugars and related monomers, which exhibit complex chain branching patterns and are less crystalline than cellulose. Polyoses form hydrogen-bonded complexes with celluloses and covalent bonds to lignin.

Seasoned wood contains very little nitrogen, and is a poor food source as a result. It can, however, be destroyed by bacteria, fungi and insects (Table 2). The polyoses are the most easily degradable components of the cell walls, followed by the loss of cellulose. Lignin is very resistant to bacterial and fungal attack, and importantly confers increased resistance to other components in the wood cell wall. Both bacteria and fungi require the wood to be at least damp before they are able to digest polyoses and cellulose. Certain bacteria are quite robust organisms and can continue functioning in both waterlogged and anoxic environments. The result of microbial decay is a progressive weakening of the wood due to the sequential loss of these structurally important polymers.

Table 2. Biological agents involved in the decay of waterlogged archaeological wood.

Organism	Limiting Factor	Result
Bacteria – anaerobic and aerobic types	Require a wet environment aerobic bacteria require oxygen	Loss of cell wall material
Fungi – wide range of types including soft, dry and brown rots	Require oxygen and a wood moisture content of > 18%	Loss of material and discoloration. Leads to a massive loss of strength and slow disintegration
Insects – main European type, *Nacerdes* melanura (wharf-*borer*)	Require oxygen, can survive down to 8% moisture content	Holes and cavities, rapid disintegration

In a waterlogged environment, chemical changes to wood results in swelling due to the cellulose molecules becoming surrounded with a sheath of hydrogen bonded water molecules. This results in an increase in size of about 25% radially, 52% tangentially, and 2% longitudinally. As cell wall material is lost, then blocks of sound material can become disconnected, and so are unable to provide useful mechanical support. As cell wall components are etched away by degradation, the water content of wood increases. Normally, for most woods the water content is between 5 and 25% but it can increase to well over 400% for degraded wood.

A useful scheme for classifying waterlogged archaeological wood has been developed by conservation scientists and divides the wood condition into three groups:

Heavily degraded: Wood containing over 400% water. This wood has lost all of its hard core.

Medium degraded: Wood containing between 185 and 400% water. A hard core is present but is comparatively small.

Slightly degraded: Wood containing less than 185% water. A hard core is present beneath a thin deteriorated surface layer.

Moisture content is an easily measured quantity which may be related to the density of the wood and thus to the state of degradation.

Sampling and assessment of decay in the MARISP project

Microscopic methods

All timber samples were examined for micro-organisms and their decay patterns using the scanning electron microscope. Sections of wood, 0.5–1mm thick, were fixed using 4% glutaraldehyde in 0.1M phosphate buffer at 4°C, for 4 hours. Samples were then washed in a phosphate buffer and post-fixed in 1% osmium tetroxide in 0.1M phosphate buffer overnight at 4°C. Fixed material was washed in buffer twice, each of 15 minutes duration, to remove excess fixative. Dehydration was then carried out in a graded alcohol series, 15 minutes in each 10% steps. Absolute ethanol was gradually substituted with acetone, and specimens were critically point dried in a Polaron E3000 apparatus using liquefied carbon dioxide as the drying agent.

Dried material was mounted on aluminium stubs using a carbon adhesive. Specimens were then kept in a vacuum desiccator for 24 hours, and gold coated using a Polaron diode sputtering system (E5000) unit. The material was examined in a JEOL SEM at an accelerating voltage of 20kV.

Chemical methods

All timbers were examined for the following features:

(i) Colour of wood
(ii) Texture of wood
(iii) Moisture content
(iv) Density
(v) Presence of sporulating structures
(vi) Presence of slime
(vii) Iron and other salt deposits
(viii) FT-IR analysis of wood to determine changes to the lignin carbohydrate complex of archaeological wood
(ix) X-ray near edge surface spectrometry (XANES)
(x) Shrinkage experiments

The maximum moisture content of timber was determined by use of the following equation:

$$\%\ \text{Moisture content} = \frac{\text{Weight of wet wood} - \text{weight of dry wood}}{\text{Weight of dry wood}} \times 100$$

Density was based on oven dry weight and the volume in water saturated conditions. The surface of timber samples was also scanned for the presence of sporulating fungal structures and bacterial slime.

FT-IR

Infrared spectra were acquired with a *Thermo Mattson Satellite* FT-IR (Fourier transform infra-red) spectrometer equipped with a *Specac Golden Gate* attenuated total reflectance (ATR) accessory. The specimens were placed on the diamond crystal of the ATR accessory clamped in place with a sapphire anvil. In each case a spectrum was obtained from a wood powder generated by rubbing the specimen against 600 grade silicon carbide papers. Spectra were recorded in transmission from 4000 to 700 cm^{-1}, with a resolution of $4cm^{-1}$, and averaged over 32 scans. Subsequent spectral processing was performed with *Grams*32/Al 9V6.0 software.

Peak positions for major wood components are given in Table 3. For the purpose of this study the bands near $1370cm^{-1}$, $1160cm^{-1}$, $896cm^{-1}$ were used to identify the cellulose portion of the wood samples. The absorption bands at approximately $1740cm^{-1}$ and $1240cm^{-1}$ are characteristic of hemicellulose. The bands in the $1200–1600cm^{-1}$ parts of the spectra arise primarily from lignin.

Table 3. Peak positions for major wood components.

Hemicellulose	Cellulose	Lignin
1740 and 1240	1370, 1160, 896	1510, 1330, 1260

XANES

X-ray near-edge spectrometry has been used to determine the presence of sulphur compounds in three samples of Somerset timbers (Bell Track timbers 1 and 2 and Meare Lake Village 3). After excavation these sulphur compounds slowly oxidise to sulphuric acid in waterlogged wood. The acid can destroy any remaining cellulose and thereby reduce the mechanical stability.

Pollen

Heather Tinsley

Field methods

Sampling for environmental assessment was carried out in the summer and autumn of 2003 by Julie Jones and Heather Tinsley, in association with the site excavations. At each site 0.5m steel monolith tins were driven into trench faces adjacent to the exposed wood archaeology, the number of tins used and therefore the depth of sample column retrieved, varied depending on the site stratigraphy. At each location the top of the upper tin was levelled to give the OD height. Bulk samples for plant macros and beetles were extracted from 0.05m spits adjacent to the monoliths.

The aim was to have a minimum of three sets of palaeoenvironmental samples per site, one from below the cultural horizon, one from the cultural horizon itself, and one from above it. However, at two sites (Abbot's Way and Bell Track) the wood was so close to the surface, and the peat above it appeared so dry, that only two sets of samples were taken. At Glastonbury Lake Village, Harter's Hill, Sharpham Park and Tinney's Tracks stratigraphic considerations made it appropriate to take more than three sets of samples. At some sites additional material was collected for snail assessment and for potential radiocarbon dating.

The monoliths were used for the pollen sub-samples and for some diatom sub-samples, the position of these sub-samples was related directly to the bulks, in the majority of cases coming from the centre of the 0.05m spit. In addition, the monoliths provide an archival sediment sequence for each site, which is available for future, more detailed analysis, where this may be deemed appropriate.

Laboratory methods and preservation recording

Samples of 1cm^3 of peat were prepared using standard techniques (Moore *et al*. 1991). Initial digestion in dilute potassium hydroxide was followed by sieving, then acetolysis. Samples were stained with safranin and mounted in glycerol. Two tablets of *Lycopodium* spores were added to each sample at the start of the preparation to allow pollen concentration to be assessed (Stockmarr, 1971). Concentrations were calculated as pollen grains per cm^3. Plant nomenclature follows Stace (1991) and pollen types generally follow Bennett (1994), a note about the pollen types is given at the end of this report. Pollen was identified using keys from Moore *et al*. (1991) and Faegri and Iversen (1989), descriptions from Andrew (1984) and type collections. Fungal and algal spores were identified using van Hoeve and Hendrikse (1998).

The methodology used for assessing pollen preservation was agreed in discussions with English Heritage. Samples were examined at a magnification of ×400, with ×1000 magnification used for critical determinations. At each sample level 100 pollen grains were identified and their state of preservation recorded individually. In addition, indeterminable grains were recorded and categorised. All fern spores seen during assessment were counted and notes made about their overall state of preservation; it was not practical to record spore preservation individually as some samples had very large numbers of fern spores. Where identification was possible, fungal, algal and moss spores were recorded. The occurrence of microscopic charcoal in the samples was noted using a simple visual scale of abundance. Each 100-grain pollen count was spread over a minimum of four traverses, which were spaced across the slide. In samples where the pollen concentration was low, the number of traverses had to be greatly increased.

Literature discussing the classification and significance of deteriorated pollen grains extends back over many years including papers by Cushing (1964; 1967), Havinga (1967; 1971; 1984), Birks (1973), Lowe (1982), Smith (1984), Tipping (1987; 2000) and Bunting and Tipping (2000). Delcourt and Delcourt (1980) provided clear descriptions of the different classes of pollen deterioration, and their system was adopted for the classification of unidentifiable grains in the standard account of pollen analysis found in the *Handbook of Holocene Palaeoecology and Palaeohydrology* (Berglund 1986). However, though unidentifiable grains are classified in routine pollen analysis, it is not usual for published accounts to include detailed observations on the preservation state of identifiable grains.

The classification adopted in this report was based on that of Delcourt and Delcourt (1980) and it was applied to all identified pollen grains. Five categories of pollen deterioration were recognised. Corrosion causes the pollen exine to be pitted, etched or perforated (Plate 1: Appendix 3). According to Havinga (1984), it is the result of biochemical attack, and this explanation appears to be widely accepted in the literature. Pollen grains with smooth exines (e.g. *Corylus*-type, *Alnus* and *Betula*) exhibit obvious signs of corrosion particularly clearly. Degradation results in general thinning of the exine and loss of structural elements, ultimately the exine may deteriorate until only an outline of the grain is left (Plates 2–3: Appendix 3). Probably the amorphous (structureless) indeterminable grains which are sometimes seen in pollen preparations are an extreme case of degradation. The cause or causes of this type of breakdown are not entirely clear, Delcourt and Delcourt (1980) suggested chemical oxidation within aerial and sub aerial environments. Breaking or splitting of grains (Plate 4: Appendix 3) can result from their physical transport pre-deposition, or from post-deposition compaction. Crumpling (Plate 5: Appendix 3) may also be associated with transport processes and/or post-depositional compaction of sediments (Smith 1984). A further category of pollen deterioration is associated with concealment of morphological features by authigenic mineral deposition (Plate 6: Appendix 3), this is not common, but is associated with some alluvial environments (see discussion in Wiltshire *et al.* 1994).

The susceptibility of pollen taxa to these types of deterioration is variable, as the chemical composition of the pollen grain exine varies from one pollen taxon to another (Havinga 1971; 1984). In assemblages where processes of pollen deterioration are marked, some taxa may ultimately decay altogether and these will initially be the least robust types, as Faegri and Iversen explained (1989) '*the more resistant types will appear to accumulate owing to the disappearance of their counterparts, the less resistant grains*'. It is for this reason that differential destruction of pollen grains has been long been recognised as a source potential error in the ecological interpretation of pollen data (Faegri and Iversen 1989).

In order to assess pollen deterioration in the MARISP samples, a 12-category grid was devised, allowing for the recognition of different types and degrees of deterioration. Each of the 100 identified grains in any sample was recorded in one or more categories of this grid (Table 4). Category 12 ('concealed by authigenic mineral deposition') was dropped from the final data analysis as partial infilling of grains was rare and, where it occurred, did not apparently result in deterioration of the grain (grains affected were noted in the summary tables). The different categories were scored in a non-hierarchical system: a well-preserved grain had no score; the biochemical deterioration categories of corrosion and degradation were scored at 1–3 levels of increasing deterioration; the physical (or mechanical) deterioration categories 'broken' and 'crumpled' were scored at 1–2 levels of increasing deterioration (Plates 7–10: Appendix 3).

An individual grain could score in one or several categories. With the exception of corrosion, scores were defined qualitatively and although this could be regarded as a weakness of this system, it is justified as it is not established that the processes responsible for pollen deterioration act in a linear way. Even with corroded grains (where pitting and etching could be seen as discrete marks on the exine) it was not possible to determine accurately the extent of damage when more than half the grain was affected.

Indices summarising the biochemical and physical preservation state of the identified grains in each sample were calculated. The scores for biochemical deterioration (corrosion and degradation) for all grains were added and then divided by 100. The scores for mechanical (physical) deterioration were added, then weighted, before dividing by 100, so the two indices were directly comparable. If all pollen was well preserved, both these indices would be 0; the higher the indices, the poorer the preservation. The lowest indices recorded were 0.14 (biochemical preservation) and 0.08 (mechanical preservation), both from the same sample at Meare Village East (2.86–87m OD); the highest indices were 2.01 (biochemical preservation) and 0.68 (mechanical preservation) both from Harter's Hill (4.18–4.19m OD). An index of 0.68 for mechanical preservation was also recorded from Sharpham Park (4.95–4.96m OD).

The indeterminable grains were also categorised, in what is accepted by pollen analysts as the routine way, into corroded, amorphous (degraded to the point where all structure appears to be lost, but staining and overall shape indicates pollen), broken and crumpled grains (Berglund and Ralska-Jasiewiczowa 1986). The higher the number of indeterminable grains in a sample, the more information will have been lost and the less reliable the sample becomes for the reconstruction of past environments, as the distribution of taxa is likely to have been altered towards more resistant types.

This classification of deterioration types appears straightforward, but there were difficulties in applying it. Though the distinctions between types seem clear in Table 4, in reality it was sometimes difficult to separate corrosion and degradation, particularly if grains were crumpled and/or broken (Plate 11: Appendix 3). Grains often exhibited more than one deterioration type, and mechanical damage in particular can make detailed observation of the exine difficult. The varying morphological characteristics of individual pollen taxa (for example differences in exine thickness and sculpturing), made comparisons between taxa, in terms of the intensity of deterioration (particularly degradation), somewhat problematic (Plates 12, 13: Appendix 3).

The distinction between well-preserved grains and those only partially degraded was sometimes surprisingly difficult to make, even within the same taxon. Some slight degree of degradation is common to most (though not all) fossil pollen grains and this has been accepted within the term 'well-preserved' as

Table 4. Preservation categories used for identified pollen grains in the MARISP samples.

Deterioration Type		Description	Processes responsible	Category	Score	Weighting for calculation of preservation indices
		After Delcourt and Delcourt (1980)				
Well-preserved		No observable deterioration		1. well-preserved	0	0
Biochemical deterioration	Corroded	Exine pitted, etched or perforated	Biochemical oxidation related to fungal/bacterial activity	2. <¼ corroded	1	0
				3. ¼-½ corroded	2	
				4. ‘½ corroded	3	
	Degraded	Exine thinned and/or structural features fused and indeterminate	Chemical oxidation within aerial and sub-aerial environments	5. partly degraded	1	
				6. extensively degraded	2	
				7. outline of grain only	3	
Mechanical deterioration	Broken	Grain split or fragmented	Physical transport of pollen gains	8. partly broken	1	X 3/2
				9. extensively broken	2	
	Crumpled	Grain squashed	Compaction of grains within the sediment, particularly resulting from the progressive extrusion of water	10. partly crumpled	1	
				11. extensively crumpled	2	
Concealed by authigenic mineral deposition		Grain infilled by metallic crystals	Deposition associated with chemically-reducing alluvial environments	12. partly infilled (no fully infilled grains were observed)	Category not used in final analysis	

used in this study. A ‘well-preserved’ grain was not, therefore, one with the appearance of a type specimen, rather it was a grain with characteristics normally accepted as indicating good preservation in fossil material (Plate 14: Appendix 3). Distinguishing between such grains and those showing more significant (but not severe) degradation was somewhat subjective.

It was also difficult to ensure consistent recording of the degree of degradation when comparing taxa with smooth exine surfaces such as Poaceae (grasses) with rough-surfaced grains such as *Quercus* (oak). The easiest category of preservation to assess was probably corrosion, as the extent of pitting, etching and holes in the exine could be measured and could usually be seen relatively clearly on taxa such as *Corylus*-type (hazel, bog myrtle) (Plates 7–10: Appendix 3), *Betula* (birch), *Alnus* (alder), Poaceae and undifferentiated fern spores, which are all smooth-surfaced. However, even here difficulties arose in making judgements on the corrosion extent for taxa with rough or highly sculptured exines; for example it was often difficult to assess the extent of corrosion in *Quercus*, particularly if some degradation had also taken place. This problem was noted by Havinga (1967); in comments on the assessment of corrosion in experimentally buried pollen, he stated: ‘... it even proved impossible to draw a sharp distinction between slightly corroded and uncorroded pollen grains’.

The recording of mechanical or physical damage to grains was relatively straightforward, except in the case of crumpling in thin-walled taxa such as Cyperaceae (sedges), these often presented as folded or somewhat crumpled even when well-preserved, a condition noted by Moore *et al*. (1991) in their Pollen and Spore Key. Tipping (2000) observed that ‘pollen of thin-walled Cyperaceae are … more susceptible to crumpling than other grains and a certain subjectivity is introduced in consideration of what constitutes a crumpled Cyperaceae grain’.

In an attempt to maintain consistency of recording throughout the whole set of MARISP samples, and reduce subjectivity as far as possible, frequent photographs were taken and these were used constantly for comparative purposes. However, it did prove to be difficult to produce meaningful images of extensively degraded pollen grains for illustrative purposes. The lack of exine definition, combined with the problem of the range of focus for three-dimensional pollen grains under the microscope, invariably resulted in the images appearing blurred. A small number of samples was assessed twice in order to examine the reproducibility of the method from day to day, when used by the same assessor. However, the question of the reproducibility of the classification, if used by different assessors, has not been tested in this study.

Presentation of results

The results are considered site by site. A series of tables is presented for each site, one for every sample assessed, showing the numbers of grains of individual taxa identified and their state of preservation. The tables form the basis for an assessment of the palaeoenvironment at each site, as well as being the means of comparison of the preservation characteristics of the different pollen taxa present at each sample level. The tables are direct compilations from the individual 12 × 100 grids used for recording; they give the numbers counted for each taxon followed by a breakdown of the deterioration types observed. In order for this data to be manageable some composite types have been created (e.g. 'Corroded and degraded', 'Broken and corroded'); these composite types include grains that are both partially and extensively deteriorated. Each site is described briefly, the palaeoenvironmental interpretation of the assessment is considered first, with an outline of the composition of each pollen assemblage, and then a brief consideration of the vegetation communities likely to have been the principal pollen sources. As all assessments are based on counts of 100 grains, the figures for individual pollen taxa shown in the tables can be converted directly to percentages. It must be stressed that the data are at assessment level only, they cannot be used for the construction of publishable pollen diagrams and therefore reconstructions are tentative.

The preservation characteristics of each pollen assemblage are described, using both the individual sample tables and a summary table for each site. The summaries record the numbers of well preserved, indeterminable and poorly preserved grains at each sample level, with the poorly preserved grains separated into the four main deterioration types. The data for each of the classes of 'extensive deterioration' in the summaries were assembled from the original count grids; it therefore includes some of the grains recorded in each of the composite deterioration classes shown in the individual sample tables. The summary tables include the pollen preservation indices and data relating to a number of assemblage properties, such as pollen concentration, total number of taxa, number of grains of taxa particularly resistant to decay and number of fern spores, which have potential for indicating differential post-depositional loss of pollen.

The pollen concentration of a sample will be reduced if extensive deterioration has resulted in complete breakdown of pollen grains. However, concentration is also influenced by the pollen productivity of source communities and by rates of sediment accumulation and therefore the relationship between pollen concentration and preservation state is not direct. If a pollen assemblage is dominated by only a few taxa, particularly if these are relatively robust types, then differential decay of more susceptible taxa may be indicated. Pollen taxa particularly resistant to decay tend to have thick walled grains (in this study the taxa listed by Bunting and Tipping (2000) were adopted – *Tilia*, Lactuceae, *Artemisia*-type, Caryophyllaceae, Chenopodiaceae and Brassicaceae). Fern spores are relatively more resistant than pollen to processes of decay (Havinga 1984) and could potentially accumulate differentially if part of the pollen assemblage decayed away completely (Dimbleby 1985; Bunting and Tipping 2000).

The description of the results from each site ends with a statement of the potential for full pollen analysis. This is a subjective assessment, based on the evidence presented, and on past experience.

Note on pollen types

The taxonomic level to which pollen grains can be identified varies; some can be identified to species level, others to family and others to group. This report mainly follows the conventions used by Bennett (1994). Pollen taxa with the suffix 'type' include different genera of the same family. In this report *Corylus*-type includes *Corylus avellana* and *Myrica gale*, the majority of grains are assumed to be *Corylus* (hazel). Cereal-type includes all grass pollen grains greater than 40 microns in diameter this includes the cultivated grasses (cereals) and *Glyceria fluitans, Aira caryophyllea, Ammophila arenaria, Leymus arenarius and Elytrigia,* the majority of grains found in these assessments are believed to be cereals.

Plant macrofossils

Julie Jones

Previous assessment of palaeobotanical preservation

Previous work on assessing the state of preservation of botanical remains has concentrated mainly on pollen and similar studies on plant macrofossil remains are lacking. One of the earliest approaches proposing a scheme for the objective assessment of plant macrofossil preservation was put forward by Murphy and Wiltshire (1994) who prepared a paper looking at archaeological deposits rather than natural or semi-natural sediments. Despite this, many of the comments they make are relevant to naturally accumulating sediments such as those examined in this project. In most archaeobotanical reports, especially assessments, the state of preservation tends to be recorded as 'poor', 'good' or 'well-preserved' without any real definition of the criteria used for these descriptions. The difficulty of establishing such criteria for plant remains, as Murphy and Wiltshire state:

> 'is understandable, for macroscopic plant remains differ very widely in gross structure, cellular structure, their degree of lignification, silicification and calcification and in their content of polyphenolic compounds (such as tannins) and other modifiers. As a result, distinct elements of different taxa survive differentially and objective assessment of preservation is difficult'.

The material considered by Murphy and Wiltshire included seeds/fruits, mosses, buds/scales, deciduous leaves and wood/twigs. With regard to seeds/fruits they concentrated on the 10 most commonly occurring taxa and defined characteristics for these which also concentrated on fragmentation of achenes/nutlets/caryopses as well as the condition of the seed testa and clarity of cell patterning. They suggested the use of a scoring system as a measure of state of preservation.

Although this paper was written 10 years ago few real advances in assessing preservational state have been made. Kenward and Hall (2000) discuss the decay of delicate organic remains in shallow urban deposits and state the need to monitor the condition of remains in relation to ground conditions and the impact this has on preservation of palaeoenvironmental data. However, even in 2000 they state:

> 'so great is the need for systematic study that we cannot yet even classify preservational states of delicate biological remains for the purposes of recording and research although the first steps have been made in papers such as Murphy and Wiltshire (1994) and Kenward and Large (1998)'.

As part of a paper concerned with the concept of preservation of archaeological deposits *in situ* (Davis *et al.* 2002) the condition of samples of archaeological deposits was considered. Although a system for assessing the condition of insect remains had already been established (Kenward *et al.* 1986) which has been more recently refined (Kenward and Large 1998) it was suggested that recording plant remains in such a way was 'surprisingly difficult as plant remains do not consist of a single kind of material and represent a wide range of parts.' Even fruits and seeds have different colours, textures and also undergo pre-burial change such as natural decay and germination. However, Hall used a subjective three-point scale from excellent to very poor, with two intermediate points making a scale of five points.

Perhaps of more relevance to the MARISP Project is another wetland project, the Planarch Project in the Netherlands (Vernimmen 2002), which looked at the quality of botanical samples with the aim of identifying factors which may have affected deterioration. The criteria used were the number of plant species present, the amount of organic matter, the number of seeds and preservation of the individual seeds. Quantifying the number of taxa is problematical as some vegetation types are species poor (in a raised bog a sample may be dominated by *Sphagnum*), others have large assemblages associated with them (alder carr may have a whole range of marsh and aquatic taxa as well as alder itself). Although Vernimmen also appreciated the difficulty of judging the preservation of individual seeds objectively, he used five categories for assessing the state of preservation of individual seeds ranging from very poor to very good, which ranged from:

> *Class 1* very poor; the sample contains no recognisable seeds. Fragments of plant material that probably come from seeds are however distinguishable
>
> to
>
> *Class 5* very good; seeds almost look recent. The structure of the surface is still entirely intact, the cell structure is clearly visible and the husk, capsule or prickles/hairs etc are still present.

Although the system used seems fairly simplistic it did allow comparisons to be made between the samples investigated and some general observations were made such as that in most cases there seems to be a correlation between a low water table and poor preservation of botanical remains. Better preserved remains generally appeared to contain a higher proportion of organic matter, shallower samples are generally less well preserved than deeper ones and date of the sample has no impact on state of preservation.

Two sites that have undergone previous assessment in the Somerset Levels are the Abbot's Way and Sweet Track (Cox *et al.* 2001; Brunning *et al.* 2000). On the former site the method of recording plant remains followed normal assessment procedures, with a scale of abundance used and preservation judged with the use of general terms like 'good' and 'excellent'. No attempt was made to record categories of deterioration such as those suggested by Murphy and Wiltshire (1994) and observations were simply made on the degree of modern root and seed penetration, especially from the mature birch trees which grew close to the track. On the Sweet Track evaluation the plant macrofossil remains were recorded on a scale of abundance with general comments made on condition such as 'good', 'well-preserved'. The overall conclusions were that material was sufficiently well preserved for further analysis and although there were signs of modern root penetration, there was little downward movement of modern material.

Methodology used in the MARISP project

A more systematic method of recording the state of preservation of plant remains was required for the MARISP project. Following consultation with English Heritage, other specialists involved in the project and Richard Brunning some initial suggestions were proposed. These included the use of 250g sub-samples with the aim of assessing the first 100 seeds/fruits from each sample, if this was possible. Two main categories for recording would include fragmentation and surface erosion/corrosion of the seed/fruit testa. Sub-division of these categories would be confirmed later once the samples were processed.

Sub-samples of 250g were therefore soaked in warm water to disaggregate the sediment and then washed through a nest of sieves to a minimum mesh size of 250µm. The wet sample floats were then placed in polythene bags in their individual fractions and stored in refrigerator for later assessment.

The aim of the assessment therefore was to count 100 seeds/fruits from each sample. With the exception of heather flowers, other macrofossils were not included, although inclusions of wood, buds/scales, moss as well as mollusca and evidence for other invertebrates such as caddis fly larvae and leech cocoons were recorded. To ensure a good range of taxa of all sizes was recorded, 25 seeds/fruits were assessed from each sieve fraction (250µm, 500µm, 1mm and 2mm). This was not always possible, for example in one of the Abbot's Way samples 93 out of 100 heather (*Calluna vulgaris*) seeds were from the 250µm mesh size. The total number of seeds was also estimated from the entire 250g sample and any additional taxa were recorded.

An attempt was also made to determine the organic content of each sample and therefore suggest the degree of humification of the peat. A second 250g sub-sample from each location was air dried and re-weighed. Each sieve fraction (250µm, 500µm, etc) from the first sub-sample was also dried after examination and then re-weighed. These weights were recorded, with the organic content expressed as a percentage figure.

Method of assessment *(images in Appendix 5)*

After an initial trial run on one of the better preserved samples, to determine how to define the different categories for recording preservation of individual macrofossils, it was decided to keep the process simple with each of the two main headings of fragmentation and erosion, sub-divided into degrees of deterioration as follows:

1. *Degree of fragmentation* showing mechanical damage to the fruit.
   Four categories, each having individual scores as follows:

Seed/fruit entire	score 0
Seed/fruit <25% fragmented	score 1
Seed/fruit 25–50% fragmented	score 2
Seed/fruit >50% fragmented	score 3

2. *Degree of erosion/corrosion* perhaps more related to chemical change.
   This would show degrees of degradation mostly to the seed testa, maybe in the form of pitting, loss of surface sculpturing or damage to epidermal cells.
   Three categories, each having an individual score as follows:

Seed/fruit <25% erosion of seed coat	score 1
Seed/fruit 25–50% erosion of seed coat	score 2
Seed/fruit >50% erosion of seed coat	score 3

Each category was given a score as a measure of state of preservation for each individual recorded. Then by totalling all the scores and dividing by the number of individuals counted, each sample would be given a preservation index. Therefore a score of 0 would be extremely well preserved, higher figures less well preserved. The highest index recorded was 3.5 from the uppermost sample at Sharpham Park.

In total 60 taxa were recorded, which includes common names and brief habitat descriptions. Nomenclature and habitat information are based on Stace (1991). As each taxon has its own characteristics it was decided to record a brief description of each species with the aim of standardising the recording. For example, birch has flattened fruits with two stigmas and translucent wings. Good preservation of these wings, the shape of which vary between the two species found here, *Betula pendula* (silver birch) and *Betula pubescens* (downy birch), are necessary to separate these. Where this occurred the fruits were recorded as entire (score 0), where the wings were missing but the rest of the fruit including the stigmas was complete, this was recorded as <25% fragmented (score 1). Further degrees of fragmentation were from breakage of the fruit, the stigmas also missing (25–50% and >50%). Seed/fruit descriptions used in the text are based on Berggren (1969; 1981), Dickson (1970).

Beetles

Harry Kenward

Palaeoecology Research Services (PRS), Shildon, Durham carried out processing of raw sediment. In the laboratory, a record was made of sample lithology, using a standard *pro forma*. A standard 1kg of sediment was processed. The sediment was sieved to 300µm, and invertebrate macrofossils recovered using procedures broadly following the paraffin (kerosene) flotation method described by Kenward *et al*. (1980; 1986). For assessment, all remains were generally recorded using a semi-quantitative scale of 1, 2, 3, 'several' (translated as 6), 'many' (15), with estimates for very large numbers (Kenward 1992). Quality of preservation was recorded using the scales of Kenward and Large (1998). In summary, preservation was recorded as chemical erosion (E) and fragmentation (F), in each case on a scale from 0.5 (in superb condition) to 5.5 (extremely decayed or fragmented), the range and mode being noted (Tables 5 and 6). Colour change was also recorded, as were any unusual features such as patchy decay on single fossils (Tables 7 and 8).

Table 5. Scale for recording chemical degradation ('erosion') of insect fossils.

Point on erosion scale	Definition (refers to individual sclerites or associated groups of sclerites)
0.5	Resembles dry museum material; sclerites often quite strongly joined; scales and hairs in very good condition though weakly attached ones will be lost; colours natural; membranous wings undecayed
1	Fossils in superb condition, associated sclerites weakly joined by intersegmental membranes or membranes lost; isolated sclerites with membranous parts partly lost, remaining as fringes in places; scales and hairs in good condition; colours natural or darkened; membranous wings only slightly decayed
1.5	Much as 1 but some, perhaps very subtle, surface and/or colour change; little trace of intersegmental membranes; some subtle degradation of hairs and scales
2	Some distinct, but perhaps only slight, surface degradation; often some colour change; intersegmental membranes lost; delicate wings show distinct degradation
2.5	Much as 2, but colour change and/or surface degradation has quite clearly occurred, although to a limited extent
3	The sclerites show appreciable degradation, in the form of thinning, colour change and/or surface modification; only the more robust hairs and scales and the tougher membranous wings in useful condition
3.5	As 3, but thinning, colour change, and/or surface modification have progressed quite strongly so that appearance is very different from fresh material
4	Much degradation; thinning usually apparent, but three-dimensional shape retained when wet; still readily identifiable; all but the toughest hairs and scales generally completely decayed; most membranous wings completely decayed
4.5	As 4, but colour mostly lost, perhaps some loss of three-dimensional form
5	Typically thin, with complete loss of colour and three-dimensional form, although in some cases these may be retained but there is profound surface erosion; no trace of membranous cuticle; identification often difficult
5.5	Only very eroded traces of tough cuticle remain

'Colour' applies to pigment, not structural colour; the latter may be retained even when decay has progressed very far. In addition to the values given, '0' or '-' is used to mean not recorded or not recordable

Table 6. Scale points for recording fragmentation of insect fossils.

Point on fragmentation scale	Definition (refers to individual sclerites or associated groups of sclerites)
0.5	Resembles dry museum material; typically groups of associated sclerites; sclerites entire (larger flat ones may be broken); bases of appendages usually present, sometimes also with more distal segments
1	Associated sclerites often present, including bases of some appendages and (rarely) more distal segments; sclerites entire (larger ones may be broken)
1.5	As 1, but some fossils with traces of edge damage; may retain some appendage bases
2	Some chipping at edges and extremities of sclerites, particularly flat ones, but entire except in large species, which typically have one to three breaks per sclerite, and medium-sized ones, which may show one break; damage does not limit identification
2.5	Intermediate; medium-sized sclerites with one or two breaks
3	One break or crack per sclerite in smaller species, two to several in large ones, usually minor edge chipping; almost always identifiable
3.5	Intermediate; fragmentation may limit identification in some cases
4	Smaller flat sclerites broken into more than two (often still identifiable) pieces, large ones into several; compact ones broken or split; typically much edge damage along breaks so that large fragments cannot be fitted together
4.5	Intermediate
5	Sclerites broken into several or many parts whether large or small; typically unidentifiable within reasonable time-scale
5.5	Reduced to fine fragments, so only those with distinctive surface sculpture or residual tough scales can be identified

Allowance has to be made subjectively for unusually fragile or tough parts or species. In addition to the values given, '0' or '-' is used to mean not recorded or not recordable

Table 7. Scales for intensity of colour change. Change beyond point 4 for brown, yellow or red would take colours towards 'pale'.

Scale point	Term	Definition
0	None	Colours as in museum material
1	Slight	Colour change subtle, just detectable; more profound in the case of species with labile colours
2	Distinct	Change has clearly occurred, but is not strong
3	Strong	Considerable change from colours seen in museum material; only traces of original colour; dark/light contrasts often obscured
4	Intense	Profound change; original colours wholly masked apart from extreme dark/light contrasts (darkened fossils entirely black); further change towards colour under consideration is unlikely

Table 8. Proportion or abundance categories for 'other properties'.

Abbreviation	Category name	Approximate proportion of fossils showing the property
T	Trace	Only very rare fossils (e.g. one or two in an assemblage of a few hundred sclerites)
S	Several	An appreciable number, but less than a quarter
M	Many	About a quarter to about three quarters
Most	Most	Over three quarters, but not all
All	All	All (or effectively all) sclerites are affected

Table 9. Definition of terms used in describing the strength of modes.

Abbreviation	Term	Definition
W	Weak	A perceptible, but only modest, proportion of the assemblage lies close to the mode
D	Distinct	A substantial proportion (about half) of the fossils undoubtedly lie close to the mode
S	Strong	Most (about three-quarters) of the fossils lie close to the mode
V	Very strong	Almost all fossils lie at or close to the mode

Note that the modes are for the whole assemblage, not just those fossils showing the property under consideration

Each deposit has been assigned a priority on the basis of the interpretative potential of its insect fauna. The categories are as follows: P1A – very good potential for archaeological reconstruction or for addressing biogeographical or climatic issues (sometimes novelty value); P1B – useful for reconstruction of local ecology and for site or inter-site synthesis; P2 – fairly limited fauna or repetitive in context of current project: useful for routine reconstruction and site or inter-site synthesis; P3 – limited fauna, giving only general information about past conditions; useful only in acquiring data for synthesis. P0 – of no value.

Although the aim of this study was to record the present condition of sediments for future comparison, within the wider objective of protecting the buried heritage, the opportunity has been taken to examine the preservation records in various ways in order to search for pattern. For this, SPSS for Windows Version 11.0 and the Excel spreadsheet package have been employed.

Foraminifera

Annette Kreiser

Only a single sample was analysed from the Harding Alignment at Harter's Hill. A total of 10cm^3 of the sample was wet sieved through 500µm, 125µm and 63µm mesh sieves. Any foraminifera retained on the 125µm sieve were picked out at 30–40× magnification under transmitted and incident light using a Brunel BMZ zoom stereo microscope. The 63µm fraction was also examined for the presence of juveniles although it is generally not possible to confidently identify juvenile tests to species level. Identification follows Murray (1979).

Diatoms

Nigel Cameron

Diatom preparation followed standard techniques: the oxidation of organic sediment, removal of carbonate and clay, concentration of diatom valves and washing with distilled water. Two coverslips, each of a differing concentration of the cleaned solution, were prepared from each sample and fixed in a mountant of suitable refractive index for diatoms (Naphrax). Slides were scanned at magnifications of ×400 and ×1000 under phase contrast illumination.

Monitoring of the burial environment

David Hogan

The hydrological regime of each monument was analysed using a series of piezometers and redox probes. This follows published advice on monitoring wetland sites (Caple 1992) and is consistent with the methodology used in the previous work on this subject in the county (Brunning *et al.* 2000).

On each site a transect was established leading away from the monument to the nearest ditch edge which can achieve summer pen levels. In the case of linear monuments the transect was at right angles to the line of the monument wherever possible. On each standard transect a series of three piezometer stations was installed, one beside the track, one 5m in from the ditch and the other spaced midway between the two (where possible). The depth of the piezometers at each station will be 0.5m, 1m and 1.5m below ground. This standard was altered to meet specific site conditions. The variations are detailed in the results section.

At the station nearest the monument redox probes were installed at three different depths with three duplicates at each depth (per station). The depths of the probes were positioned to be at, above and below the monument. The tops of all the piezometers and redox probes were levelled to OD to allow exact comparison with the archaeological remains. Redox probes are inserted into the profile in triplicate at selected depths, and secured at the ground surface under a protective metal cover.

Redox potential was measured on field visits using a portable meter connected by a two-way adaptor to the copper wire of the probe and a calomel half cell that is pushed into the soil surface. Measurements of redox (R) are made for each depth and recorded on a spreadsheet. Mean values of the three replicates are quoted, corrected for the calomel half cell by subtracting a value of -244 (i.e. 244 is added to the millivolt reading). For example, mCR50 would be the final value used in this report for the mean of three field readings of the 50cm deep probes at a particular site, corrected for the calomel cell.

Table 10. Categories of redox potential.

Redox potential (mV)	Category
>+400	Oxidised
+400 to +100	Slightly reduced
+100 to -100	Moderately reduced
-100 to -400	Highly reduced

In the discussion of results, reference is made to the categories of redox potential shown in Table 10. For the purposes of this report, where these specific categories are used in the text, the terms appear in italics.

Water levels and redox were monitored every four weeks except when the stations could not be located because of flooding or vegetation growth. The redox probes were monitored using a calomel half-cell. Draw down tests were conducted on some of the deeper piezometers to calculate saturated hydraulic conductivity and thereby assess the permeability of the peat. This is relevant for the peat's potential to conduct nutrients via shallow groundwater and for calculating the changes to the hydrological system that may be required, especially the proximity to the monument of any new irrigation method.

Water samples were taken from the piezometers nearest to the sites and from the adjoining field ditches. Water chemistry tests included pH, ammonia, nitrate, potassium, chloride, electrical conductivity and phosphorous as outlined in Brunning *et al.* 2000. In some instances there was not enough water in the piezometers to do all the testing. Initially it was hoped that water quality samples could be taken in midsummer but this was prevented by the low groundwater table causing a lack of water in the piezometers.

3. Trackways

Richard Brunning

The excavation, condition assessment and monitoring results are presented separately for each site in this and the following three chapters. For each site the excavation results are considered first, followed by the condition assessment and monitoring studies.

After the individual site results, Chapter 7 presents the overall conclusions of the condition assessment and monitoring results and then concludes with a summary of environmental change in the study area incorporating the new evidence generated by the project.

1. Bell Tracks fieldwork

Somerset HER 23793; SM 27992

Previous fieldwork

The Bell Tracks were discovered in 1966 in a field at ST428422 on the western edge of Westhay Island when Mr Edward Bell found some sticks while digging a hole to bury a dead dog. Subsequent excavation directed by John Coles revealed two overlapping trackways along the length of an irregular trench that was 14m long and up to 3m wide (Coles and Hibbert 1968, pl. xv).

The lower track, Bell A, was formed of birch brushwood placed around the stumps of birch and alder trees and held in place by large numbers of pegs in two lines, 0.9–1.1m apart. The pegs were mainly hazel with some ash and birch and were up to 0.61m long (Coles and Hibbert 1968). The trackway has been dated to 2900–2200 cal BC (BM-383, 4021±103 BP).

The upper track, Bell B, may represent a rebuild of Bell A on the same line. It was a complex roundwood track, 1–2m wide, composed of several layers. The basal timbers were split ash, *c.* 1m long and 80–150mm in diameter. Numerous small birch, hazel and yew twigs were placed between the basal logs and along the line of the trackway above them. They were held in place by hazel and ash pegs or stakes at the edges. Heavy ash poles, up to 2m long, were placed transversely across the brushwood 150–600mm apart, with a layer of birch on top (Figure 29). The upper structure was also secured by the roundwood pegs. An anthropomorphic ash wood figurine, named the 'God dolly' by the excavators, was found under the trackway, placed upside down and held in place by several pegs (Figure 30). It is thought to be the oldest human figurine from the UK.

The Bell B track has been dated to 3950–3350 cal BC (GaK-1600, 4840±100 BP) and 2900–2200 cal BC (BM-384, 3975±92 BP). The earlier of these two dates seems less likely to be a true reflection of the date of the trackways construction than the latter, not least because it is inconsistent with the date of the earlier Bell A track. Both the Bell tracks existed at the edge of a lagg area with fen woodland that the tracks crossed to reach the open raised bog.

MARISP excavation results

Two trenches were excavated (Figure 31). Trench 1 was located in the field immediately to the west of the eastern terminal of the trackway. Coring with a gouge auger to try and locate the reported line of the trackway in this field failed to produce a definite contact. This was probably due to the small diameter of the auger and the limited thickness of the structure. Trench 1 was therefore positioned across the reported line of the trackway where the auger had encountered some wood.

Trench 1 was 7.8m long across the suspected line of the track and 1m wide. The ground surface was at 2.29m OD and an intermittent layer of bark and small roundwood (mainly roots) was encountered between 1.71m OD and 1.61m OD. This appeared to be an entirely natural fen wood deposit and was removed

Figure 29. Bell B trackway during excavation by the Somerset Levels Project.

Figure 30. The 'God Dolly' figurine found beneath the Bell Track.

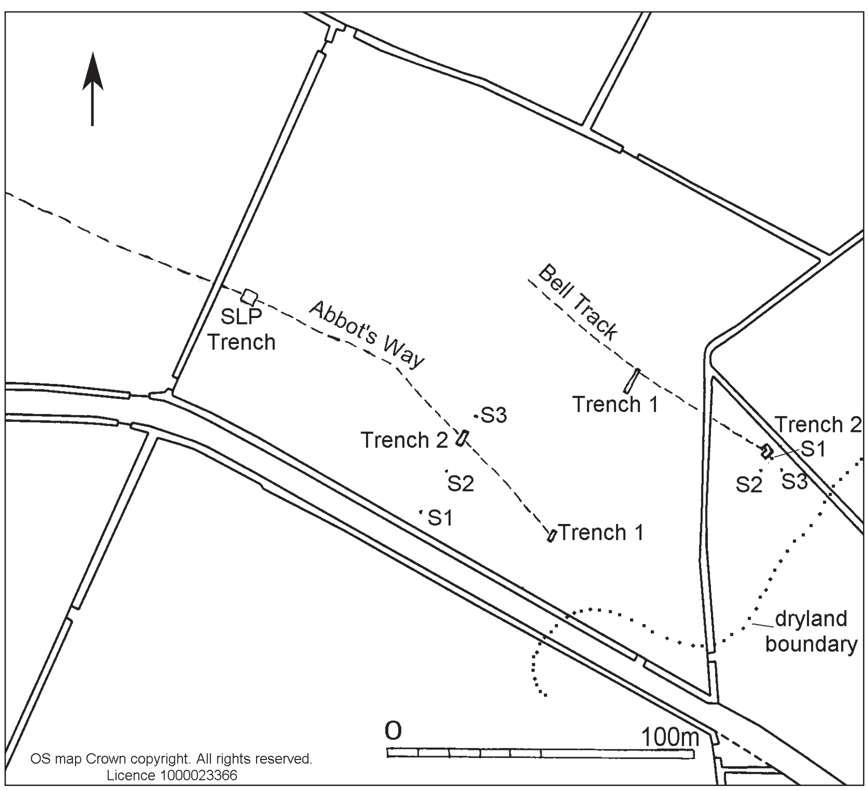


Figure 31. Bell Track and Abbot's Way location map.

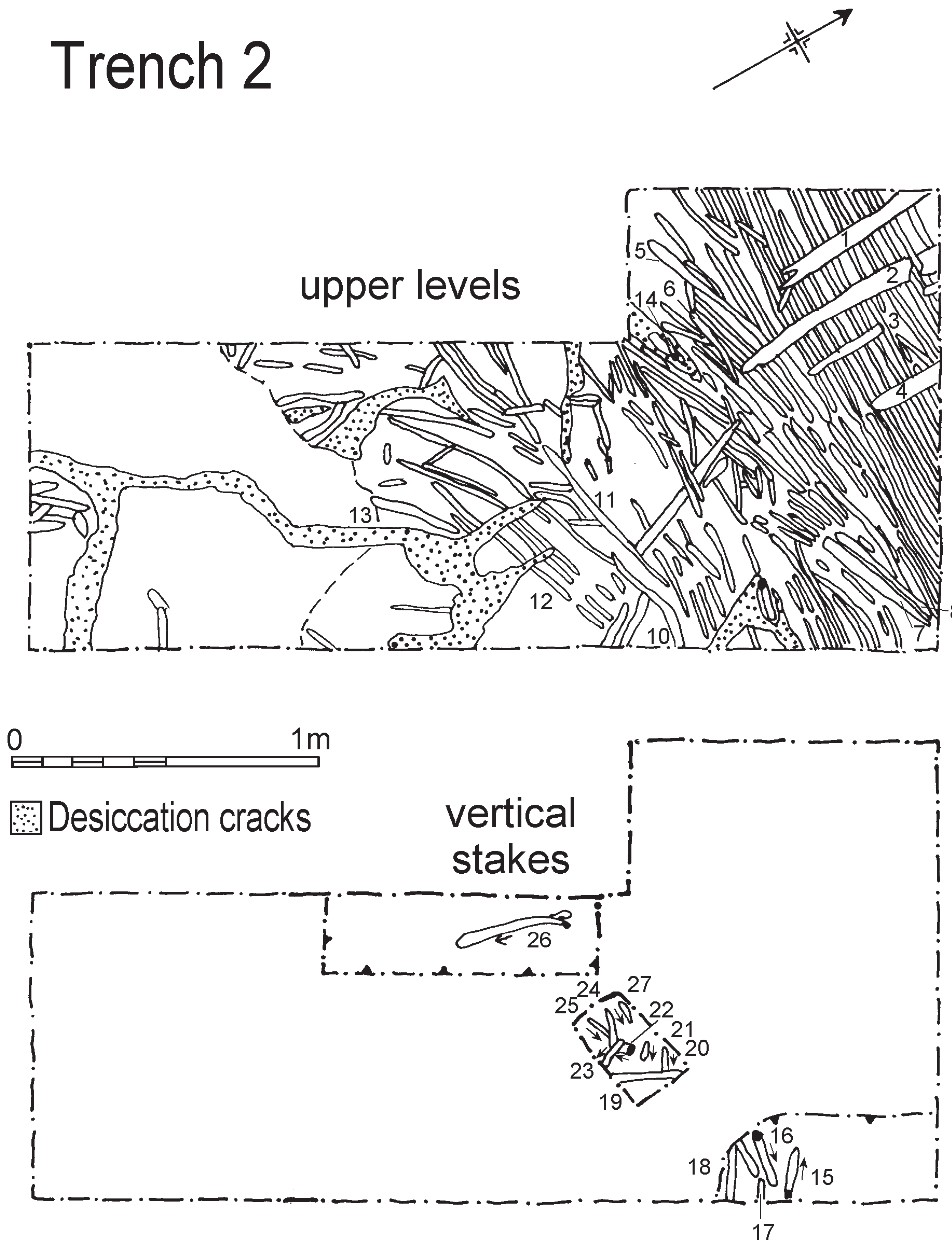


Figure 32. Bell Track trench plan.

after planning. Excavation was carried down to 1m below the ground surface with no evidence of the structure. The trench was therefore abandoned.

Trench 2 was located very close to the reported eastern terminal of the trackway excavated in 1968. It was 3m long across the predicted line of the track and 1m wide, subsequently extended to a width of 1.5m at its northern end. The Bell Track was recorded in the northern half of the trench running at a slight angle across the trackway (Figure 32). The ground surface was at 2.15–2.17m OD and the trackway was encountered between 1.95 and 1.85m OD, a depth of 21–31cm. A partly decayed black plastic sheet directly overlay the wooden remains at a depth of 21–25cm. This had been laid down at the end of the Somerset Levels Project excavations, the material above representing backfill from the excavations that now formed the dry peaty topsoil of the field. The bottom of the vertical stakes extended down to 1.40m OD, a depth of 76cm.

Only the southern edge of the trackway lay within the trench. The main part of the trackway extended across 1.1m of the trench with associated brushwood extending for another metre. The character of the structure corresponded well to that previously recorded in the Somerset Levels Project excavations. A large quantity of brushwood had been neatly laid out along the line of the route. Then a series of four half-split ash timbers had been laid at right angles across the brushwood, presumably to help retain it in position, although there was no evidence of any method of anchoring them in position (Figure 33). The timbers retained their bark and were between 35mm and 70mm in diameter, although these measurements may be distorted by compression.

Along the edge of the trackway were a few dispersed pieces of brushwood and a line of small stakes driven in at a variety of angles. These presumably held the brushwood in place. Eight pieces of brushwood from the southern edge of the structure were examined in detail, six of which were whole roundwood and the other two half split pieces. The brushwood was between 20mm and 50mm in diameter.

The small stakes varied in surviving length from 60mm to 609mm. A total of 10 stakes were recorded from the excavation but many of these were at a slightly lower level and were only seen during the process of extracting some of the other stakes. This suggests that the true density of the stakes is far greater and that the trackway material has spread laterally to cover up some of the stake tops. Five of the stakes were whole roundwood of 20–55mm diameter, four were half split, from stems of 26–33mm diameter, and one was quarter split from a stem c. 30mm in diameter. The stakes were either hazel, alder, willow or poplar, none of them being identifiable to a single species.

Wood species identification

Rowena Gale

A total of 26 samples were taken for species identification. A combination of compression and decay meant that only nine could be identified. Four of these were the split ash timbers (1–4) on top of the structure. All the other five which could be identified were small stakes. Two of these (22 and 26) were identified to one of four species (alder, hazel, willow or poplar), two (17 and 27) were either hazel or alder and the remaining one (16) was ash.

Dating

No radiocarbon dates were taken because several are already available for the trackway. Samples of the small transverse ash timbers were taken for dendrochronological analysis but the very narrow ring widths meant that accurate measurement and dating was not possible (Locatelli pers. comm. 2004).

Palaeoenvironmental analysis

No analysis was undertaken because the previously published work provided sufficient landscape setting for the monument.

Fieldwork conclusion

The excavations have raised a significant question mark over the surviving length of the trackway. The trackway could not be found on its reported line in the field west of the east terminal. As the trackway is significantly older than the Abbot's Way it seems extremely unlikely that it has been destroyed by desiccation while the Abbot's Way still survives (see below). This is supported by the continued existence of the trackway in an easily recognisable form at a shallow depth at the eastern terminal.

As Trench 1 encountered significant deposits of natural fen wood there is the possibility that the coring by the Somerset Levels Project mistook such material for the line of the trackway. This seems unlikely because of the conviction of the trackway identification in the SLP report. It is possible that the trackway runs just north of Trench 1 and still exists within that field and possibly further fields to the west. Further small scale trenching could easily determine if this was the case and could clarify the depth of burial and the route of the structure.

The preservation of the toolmarks on the bottoms of the cut stakes suggests that surface detail is good on wooden material in the lower levels of the structure. This is highly significant because of the possibility that other carved wooden objects might be present in addition to the 'God Dolly' figurine. Such material would be of international importance if it was present.

Bell Tracks assessment and monitoring

Assessment of preservation

Visual assessment of wood

The surface condition of the wood appeared poor, very desiccated and vertically compressed. This is supported by the difficulty experienced in species identifications (see above). Apart from the ash timbers that overlay the brushwood, the only other successful species identifications were derived from the small stakes. They were not in a good condition but were better preserved and less compressed than the horizontal brushwood. Even they could not be identified to a single species however. The toolmarks at the tips of the stakes survived in a generally poor condition, showing signs of desiccation and compression. Desiccation cracks were visible in the peat beside the trackway timbers (Figure 34).

Figure 33. Bell Track during excavation, looking south. Scale 1m.

Detailed examination of wood structure

Mark Jones

Some of the best and worst preserved timbers were found at this site. Table 11 lists the range of moisture content values of each sample. A relatively wide range was observed for ash samples and the condition ranged from slightly degraded to heavily degraded. At this site, the state of degradation of the excavated samples ranged from slightly, medium to heavily degrade. There are also large variations in the degree of degradation within the various ash samples.

Table 12 lists original and present density values. All samples at this site showed decreases in density values indicating loss of original cell wall material. Ash sample density ranged from 0.41 (best preserved) to 0.10 (least preserved).

Samples provided were either slightly degraded (samples 1 and 2) or highly degraded (sample 16, Figure 35). In samples 1 and 2, cells in the outer surface were highly decayed and different stages of degradation apparent. The cells in the core were better preserved with intact secondary wall layers**.** FT-IR analysis of the outer surface suggests a reduction of cellulose content and complete degradation of the hemicellulose component (Figure 36).

Cells in the more decayed ash sample (16, Figure 36) were heavily degraded with extensive attack of the secondary wall layer (S2). The highly degraded timbers (15, 16 and 26) would irreversibly collapse upon drying.

Figure 34. Desiccation cracks visible in excavation, looking north.

Pollen evidence

Heather Tinsley

Samples for assessment were taken below the track at 1.68–1.69m OD, and from the level of the track at 1.93–1.94m OD.

Table 11. Moisture content values and state of degradation.

Timber no.	% Moisture content	Timber condition
1	194	Slightly degraded
2	175	Slightly degraded
9	219	Medium degraded
11	215	Medium degraded
15	640	Heavily degraded
16	903	Heavily degraded
26	1168	Heavily degraded

Table 12. Wood species, % moisture content (MC) and density values.

Timber no.	Wood species	% MC	Original density	Present density
1	Ash	194	0.67	038
2	Ash	175	0.67	0.41
9	No ID	219		0.35
11	No ID	215		0.35
15	No ID	640		0.14
16	Ash	903	0.67	0.10
26	Alder/willow/ poplar/hazel	1168		0.08

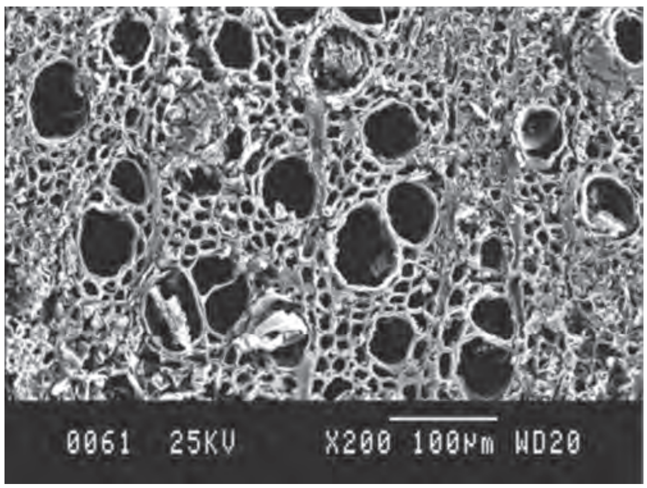


Figure 35. SEM of ancient ash (16).

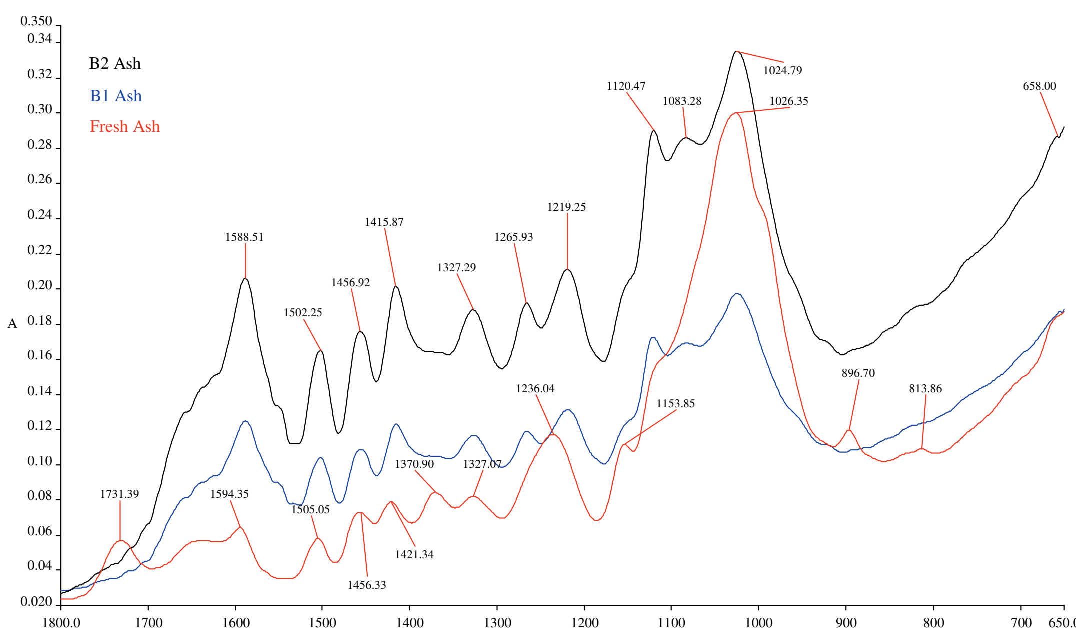


Figure 36. FT-IR spectra of timbers 1, 2 (both ash) and modern ash.

Palaeoenvironmental assessment

1.68–1.69m OD. Tree pollen: 53% TP, principally *Corylus*-type (19%) along with *Betula, Quercus* and *Alnus*, occasional grains of *Pinus* and *Ulmus*. Herbaceous pollen: 47% TP, dominated by Cyperaceae (sedges), with occasional Poaceae (grasses). 122 undifferentiated fern spores with 2 Polypodiaceae (polypody fern). 5 spores of *Sphagnum* and 3 spores of the fungal taxon *Diporotheca.*

1.93–1.94m OD. Tree pollen: 56% TP, dominantly *Corylus*-type and *Alnus*, with some *Quercus* and *Betula* and occasional grains of *Ulmus, Tilia, Salix* (willow) and *Hedera* (ivy). Herbaceous pollen: 44% TP, dominated by Cyperaceae with occasional Poaceae and a single grain of *Calluna*. Very abundant fern spores, 671 undifferentiated, 2 spores of Polypodiaceae, and 1 of *Pteridium aquilinum* (bracken). 4 spores of *Sphagnum*. I spore each of the filamentous algae *Spirogyra* and *Mougeotia.*

Prior to the construction of the track, sedges dominated the local vegetation around this site. The occurrence of occasional bog moss spores suggests the possibility that this was part of a raised bog community. Ferns appear to have been common, as fern spores are very abundant in both samples assessed (though particularly so at 1.93–1.94m OD). Ferns must have grown close to the site as the pollen preparations contain sporangia, some still holding spores, which resulted from the *in situ* decay of fern fronds. Drier land in the wider area supported mixed deciduous woodland. At the level of the track, at 1.93–1.94m, alder appears to have increased in importance and willow was also present; possibly these changes may reflect wetter conditions at the woodland margins; the presence of spores of filamentous green algae at the same horizon indicates that there were some pools of water on the peat surface. Alternatively, alder may have spread onto the peat itself as part of hydroseral succession. Full pollen analysis would be needed to investigate this further.

Pollen preservation

Pollen preservation is not good in the two samples assessed from this site (Table 13). At 1.68–1.69m OD 13% of all grains identified were well preserved. There were 27 indeterminable grains, some of these were amorphous, some showed very severe corrosion and four were mechanically damaged. 38% of all grains identified were poorly preserved, extensive corrosion was particularly apparent on the *Betula* grains, but also affected *Alnus* and *Corylus*-type. 8% of grains were extensively degraded. Partial corrosion affected 12% of grains and a further 25% were partially degraded, particularly the Cyperaceae. However, given the poor condition of the majority of *Betula* grains and some of the *Alnus* and *Corylus*-type, the thin walled Cyperaceae (37% of the sample) were in surprisingly good condition (Plate 15: Appendix 3). Mechanical damage affected 17% of all pollen grains. The biochemical preservation index was 1.60 and the mechanical preservation index was 0.33. Quite a number of the fern spores were split and broken. Only occasional spores showed etching of the surface.

Table 13. Bell Track: Summary of pollen preservation.

	1.68–1.69m OD	1.93–1.94m OD
Total identified pollen grains	100	100
Pollen concentration	96,200	89,700
Number of pollen taxa	8	11
Total indeterminable grains	27	7
Total identified extensively corroded grains (a)	27	19
Total identified extensively degraded grains (b)	8	10
Total identified extensively crumpled grains (c)	1	
Total identified extensively broken grains (d)	2	1
Total identified grains with poor preservation (a+b+c+d)	38	30
Total well-preserved grains	13	21
Total grains of resistant taxa	0	1
Total ferns	124	674
Biochemical preservation index	1.6	1.52
Mechanical preservation index	0.33	0.35

Preservation was slightly better at 1.93–1.94m OD, 21% of grains were well preserved and there were only seven indeterminable grains, four of which were amorphous, the others were mechanically damaged. 30% of grains were poorly preserved, mostly due to extensive corrosion. Partial corrosion affected 19% of all grains and partial degradation was observed in 24% of grains. Mechanical damage affected 17% of all grains. The biochemical preservation index was 1.52 and the mechanical preservation index was 0.35. About 25% of all fern spores were mechanically damaged, and some were also etched.

The variation in preservation characteristics between these two samples was not great, apart from the number of indeterminable grains that was much higher at 1.68–1.69m OD. The difference in the pollen preservation indices (which are based solely on the characteristics of the identifiable grains) is not significant. Extensive corrosion of the pollen taxa with smooth exines, such as *Betula, Alnus* and *Corylus*-type was marked in the lower sample at 1.68–1.69m OD; with *Betula* particularly susceptible (Plate 16: Appendix 3), partially corroded grains were more frequent at 1.93–1.94m OD. Surprisingly, corrosion accounts for only six of the 24 indeterminable grains at 1.68–1.69m OD. However, it is difficult to be certain of the deterioration type in grains which are very badly preserved; possibly some of those classified as amorphous at 1.68–1.69m OD were in fact corroded to the point where little of the exine was left. It is not clear why corrosion should have been more intense lower down the stratigraphic sequence at this site: it had been expected from examination of the stratigraphy in the field that the lower peat would show better preservation than that from the level of the track. Both these samples contained large numbers of fern spores (undifferentiated) – 122 were recorded at 1.69–1.69m OD and 671 at 1.93–1.94m OD. In certain circumstances of poor pollen preservation such high fern frequencies have been linked to differential accumulation of the relatively more resistant spores, as pollen is destroyed (Dimbleby 1985; Bunting and Tipping 2000). This may partially account for the high frequencies of spores in the Bell Track samples, but it is not the whole story, as the presence of the sporangia in the pollen preparations indicates.

In terms of the potential for full pollen analysis, the sample from 1.68–1.69m OD must be regarded as marginal on account of the relatively high number of indeterminable grains which form 22% TP + indeterminables and the poor pollen preservation. These features clearly indicate the likelihood of bias in the assemblage, with less robust taxa having been differentially lost. The sample from 1.93–1.94m OD has far fewer indeterminable grains but is probably still of only marginal value on account of the poor pollen preservation. The presence of the surprisingly well-preserved sedge pollen at 1.68–1.69m OD could indicate some contamination of this sample by pollen originating higher in the stratigraphy, or indeed at the ground surface. However, there are other possible explanations, the main deterioration process which has affected this sample is corrosion, and sedge pollen may be less susceptible to this than some of the tree pollen taxa. The differing predepositional histories of sedge and tree pollen could also be involved, sedge pollen is released close to the ground and can potentially be immediately incorporated into accumulating peat, whereas tree pollen is released from the canopy and reaches peat bogs following wind dispersal.

Plant macrofossils

Julie Jones

Two bulk samples were taken, one from the level of the trackway (1.91–1.96m OD) and one from the well humified-fibrous peat below (1.66–1.71m OD) (Tables 14–17).

Palaeoenvironment

A rather limited assemblage from the peat below the trackway is dominated by the bracts and seeds of birch (*Betula*), with several well preserved examples indicating the presence of downy birch forming a wooded environment with alder (*Alnus glutinosa*). Both alder and downy birch prefer damp peaty soils and are likely to have grown in a wet carr environment with greater tussock sedge (*Carex paniculata*) and great fen-sedge (*Cladium mariscus*), also present.

The sample from the level of the track (1.91–1.96m OD) suggests similar environmental conditions although only birch and sedge (*Carex* spp.) were recovered.

Preservation

1.66–1.71m OD: The sample float obtained from the peat below the track was primarily composed of wood fragments, presumably relating to the birch macrofossils that form the bulk of seeds and fruits assessed. Birch fruits are flattened with two protruding stigmas and translucent wings and it is the preservation of these wings that is necessary to determine the species. In *Betula pubescens* (Figures 4 and 5; Appendix 4) each wing is 1–1.5 times as wide as the body, with the wings not extending beyond the stigmas at the apex of the body; only two fruits were identified as *Betula pubescens*. In most fruits no wings were preserved, although the bodies were complete with the stigmas retained. These have been recorded as <25% fragmented and have been

Table 14. Bell Track: stratigraphy.

Stratigraphy	Plant macrofossil/ beetle samples
2.02–2.09m OD Non-stratified peat (1968 backfill). Modern roots, worms. Polythene membrane at base.	
1.96–2.02m OD Dark brown, dry, very well humified and compacted peat. Level of top of trackway wood at 1.96m OD.	1.91–1.96m
1.93–1.96m OD Dark brown, dry very well humified compacted peat with abundant wood remains	
1.59–1.96m OD Dark brown well humified fibrous peat, gradually becoming less well humified with more obvious plant remains and frequent wood fragments and compressed bark. Occasional roots to 1.9m OD	1.66–1.71m

determined as *Betula* sp. Most of the few birch bracts recorded were >50% fragmented.

It was possible to distinguish greater tussock-sedge from the irregular lozenge-shaped fruits, which were mostly entire and with little erosion of the surface cell structure. Complete examples of great fen-sedge and alder were also recorded.

Preservation index 1.93. Seven taxa in 100 counted. Analysis not recommended

1.91–1.96m OD: The sample at the level of the track contained few wood fragments, with approximately 60% of the float consisting of small lumps of sediment. Only 29 macrofossils, representing three taxa, were recorded from here, all retained on the 0.5mm mesh. Most of these were greater tussock-sedge, although in contrast to the sample below the track these showed a greater degree of fragmentation, 68% being <25–50% fragmented, with evidence of deterioration of the fruit epidermis. None of the birch fruits preserved wings and are therefore recorded as *Betula* sp. All examples were fragmented and abraded to some degree.

Preservation index 3.24. Three taxa in 29 counted. Analysis not recommended

Table 15. Bell Track: plant macrofossil preservation.

Peat below trackway								
		Fragmentation				**Erosion**		
1.66–1.71m OD (38–43cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alnus glutinosa	2	1	1	0	0	1	0	0
Betula pubescens	2	2	0	0	0	0	0	0
Betula sp. (seed)	73	0	41	26	6	0	4	9
Betula sp. (bract)	6	0	0	1	5	0	6	0
Carex paniculata	14	9	4	0	1	6	1	1
Carex sp.	1	0	1	0	0	0	0	0
Cladium mariscus	1	1	0	0	0	0	0	0
Poaceae indet	2	1	1	0	0	0	0	0
Level of trackway								
1.91–1.96m OD (13–18cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula sp. (seed)	7	0	2	4	1	2	4	1
Carex paniculata	19	2	8	5	4	5	6	2
Carex spp.	3	0	0	0	3	1	1	1
Other macrofossils: abundant wood fragments, occasional leaf abscission pads, buds, and charcoal								

Table 16. Bell Track: summary macrofossil table.

	1.66–1.71m OD	**1.91–1.96m OD**
Total macrofossils counted	100	29
Estimated total in sample	120	29
Total taxa	7	3
Total well preserved	14	2
Total <25% fragmented	47	10
Total 25–50% fragmented	27	9
Total >50% fragmented	12	8
Total <25% erosion	7	8
Total 25–50% erosion	11	11
Total >50% erosion	10	4
Preservation index	**1.93**	**3.24**

Table 17. Bell Track: Properties of 250g unprocessed samples.

	Dry weight	**0.25mm**	**0.5mm**	**1mm**	**2mm**	**Organic matter %**
1.66–1.71m OD	65.74g	7.1g	7.3g	6.5g	6.3g	42%
1.91–1.96m OD	88.02g	8.5g	13.9g	5.2g	4.7g	37%

Recommendations

This trackway lay close to the contemporary ground surface in dry, compacted, well-humified peat and had been covered by a polythene membrane since it was last exposed in 1968. A fairly restricted assemblage was recovered especially from the peat at the level of the trackway. Much of the deterioration to the birch fruits in the peat below the trackway resulted in the loss of the delicate wings with only the stigmas remaining although identification of a few better preserved examples was possible. As with the Abbot's Way processing of larger samples would increase counts and probably the number of taxa recovered and the quality of preservation seen here would allow identification of much of this material. It seems unlikely however that fuller interpretation of the environment would be possible and therefore full analysis is not recommended.

Coleoptera

Harry Kenward

Two samples were taken, one from the level of the trackway (1.91–1.96m OD) and one from 25–30cm below the top of the track (1.66–1.71m OD). Insects in the upper sampled layer ranged from fairly to very decayed (E 3.5–5.5), and some were very fragmented (to F 5.0); in each case the mode fell at 4.0, indicating fossils mostly in poor condition (Tables 18–19). This layer also yielded some rather shrivelled remains, and overall the evidence suggests recent damage in this 'very well humified compacted peat with abundant wood remains', the wood perhaps contributing to a variable regime which promoted decay, and perhaps hinting at a greater opportunity for decay during deposit formation. The lower sample gave quite well preserved to rather decayed remains.

Monitoring of the burial environment

David Hogan

Site description

Transect: Station 1 at 5m from ditch (by excavation, within liner), Station 2 at 10m (beyond the liner) and Station 3 at 5m from Station 1 parallel to ditch (Figure 31).

Land use: Permanent pasture of mesotrophic grassland, grazed by sheep at time of visit. Molehills in field. The site is close to a fenced-off field corner, which has willow scrub, tufted hair-grass tussocks and stinging nettle.

Station 1 (Table 20). Instrumentation: piezometers at 40cm (not penetrating the liner) and 100cm depth. Redox probes at 15cm, 25cm and 40cm depth. Water table at 38cm depth in auger hole. Arrangement of covers is to try and offset the effects of local slope changes.

Table 18. Bell Track: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
1.91–1.96	Small flot, woody and herbaceous detritus. Aquatics and damp ground taxa, with a few suggesting drier conditions. Wood associated taxa present (*Anobium* sp. and a rhyncholine weevil). Clearly more terrestrial than most assemblages examined here.	A large sub-sample would probably give a useful and interesting group, though some identifications would be difficult. P1B
1.66–1.71	Flot small, with crumbs of organic sediment, ?rhizome fragments, moss leaves. Few insects: aquatics and swamp-tolerant forms.	Very large sub-sample (>5kg) would give just usable group, but very difficult to identify and a large proportion beyond identification. P3

Table 19. Bell Track: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical erosion				Fragmentation				Colour change					Other properties
	range		mode	str	range		mode	str	To	range		mode	str	
1.91–1.96	3.5	5.5	4.0	W	2.5	5.0	4.0	W	Pale	1	3	2	W	Some rather shrivelled fossils; ?dried in ground at some stage
1.66–1.71	2.0	4.0	3.0	W	2.5	4.0	3.0	W	–	–	–	–	–	

Table 20. Bell Track: Station 1.

Depth (cm)	Description
0–25	Dark reddish brown (5YR 2/2) slightly moist, crumbly loamy peat
25–40	Dark reddish brown (5YR 2/2) moist loamy peat with wood (remains); liner at 40cm
40–82	Dark reddish brown (5YR 3/2), darkens rapidly on exposure, waterlogged amorphous peat (H8) with roots and a few leaves; woody remains at 70cm
82–100	Dark reddish brown (5YR 3/2) to brown to dark brown (7.5YR 4/4) waterlogged semi-fibrous grass-sedge peat with small twigs

Table 21. Bell Track: Station 2.

Depth (cm)	Description
0–15	Dark reddish brown (5YR 2/2) slightly moist, crumbly loamy peat
15–40	Dark reddish brown (5YR 3/2) moist, firm loamy peat; liner at 35cm; becoming wetter below 40cm depth, ie below liner
40–67	Dark reddish brown (5YR 3/2) wet firm amorphous grass-sedge peat (H7)
67–170	Dark reddish brown (5YR 3/4) waterlogged semi-fibrous grass-sedge peat (H5) with prominent *Typha* remains and becoming woody below 140cm

Table 22. Bell Track: Station 3.

depth (cm)	Description
0–15	Dark reddish brown (5YR 2/2) slightly moist, crumbly loamy peat
15–35	Very dark grey to dark grey (5YR 4–5/1) loamy peat with common fine mottles of yellowish red (5YR 4/6)
35–50	Black (5YR 2/1) wet loamy peat
50–90	Black (5YR 2/1) waterlogged amorphous grass-sedge peat (H7) with some soft wood.
90–150+	Dark reddish brown (5YR 3/2) semi-fibrous woody grass-sedge peat (H5) with occasional *Typha* remains

Station 2. (Table 21). Instrumentation: piezometers at 50cm and 100cm depth. Arrangement of covers is to try and offset the effects of local slope changes.

Station 3 (Table 22). Instrumentation: piezometers at 50cm and 100cm depth. Water table at 45cm depth in auger hole.

Results

The organic remains occur at shallow depth, within 20–30cm of the ground surface, while the water table fluctuates at greater depth (Figure 37). In winter it rises to the base of the remains, but falls from April to reach a maximum depth of around 100cm below the surface in September at all stations (Figures 37, 39 and 40). Redox potential (Figure 38) indicates predominantly *oxidised* or occasionally *slightly reduced* conditions both above and below the level of the archaeology throughout the year. *Highly reduced* conditions were limited to early spring (at 40cm depth), and a single record at the end of June at shallow depth, which may have been the result of a rainfall event. The pH of the groundwater taken from the piezometers beside the trackway was 7.1, which was the same as samples from the ditch at the northern edge of the field.

Conclusions

The water table remains permanently below the level of the archaeology, leading to a failure to establish the anoxic conditions necessary for the preservation of the archaeology. There are no prospects for preservation of organic materials under current environmental conditions.

Preservation Conclusion

The survival of the trackway is surprising because of its shallow depth below the ground surface and because the summer water table has dropped below the level of the trackway, probably for many decades. The reasons why organic remains can survive such seasonal desiccation and associated aerobic conditions deserve further investigation. The available information on the burial environment suggests that the trackway should be at high risk from desiccation. Its somewhat surprising survival to date does not necessarily mean that it will remains in the same state of preservation over the short term.

2. Abbot's Way fieldwork

HER 23789: SM 27990 and 27992

Previous fieldwork

The Abbot's Way was first discovered in 1834 and was given its name because it was considered to be a creation of the Abbot of Glastonbury to join up his landholdings. The tenant of Honeygar Farm uncovered a small section in 1864 for a visit by the Somerset Archaeological and Natural History Society and again in 1873 when Mr C. W. Dymond made a careful record of the structure including a cross section and a reconstruction drawing

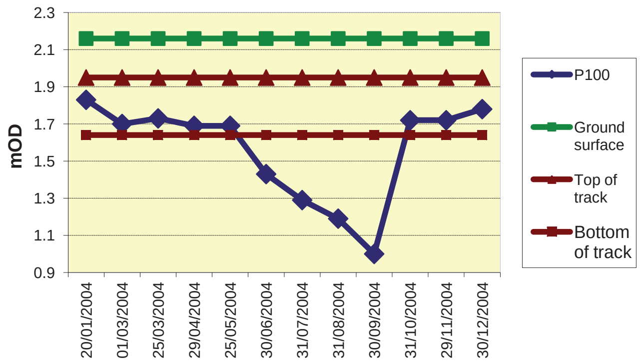


Figure 37. Water table at Station 1.

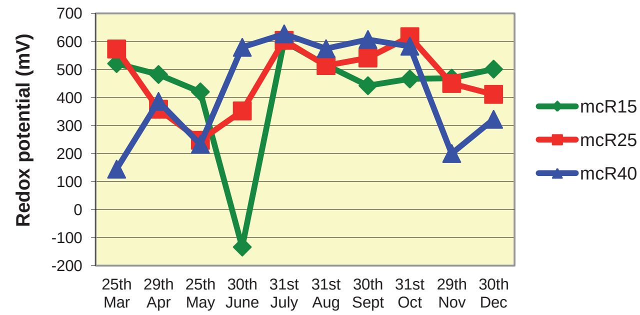


Figure 38. Redox potential at Station 1.

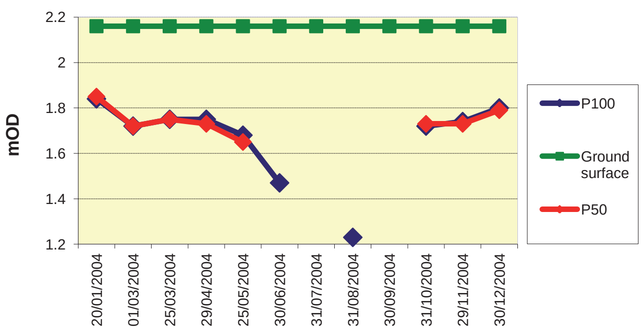


Figure 39. Water table at Station 2.

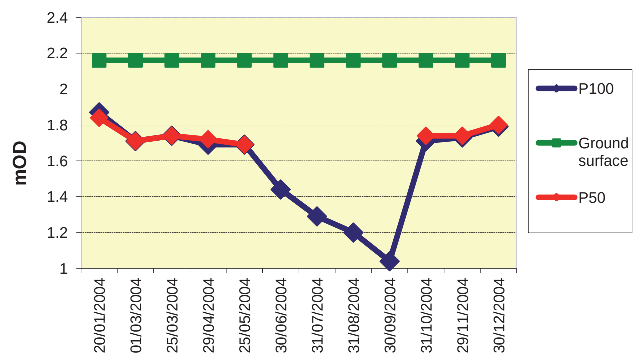


Figure 40. Water table Station 3.

(Dymond 1880). Bulleid mentions a further exposure in 1883 (Bulleid 1933), but after this no further records of the trackway were made until Prof. H. Godwin obtained dating samples from exposures in peat cuttings.

The threat from peat extraction led to the first large scale excavation in 1964 and the trackway was traced over a distance of 1100m using a 6 inch post-holing machine (Coles and Hibbert 1968). The Somerset Levels Project excavated other sections in 1974 and 1979 (Coles and Orme 1976b; Coles 1980) (Figure 41). Since then the only intervention has been a minor examination of the condition of the trackway in one field (Cox *et al.* 1992).

The structure is a corduroy log track that crossed an area of raised bog between Westhay and Burtle islands (Figure 28). The trackway can be dated to 2620–2300 cal BC on the combined results of four radiocarbon measurements (GaK-1940, 4040±90 BP; Q-926, 4018±80 BP; Lu-298, 3940±65 BP; BM-386, 3934±111 BP).

The track was formed of transverse logs 1.1–2m wide, with pegs at the edges spaced 0.5–1.1m apart. The logs were overwhelmingly (88 out of 92) alder timbers that had been tangentially or radially split or boxed (cut flat on four sides). Some had carefully squared edges and flattened surfaces. The dimensions of the logs varied from 1–2m in length, 70–300mm in width, and thickness up to 150mm. The pegs were 25–80mm in diameter and 225–880mm long, and were 50% hazel, 29% alder, 19% ash and 2% willow although they are described as universally birch by Dymond (1880) and Coles and Hibbert (1968). Some small birch roundwood, 30–40mm in diameter, was woven in and out of the pegs in places forming a slightly raised lip to the structure. Transverse roundwood (66% alder, 21% hazel, 8% ash, 3% oak and 2% elm), 70–100mm in diameter, was used as packing and for repairs in some places. The packing also includes smaller offcuts and slats of alder 380–950mm long.

It is thought that the trackway originally connected the islands of Burtle and Westhay over a distance of 2560 m. All the eastern half of the trackway has been lost to peat cutting as has other short stretches to the east. The trackway is most deeply buried in a Scheduled field surrounded by peat former extraction areas. The eastern section is not deeply buried and may no longer exist in two ploughed fields. The eastern terminal is a pasture field and this was chosen as the site for the assessment as it was hoped that it would survive better there than in the adjoining arable fields.

Figure 41. Excavation of the Abbot's Way by the Somerset Levels Project.

MARISP excavation results

Two trenches were excavated across the line of the trackway (Figures 31 and 42). Trench 1 was 4m by 1m in size and revealed the very desiccated remains of the structure in black well humified peat at just 27cm below ground level, immediately under the organic clay topsoil. The remains consisted of five fragments of planks laid across the line of the trackway. The extremely poor condition of the trackway in this trench is probably partly due to the fact that it was approaching the dryland terminal of the structure. The top of the horizontal wood was at 1.96m OD and the ground surface at 2.23m OD.

Trench 2 was 6m by 1m in size, the trackway structure being present at a depth of 25–30cm below ground in black well humified peat underneath 20cm of organic clay topsoil. The top of the horizontal wood was between 1.89–1.96m OD and the top of one of the stakes at 1.91m OD. The ground surface varied between 2.19 and 2.26m OD.

The structure in Trench 2 consisted of split alder logs, laid transversely across the trackway and held in place with three small stakes on one side (Figure 43). The logs were radially split into half, third or quarter logs of *c.* 30mm by 45mm in width and height and between 630mm and over 890mm in length. The dimensions were affected by both compression and desiccation. The stakes were all roundwood with simple chisel shaped points. Two of the stakes were 352mm and 360mm long and 30mm in diameter, but the third was shorter (80mm) and smaller (16mm in diameter). The two larger stakes were both badly buckled at the top. This suggests that they were driven in 'green' and that when their tips encountered a compact woody layer in the peat they failed to penetrate further but instead their tops buckled, unbeknown to the person hammering the top. This suggests that the original tops of the stakes were significantly higher than their excavated position, otherwise the buckling would have been apparent to the person hitting the stakes in.

Wood species identification

Rowena Gale

Four samples were taken from Trench 1 and six from trench 2. Two of the samples from trench 1 and three of the samples from Trench 2 were too degraded for species identification. Three of the timbers (7, 8 and 9) from Trench 2 could be identified as alder (*Alnus glutinosa*) and two timbers from Trench 1 (1 and 4) and timber 6 from Trench 2 were so poorly preserved that they could only be identified to one of four possible species, alder (*Alnus glutinosa*), hazel (*Corylus avellana*), willow (*Salix* sp.) or poplar (*Populus* sp.).

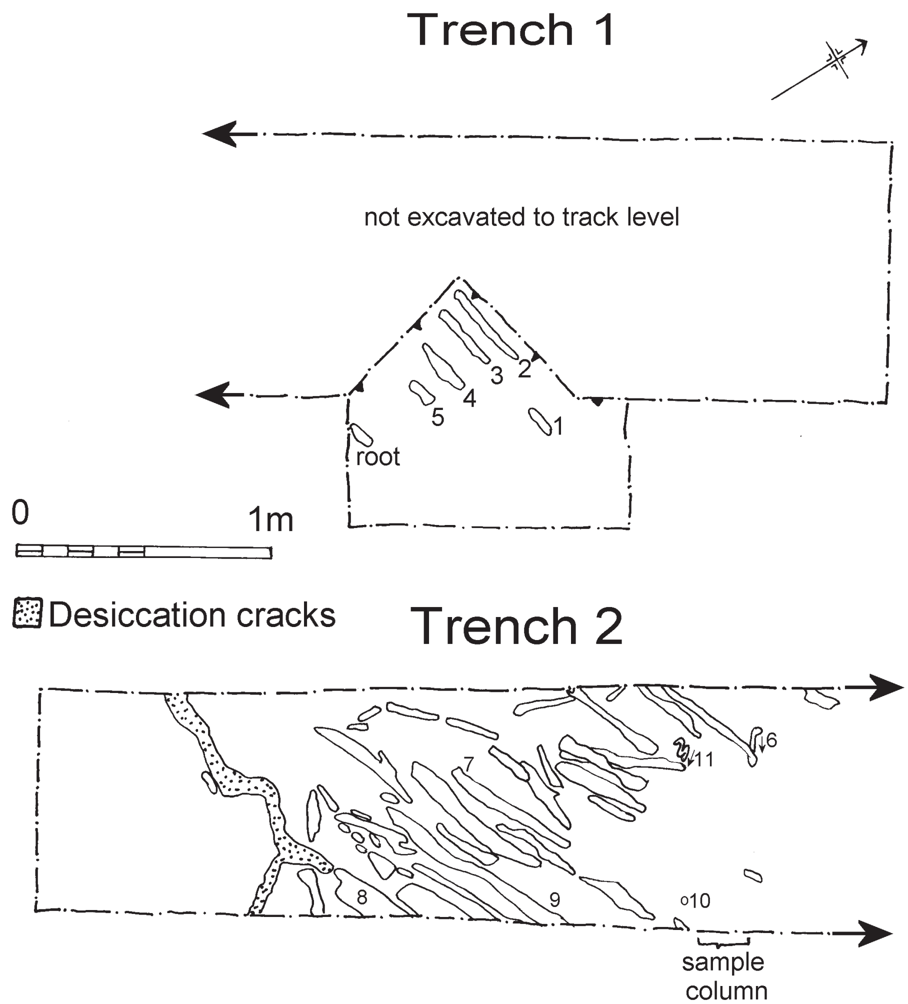


Figure 42. Abbots Way trench plans.

Figure 43. Excavation of Abbot's Way, Trench 2, looking west. Scales 1m.

Fieldwork conclusion

The excavations clarified the line of the trackway at its eastern terminal where it bends southwards to meet a spur of hard geology projecting from the west side of Westhay Island. The species identifications and wood character are consistent with the findings of previous investigations of the structure. The poor condition of the wood means that the potential for toolmark analysis is now very low in this field. Despite the threat to the survival of the monument, further rescue excavation is unlikely to answer significant research questions using currently available techniques.

Abbot's Way assessment and monitoring

Assessment of preservation

Visual assessment of wood

The visual condition of the horizontal wood was very poor. All the material had clearly suffered from shrinkage and cracking associated with desiccation. Surface detail was lacking on all the horizontal elements and the toolmark preservation on the stakes was also very poor.

Detailed examination of wood structure

Mark Jones

Table 23 lists the range of moisture content values of each sample. All alder samples have moisture content above 400%. Based upon moisture content values, timber sample 4 is of medium degrade, the rest are classified as heavily degrade type.

Table 24 lists original and present density values. Density values for timbers samples range from 0.26 to 0.11. These low values indicate considerable loss of original cell wall material.

With the exception of sample 4 (medium degrade), all other timber samples were highly degraded. The secondary cell wall (S_2) was highly deteriorated and had become detached from the middle lamella. Fungal hyphae have been observed in alder timber sample 7 (Figure 44). Evidence of wood decay patterns associated with fungi was not obtained. The remaining porous nature of the secondary wall layer suggests bacterial rather than fungal attack.

FT-IR analysis (Figure 45) elaborates this picture of decay. Both hemicellulose and cellulose components have been degraded by microbes leaving a network of lignin. Condition of wood found at Abbot's Way track would irreversibly collapse upon drying.

Pollen evidence

Heather Tinsley

Palaeoenvironment

Samples for assessment were taken from well-humified peat at 1.75–1.76 m OD, 0.07m below the track, and from the level of the track at 1.85–1.86m OD in Trench 2.

1.75–1.76m OD, 1.85–1.86m OD. Tree pollen: 74–83% TP, dominantly *Corylus*-type (hazel), (53–54% TP) with some *Quercus* (oak) and *Alnus* (alder) and occasional grains of *Pinus* (pine), *Fraxinus* (ash), *Ulmus* (elm), *Tilia* (lime), and *Betula* (birch). Herbaceous pollen: 17–26% TP, principally *Calluna vulgaris* (heather) with occasional grains of *Vaccinium*-type (heaths and bilberry), Cyperaceae (sedges) and Fabaceae (pea family). 6–19 spores of *Sphagnum* (bog moss) and occasional spores of the fungus *Tilletia sphagni* which parasitises *Sphagnum*.

Prior to the construction of the track, when the peat at 1.75–1.76m OD was forming, the assessment suggests that the local environment was raised bog, with heather growing on drier hummocks and bog moss and cotton grass (a member of the sedge family) occupying wetter hollows. There appears to have been mixed deciduous woodland with an extensive understorey of hazel on the drier ground. This is in good agreement with the interpretation based on full analysis by Beckett and Hibbert (1976), from a different location on the Abbot's Way, and with the unpublished assessment data of West and Straker (pers. comm.). The presence of occasional fragments of microscopic charcoal in the

Table 23. Abbot's Way: moisture content values and state of degradation.

Timber no.	% Moisture Content	Timber condition
4	316	Medium degraded
6	613	Heavily degraded
7	403	Heavily degraded
8	418	Heavily degraded
9	415	Heavily degraded
11	773	Heavily degraded

Table 24. Abbot's Way: wood species, % moisture content (MC) and density values.

Timber no.	Wood species	% MC	Original density	Present density
4	No ID	316		0.26
6	No ID	613		0.14
7	Alder	403	0.48	0.21
8	Alder	418	0.48	0.2
9	Alder	415	0.48	0.2
11	NoID	773		0.11

pollen preparations suggests some human presence in the wider area. These communities appear to have persisted with little change during the period of track construction and use.

Pollen preservation

At 1.75–1.76m OD pollen preservation was excellent, with 86% of grains well preserved (Table 25). There were 5 indeterminable grains, but these were mainly physically damaged rather than corroded or degraded. Only 2% of grains identified were poorly preserved, one due to extensive corrosion and one to physical damage.

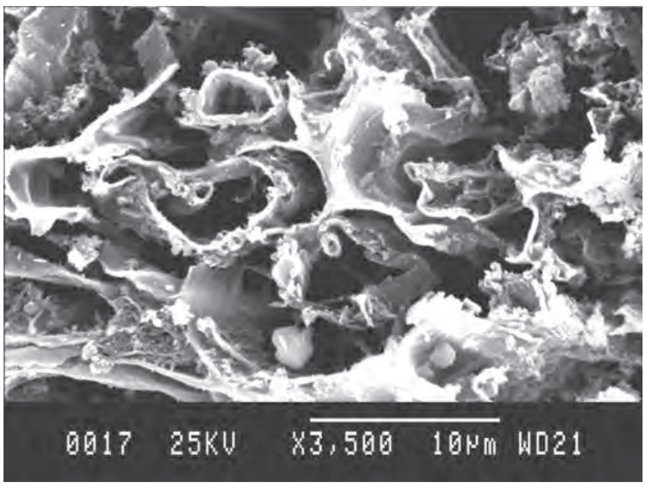


Figure 44. SEM of ancient alder (7).

Partial corrosion and degradation were very limited. The biochemical preservation index was 0.17 and the mechanical preservation index was 0.14.

Higher in the stratigraphy, at 1.85–1.86m OD, pollen preservation had deteriorated a little, only 67% of grains were well-preserved. There were 2 indeterminable grains and 15% of identified grains were poorly preserved, largely due to extensive corrosion of susceptible *Corylus*-type grains. Partial corrosion affected 8% of grains identified. The biochemical preservation index was 0.54 and the mechanical preservation index was 0.21.

The pollen preservation at 1.85–1.86m OD is good, and at 1.75–1.76m OD it is excellent, with the second lowest biochemical and mechanical preservation indices found in all the MARISP samples. These results were unexpected and belie the appearance of the peat in the excavated section, which looked dry and well humified at the levels sampled. In this condition, poor preservation as a result of active biological and chemical oxidation would not have been surprising. In fact, corrosion due to biochemical activity is the commonest deterioration type seen in both these samples but this has not progressed to the extent where significant numbers of pollen grains are affected. It is possible that the layer of clay, which seals the peat and forms the topsoil at the ground surface, has protected the sediments below from excessive oxidation. Comparison with the data of West and Straker (pers. comm.), from the Abbot's Way close to Godwin's Peat Factory, where birch trees have been planted on the peat, suggests that preservation of pollen is better at the MARISP location.

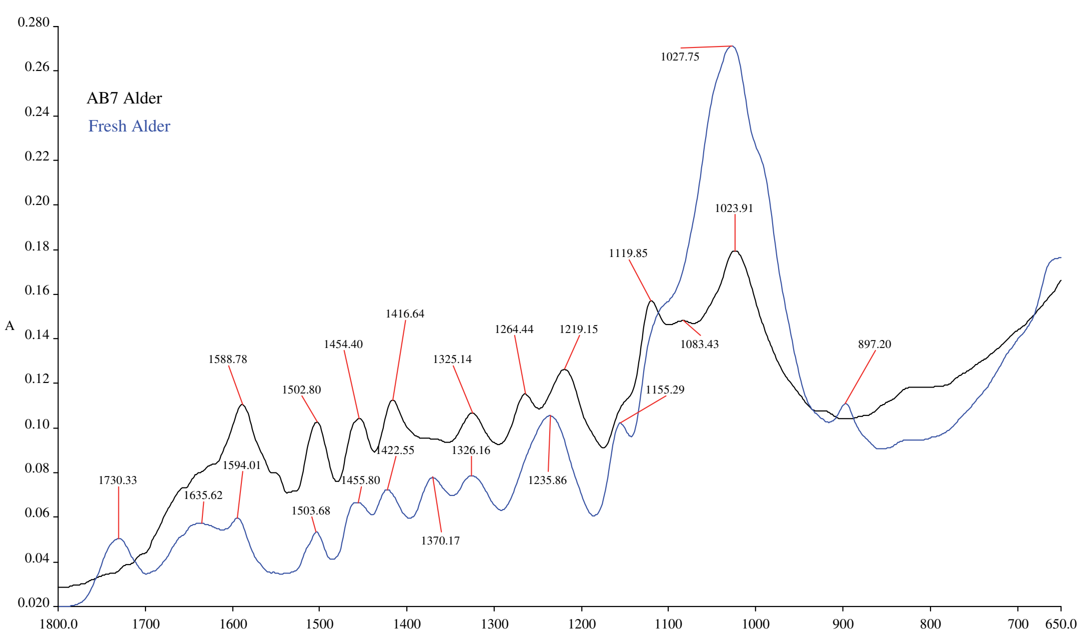


Figure 45. FT-IR spectra of timber 7 (alder) and modern alder.

Table 25. Abbot's Way pollen preservation summary.

	1.75–76m OD	**1.85–1.86m OD**
Total identified pollen grains	100	100
Pollen concentration	464,000	185,000
Number of pollen taxa	11	9
Total indeterminable grains	5	2
Total identified extensively corroded grains (a)	1	13
Total identified extensively degraded grains (b)	0	1
Total identified extensively crumpled grains (c)	0	0
Total identified extensively broken grains (d)	1	1
Total identified grains with poor preservation (a+b+c+d)	2	15
Total well-preserved grains	86	67
Total grains of resistant taxa	1	0
Total ferns	0	1
Biochemical preservation index	0.17	0.54
Mechanical preservation index	0.14	0.21

These samples have the potential for full pollen analysis, this could be undertaken with confidence, and the samples are unlikely to show any bias due to differential preservation. The MARISP samples show no evidence of contamination by modern pollen, in contrast to the situation found by West and Straker (pers. comm.) at their sites.

Plant macrofossils

Julie Jones

One sample (1.83–1.88m OD) spanned the depth of the trackway with a second sample (1.73–1.78m OD) from the peat below the trackway (Table 26). The results are shown in Tables 27–29.

Palaeoenvironment

Both the samples were dominated by remains of heather (*Calluna vulgaris*) in the form of small twigs, seeds, occasional flowers and leaves. The diagnostic sclerenchymatous spindles from the leaf bases of hare's-tail cottongrass (*Eriophorum vaginatum*) indicate the presence of this tussock-forming species. There were also individual leaves and frequent capsule lids of *Sphagnum* (bog-moss). A community typical of heathland or a drier habitat within a raised bog is suggested. Hare's-tail cottongrass is not typical of the wettest habitats within raised bogs, being an important tussock builder and together with heather is often restricted to better drained situations such as hummock tops. *Sphagnum* is able to exploit a wide range of habitats and may have formed clumps on the drier hummocks or could have grown submerged in pools in the bog.

Preservation

Between 50% and 95% of the floats from the individual sieve fractions comprised unbroken down sediment, suggesting a high degree of humification and a relatively low organic content (37% and 24%) in the two samples examined. Both species diversity and abundance is low with only two taxa recorded in the assessment count. A count of 100 individuals was possible from both samples, although this was mostly restricted to heather seeds, with occasional dried capsules from heather flowers. Other macrofossils recorded include small woody fragments and twigs of heather, with its distinctive wrinkled bark, sclerenchymatous spindles of hare's-tail cottongrass and individual leaves and capsule lids of *Sphagnum*. The *Eriophorum* spindles form elongated aggregates of woody tissue and are seen as the last stages of disintegration of the fibrous leaf bases of this tussock-forming plant (Godwin 1956).

Calluna vulgaris seeds (Figures 6 and 7: Appendix 4) are small, *c*. 0.5 × 0.3mm, elliptic in outline, rounded at one end and somewhat truncated at the other. They appear to be relatively delicate, although in both samples a good proportion of seeds were entire; 28% from the level of the track and 31% from the peat below the track. Approximately 15% from both samples were >50% fragmented. The epidermis cells are relatively large and of elongate shape. In a high proportion of the seeds examined the cell patterning was not clear; 86–91% showing some degree of damage to this epidermal layer. The *Calluna* flowers appeared to represent the dried capsules which succeed the flowers and which contain the vast quantities of seeds which heather produces. The few recorded examples were in a fragmented state; those still preserving traces

Table 26. Abbot's Way: stratigraphy.

Stratigraphy	Plant macrofossil/ beetle samples
1.69–1.95m OD Black, very well humified, dry compact peat. Patches of fibrous material in places. Modern roots frequent. Woody fragments at the level of the trackway (1.83–1.88m OD) Gradual boundary	1.83–1.88 1.73–1.78
1.45–1.69m OD Dark brown peat, becoming increasingly less humified, more fibrous and wetter towards base. *Eriophorum* peat below this level.	

Table 27. Abbot's Way: plant macrofossil preservation.

Peat below trackway								
		Fragmentation				**Erosion**		
1.73–1.78m OD (17–22cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Calluna vulgaris (seed)	93	29	39	14	11	40	34	6
Calluna vulgaris (flower)	7	0	0	2	5	0	0	0
Other macrofossils: wood/twig frags ? frequent *Calluna*, *Eriophorum* spindles, rare *Calluna* leaf, occsional *Sphagnum* leaves and capsule lids, charcoal, and modern roots								
Level of trackway								
1.83–1.88m OD (7–12cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Calluna vulgaris (seed)	97	27	47	9	14	32	40	16
Calluna vulgaris (flower)	1	0	0	1	0	0	1	0
Carex spp.	2	0	1	0	1	0	1	0
Other macrofossils: wood/twig frags ? *Calluna*, occassional *Eriophorum* spindles, *Sphagnum* leaves and capsule lids and charcoal, frequent modern roots								

Table 28. Abbot's Way: macrofossil summary table.

	1.73–1.78m OD	**1.83–1.88m OD**
Total macrofossils counted	100	100
Estimated total seeds	<500	<400
Total taxa	1	2
Total well preserved	29	27
Total <25% fragmented	39	48
Total 25%–50% fragmented	16	10
Total >50% fragmented	16	15
Total <25% erosion	40	32
Total 25%–50% erosion	34	42
Total >50% erosion	6	16
Preservation index	**2.42**	**2.77**

of leaf around the base of the capsule were recorded as 25–50% fragmented, where no leaf remained >50% fragmentation was recorded.

1.73–1.78m OD: Preservation index 2.42. One taxa in 100 counted. Analysis not recommended
1.83–1.88m OD: Preservation index 2.77. Two taxa in 100 counted. Analysis not recommended

Recommendation
The samples examined from the Abbot's Way were close to the contemporary ground surface beneath a 24cm depth of clay topsoil. Although the peat was very dry, well humified, with a fairly low organic content, preservation of an abundance of the fragile remains of heather seeds occurred. Although these had undergone a degree of both fragmentation and erosion, the seeds were still recognisable as heather and with the other heathland/bog taxa present allow an environmental reconstruction of this site to be made. Further analysis would be possible, although in view of the fairly restricted community that grows in this type of habitat, examination of larger samples may not yield additional taxa. Further analysis is therefore not recommended. The assessment has shown the fragile nature of the plant remains here and in the future further deterioration is likely to occur from any increased desiccation.

Coleoptera

Harry Kenward

Two samples were taken at 1.83–1.88m OD (the level of the trackway) and just below the trackway at 1.73–1.78m

Table 29. Abbot's Way: properties of 250g unprocessed samples

	Dry weight	0.25mm	0.5mm	1mm	2mm	Organic matter %
1.83–1.88m OD	74.47g	5.9g	8.2g	8.4g	5.2g	37%
1.73–1.78m OD	79.17g	5.8g	6.7g	3.6g	2.8g	24%

Table 30. Abbot's Way: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
1.83–1.88	Flot small, consisting of herbaceous detritus with appreciable numbers of insects. Mites quite common. Some aquatics but an appreciable terrestrial component of ground beetles and plant feeders: more terrestrial than most samples examined in this study; heathland indicated.	Large sub-sample (3–5kg) would give useful group, though identifications often challenging. P1B
1.73–1.78	Small flot, plant fibres and fragments. Few insects, including trace of wetland forms, and several ants and some beetles suggesting drier conditions.	Rather limited potential even from a large sub-sample (>5kg). P3

Table 31. Abbot's Way: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical erosion				Fragmentation				Colour change					Other properties
	range		mode	str	range		mode	str	To	range		mode	str	
1.83–1.88	2.0	4.5	3.5	D	2.5	4.5	3.0	W	Pale	0	3	2	W	Some fossils with patchy decay
1.73–1.78	2.5	4.0	3.0	W	2.0	3.5	2.5	W	–	–	–	–	–	

OD. Both samples gave insect assemblages showing slight to appreciable erosion and fragmentation (Tables 30 and 31). The uppermost sample included some fossils with patchy decay, perhaps the result of root penetration.

Monitoring of burial environment

David Hogan

Site description

Transect: From SW field boundary starting at first fence post after short hedge run (95m from gate), towards opposite gate. Stations 1–3 were at 5m, 20m and 40m from ditch (Figure 31).

Land use: Permanent pasture of mesotrophic grassland, grazed by sheep at time of visit. Many molehills are present in the field.

Station 1 (Table 32). Instrumentation: piezometers at 50cm and 100cm depth.

Station 2 (Table 33). Instrumentation: piezometers at 50cm and 100cm depth.

Station 3 (Table 34). Instrumentation: piezometers at 50cm and 100cm, redox probes at 20cm, 30cm and 45cm depth.

Results

The remains lie in a narrow band at a shallow depth of only about 25–30cm below the ground surface, while water levels were almost entirely at greater depths (Figures 46, 48 and 49). A seasonal fluctuation in water level of between about 50cm and 100cm depth can be seen from April to September, after which recharge takes place. Some gaps in data are accounted for by the water levels dropping below the base of the piezometers (maximum depth 100cm) used at this site. Redox potentials (Figure 47) recorded at the upper and lower limits of the wood (20cm and 30cm depths) remained almost entirely *oxidised*, and even conditions recorded by the deepest probe at 45cm below the surface indicated predominantly *oxidised*, or occasionally only *slightly reduced* conditions. Groundwater sampled from piezometers beside the trackway had a pH of 6.7, and water taken from the ditch to the south had a pH of 6.6.

Conclusions

The water table remains almost permanently below the levels of the archaeology, leading to overwhelmingly oxidised conditions promoting the degradation of organic remains. There are no prospects for preservation under current environmental conditions.

Table 32. Abbot's Way: Station 1.

Depth (cm)	Description
0–30	Very dark greyish brown (10YR 3/2) humose silty clay (horizon includes areas of paler material – spoil from ditch cleaning?)
30–75	Black (5YR 2/1) moist greasy amorphous peat (H9)
75–90	Dark yellowish brown (10YR 4/4) wet semi-fibrous peat with layers of *Eriophorum* and *Sphagnum* (H5)
90–120+	Dark reddish brown (5YR 3/2) wet semi-fibrous grass-sedge peat (H5)

Table 33. Abbot's Way: Station 2.

Depth (cm)	Description
0–25	Black (5YR 2/1) humose silty clay loam / silty peat; contains stones (from past liming?)
25–90	Black (5YR 2/1) amorphous peat (H8) with occasional twigs and leaves; below 70cm depth more fibrous bands occur
90–130+	Dark yellowish brown (10YR 3/4) wet semi-fibrous grass-sedge peat (H5)

Table 34. Abbot's Way: Station 3.

Depth (cm)	Description
0–25	Dark reddish brown (5YR 2/2) moist, crumbly, humose silty clay loam; contains stones (from past liming?)
25–50	Black (5YR 2/1) moist amorphous peat (H9)
50–85	Dark reddish brown (5YR 2/2) very moist amorphous grass-sedge peat (H8)
85–90	Dark yellowish brown (10YR 4/4) semi-fibrous *Sphagnum* peat (H4)
90–150	Dark brown (10YR 3/3) wet semi-fibrous grass-sedge peat (H5) with many remains of roots and with *Typha* in the lower part

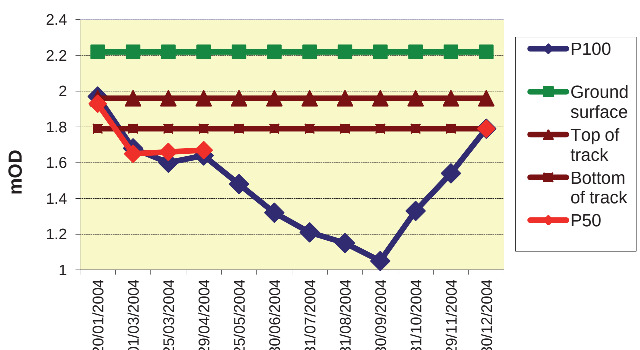


Figure 46. Water table at Station 3.

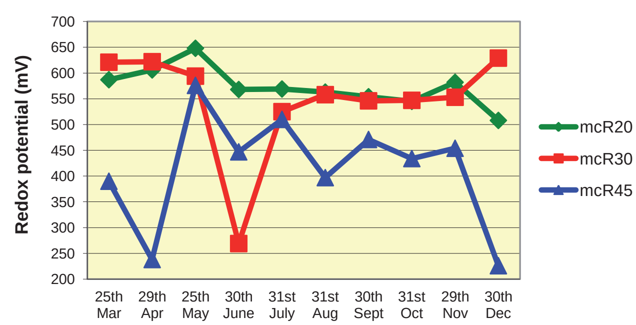


Figure 47. Redox potential at Station 3.

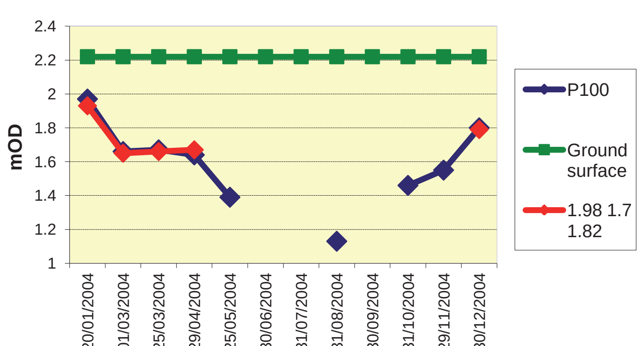


Figure 48. Water table at Station 1.

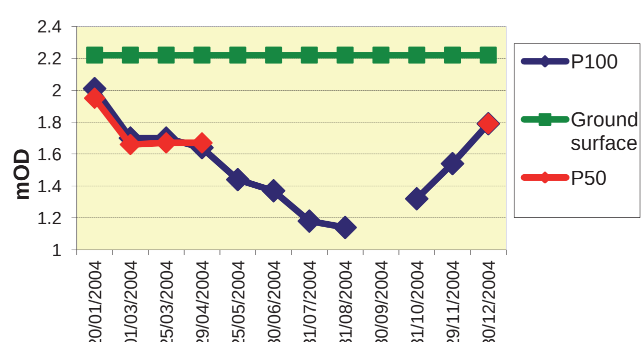


Figure 49. Water table Station 2.

Figure 50. Excavation of the Tinney's Tracks (Somerset Levels Project).

Preservation conclusion

The condition of the monument in the field studied is extremely poor. The wooden remains are very poorly preserved and have lost a large amount of their archaeological value. It is unlikely that excavation of the structure in this location would be of any significant benefit with the presently available techniques.

The water table lies below the structure throughout the year and the establishment of a water table that could ensure preservation *in situ* of the remaining archaeology would probably be incompatible with a farmed regime.

3. Tinney's Tracks fieldwork

HER 24902; SM 27975

Previous fieldwork

The Somerset Levels Project recorded numerous trackways in peat cuttings in the 1970s, crossing a single field at Sharpham Moor (Coles and Orme 1978; 1980; Coles *et al*. 1975a). At least nine different trackways were recorded in excavations and monitoring of cut peat faces (Figures 50 and 51). The tracks were formed of longitudinal brushwood, some only comprising short stretches of 15–40m long, but others over 200m long. The tracks were 0.3–2.0m wide and 0.1–0.3m thick. Occasional transverse rods were laid underneath the structures and sometimes a substructure of brushwood and/or reused timbers and woodworking offcuts was utilised. Central and lateral pegs were commonly used to hold the structures in position.

The brushwood bundles were mainly alder, with a little willow, birch and some hazel and occasional viburnum and smaller bog myrtle twigs. Diameters ranged from 15–40mm (mostly 20–30mm) with some larger pieces up to 90mm diameter and 0.2–3m long. The pegs were often alder, 0.4–0.72m long and 20–85mm in diameter augmented by the occasional use of split oak. In track D the substructure included an oak plank held down by a yew stump.

Track A used oak slats, boards and planks on top of brash, roundwood, woodchips and offcuts in its substructure. The oak planks were 0.5–2.25m long, 0.15–0.35m wide and 20–50mm thick. These were overlain by additional brash and heavier roundwood, on top of which was formed a walkway surface of bundles of alder brushwood.

The trackways crossed part of a raised bog from a position close to the edge of the bog, up onto its raised dome (Beckett 1978; Girling 1978). The tracks become slighter and peter out to the east as they get onto the drier dome of the bog, presumably because they were no longer required.

Oak planks used in the trackways have recently been dendrochronologically dated to the middle Bronze Age

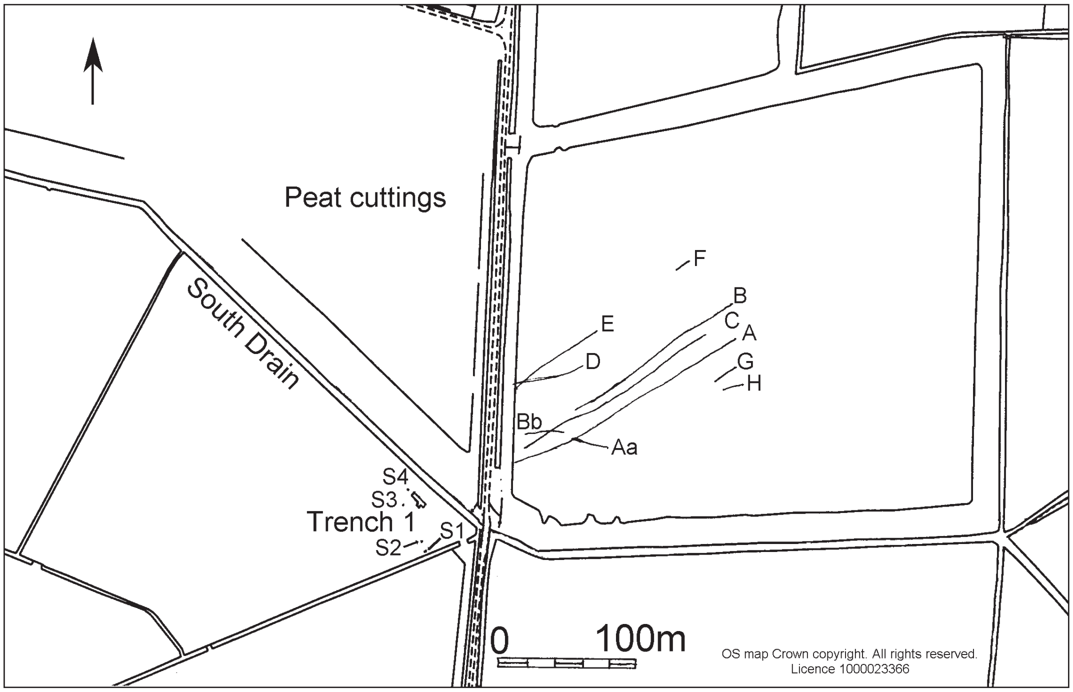


Figure 51. Tinney's Tracks location plan.

(Tyers 2004). The dated samples were some of the planks used in the substructure of the trackways. These may have been reused from previous structures so the actual construction of the trackways may be somewhat later.

MARISP excavation results

The MARISP excavations were located to the west of the previous discoveries of the trackways, in a field that should contain the terminal of the trackways as they reach the dry land of the Polden ridge (Figure 51).

A 10m by 1m trench was excavated along the projected line of the trackways with an extension of 3.2m by 0.8m where the track was encountered (Figure 52). Two superimposed brushwood trackways were located, separated by *c*. 2cm of peat (Figure 53). The top trackway was in a humified moss peat and was *c*. 77cm below the ground surface under *c*. 30cm of clay and 47cm of well humified peat, which contains a band of poorly humified light brown peat within it. The clay deepens away from the trench and may be the remains of a flood bank or a product of deposition of dredged material from the adjoining watercourse. The ground surface was between 3.55–3.59m OD, the top of the upper track at 2.82m OD and the top of the lower track at 2.67–2.70m OD.

A nearby core, located under dredgings from the adjoining watercourse, recorded one metre of silty clay, becoming increasingly organic from a depth of 0.79m. Below this was 2.7m of peat overlying a blue-grey clay containing reed macrofossils. Observed macrofossils suggested that the lowest 0.4m of peat was formed in reedswamp, succeeded by fen woodland that deposited the next 1.2m, above which was raised bog peat.

Both trackways were composed of brushwood, laid along the direction of the route. The upper track was *c*. 0.5m wide and stretched across the width of the trench although the wood became very sparse over the last 0.2m on the southern side. Of the 20 pieces of wood examined from the trackway 16 were thought to be roundwood and four half split. Lengths varied widely between 110mm and 520mm, and diameters between 5mm and 25mm (av. 12.7mm). Well preserved cut marks were only visible on one piece.

The lower track was 0.8m wide with a few outlying pieces over another 0.2m on the west side. It was only exposed over half the trench (i.e. 0.5m). A total of 25 pieces of wood were examined from the structure, all of which were highly compressed, which makes accurate estimates of their original diameters somewhat unreliable. Some of the most compressed roundwood pieces were 40mm wide but only 5mm across. Maximum diameters varied between 15mm and 40mm and lengths of 130–480mm. Four pieces exhibited simple chisel shaped cut ends.

A small scatter of 16 pieces of wood was recorded

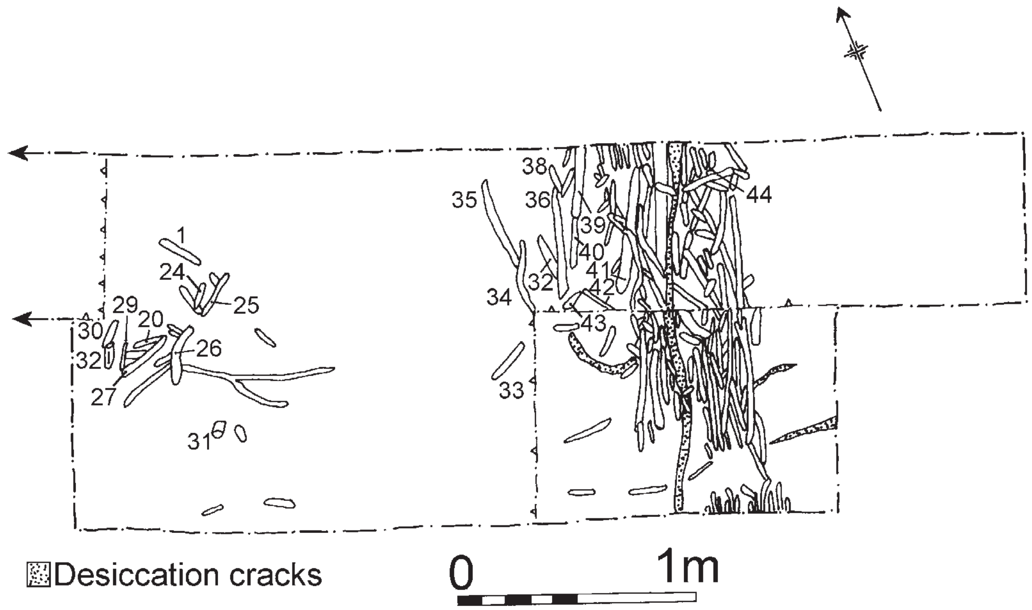


Figure 52. Tinney's Tracks trench plan.

Figure 53. Tinney's Tracks with half of upper track removed, looking west. Scales 1m.

c. 1.4m west of the two brushwood trackways, covering an area of about a metre square. These wooden remains were between 2.67 and 2.71m OD and may relate to the earlier of the two trackways, which was at the same level in the peat.

The scatter was composed of roundwood stems between 84mm and 350mm in length and 10–35mm in diameter. The only exception was a small woodchip (31), 45mm long, 35mm wide and 10mm thick, which was broken at one end and cut at the other. Five of the roundwood pieces (1, 3, 24, 29, 32) exhibited axe cuts at one end forming simple chisel points. The stems appeared to have been cut through with a single blow leaving a slightly concave toolmark. This scatter may represent the remains of a stock pile utilised during the building of the trackways. It does not appear substantial enough to have formed a distinct platform. All the identified pieces, including the cut stems and the woodchip, were of alder wood.

Wood species identification

Rowena Gale

A total of 35 samples was analysed from the excavation, 11 from the western group, 10 from the upper track and 14 from the lower track. A total of 31 of the samples were identified as alder (*Alnus glutinosa*), two of the others being either alder (*Alnus glutinosa*), hazel (*Corylus avellana*), willow (*Salix* sp.) or poplar (*Populus* sp.) and one being either alder or hazel. The only stem that could not have been alder was a piece of willow or poplar from the upper track. The age of the roundwood (measurable on 25 samples) varied from two to nine years (average 4.5). In seven cases it was identifiable that the stems had been felled during the dormant season. Six of these were from the western group and one from the upper track.

Tree-ring dating of Tinney's and Meare Heath tracks

Ian Tyers

Introduction

The excavations at the Middle Bronze Age sites of Meare Heath and Tinney's Ground on the Somerset Levels during the 1970s and 1980s both recovered series of timber samples which were dendrochronologically analysed by Ruth Morgan (Morgan 1978a; 1978b; 1979; 1980; 1982; 1988; 1989). The two site chronologies produced were cross-matched with each other, demonstrating the sites were broadly co-eval, but neither could be cross-matched to the absolutely dated prehistoric tree-ring sequences from England and Ireland. Bi-decadal blocks of tree-rings from timbers in both the site chronologies were sampled for radiocarbon dating (Morgan 1979). The tree-ring data was subsequently reworked as part of an English-Heritage-funded project *Building Prehistoric Tree-ring Chronologies from England*. This project was intended to strengthen the existing network of oak tree-ring data from southern England, and was being undertaken by Jennifer Hillam at Sheffield University. Over the subsequent decade prehistoric assemblages of oak timbers were analysed and dated from throughout the 4th–1st millennia BC, but no material was analysed that cross-matched these two sites, and no timbers were excavated that provided a datable sequence across the middle part of the 2nd millennium BC from the southern part of England.

Excavations at Meadow Lake in 1996 and Testwood Lake in 1999 as part of Southern Water's Testwood Lakes Scheme, near Netley Marsh, Hampshire, recovered oak timbers suitable for dendrochronological analysis. Provisional radiocarbon results indicated these were Middle Bronze Age in date. The tree-ring analysis of the Testwood Lake samples was undertaken in 2004 (Tyers 2004). This analysis provided absolute dates for samples from the Testwood Lake excavations and through their cross-matching with earlier data allowed absolute calendrical dates to be applied to undated tree-ring sequences from Meadow Lake, Meare Heath and Tinney's Ground. This section outlines the new dating evidence. These various samples not only provide data for the archaeological interpretation of their specific sites but they have also provided a significant opportunity to strengthen the national network of prehistoric tree-ring chronologies.

Results

The Meare Heath assemblage

The Meare Heath trackway ran for *c*. 2.5km approximately south from Meare to Shapwick. By 1985 apart from a small section in a Scheduled Ancient Monument the entire trackway had been lost to peat cutting. Excavations were undertaken by the Somerset Levels Project on active peat cutting exposures during the period 1974–80 (Coles and Orme 1978a), with a further section excavated during 1984–5 (Coles *et al.* 1988). Many structural oak timbers were recovered from these excavations, and from other peat cuttings crossing the track. The extensive series of tree-ring analyses on groups of this material by Ruth Morgan were summarised for the earlier sites in 1982 (Morgan 1982) and for the later material in 1988 (Morgan 1988). By 1988 424 samples had been taken of oak timbers from the track, of which *c*. 130 samples contained 50 or more tree-rings (Morgan 1988, table 4). The assemblage was clearly difficult to analyse; throughout the various *SLP* reports there are persistent comments that suggest that the timbers included a significant number of samples with aberrant growth sequences, that the sapwood was usually crushed and that the sapwood and bark boundaries were difficult to determine.

In *c*. 1978 three bi-decadal blocks of an interim reference sequence were submitted for radiocarbon dating, the results indicated the Meare Heath track was of middle Bronze Age date (Morgan 1979, 100; 1982, 43). In 1988 cross-matching of the Meare Heath data with the Tinney's A track sequence (discussed below) was reported (Morgan 1988, 28). In 1990 about 40% of the material was remeasured (many samples could not be remeasured due to sample disintegration) and the entire data assemblage was subjected to improved

Table 35. Summary of the Meare Heath oak samples.

	Collected 1974/5	Collected 1976–8	Collected 1979–80	Collected 1984–5	Total
Measured	26	31	9	64	130
Dated	13	13	4 (+2)	36 (+4)	66 (+6)
Dated with sapwood	–	1	1	2	4

+figures indicate multiple samples derived from a single tree

methods of cross-matching, data derived from single trees were combined into tree groups, and the shorter tree-ring sequences were excluded from the data analysis. A total of 66 series of both new and original data were combined to create a reference chronology of 191 years length (sequence MH_T66, Table 35, Hillam pers. comm.). This reference chronology, and its component samples are used as the basis for the subsequent discussions.

From its numerous exposures it was clear that the Meare Heath track was an impressive 2-lane structure, clearly built to a single plan (see photos and plans in Coles and Orme 1978a; Coles *et al.* 1988). From a dendrochronological perspective its purpose means that its timbers must have been abraded by passers by, and it is reasonable to assume it was being alternately soaked and dried out by seasonal, and perhaps longer term, changes in water-table. Both these activities are not conducive to the survival of the delicate sapwood on the outer surfaces of oak. The assemblage contained 130 analysed oak timbers, 15 of which retained some sapwood, but the cross-matched group of 66 sequences includes only four that retained sapwood, and none that retained bark-edge. This lack of sapwood and bark means that it is impossible for dendrochronological analysis to identify a single felling year for oak timbers from the Meare Heath track.

The Tinney's Ground assemblage

The Tinney's Ground field was excavated by the Somerset Levels Project on active peat cutting exposures over the period 1974–7 (Coles and Orme 1978b). The tree-ring analyses on this material by Ruth Morgan were summarised in 1978 (Morgan 1978b). One hundred and fourteen samples of oak timbers were taken from this track, the vast majority of these were wood-working chips and small stakes, the principal material of dendrochronological value comprised 29 boards. In total *c.* 34 samples contained 50 or more tree-rings. The timbers were slow grown and some of the material contained groups of very narrow tree-rings indicative that the trees suffered from periods of stress (Morgan 1978b, 83–4). It was thought likely that the timbers were re-used from an earlier structure, and do not directly relate to the date of the Tinney's A trackway. In *c.* 1978 two bi-decadal blocks of an interim reference sequence were submitted for radiocarbon dating, the results indicated the Tinney's A track was of middle Bronze Age date (Morgan 1979, 100; 1982, 43). In 1988 cross-matching with the Meare Heath data (discussed above) was reported (Morgan 1988, 28). In 1990 about 50% of the material was remeasured and the data assemblage subjected to improved methods of cross-matching, groups of data derived from single trees were combined into tree groups, and all the shorter tree-ring sequences were excluded from the data analysis. At this stage a reference chronology of nine samples was constructed from the remeasured and original data to form a sequence of 226 years length (sequence TINNEYS, Hillam pers. comm.). This reference chronology is used in the subsequent discussions.

None of the cross-matched Tinney's A track oak timbers retained sapwood. This lack of sapwood and bark means that it is impossible for dendrochronological analysis to identify a single felling year for the oak timbers from the Tinney's A track.

Relative dating of the Meare Heath and Tinney's A oak chronologies

As noted above by 1988 cross-matching between the Meare Heath and Tinney's A data was reported (Morgan 1988, 28). Despite the complete absence of sapwood and bark from Tinneys, and the almost complete absence from Meare Heath it was possible to conclude from the relative positions of the two data sets that the Tinney's A timbers were felled several decades later than the Meare Heath timbers (Morgan 1989a, fig. 35). In their final form these two sequences match very strongly (t = 9.28) and yield a composite sequence of 245 years with MH_T66 at relative years 1–191, and TINNEYS at relative years 20–245.

The Meadow Lake assemblage

A total of 88 samples from timbers from the Meadow Lake bridge structure in Hampshire were submitted for dendrochronological analysis in 1997. Boswijk

Table 36. Correlation t-values (Baillie and Pilcher 1973) between the Meadow Lake and Testwood Lakes series, used to construct the TESTWOOD sequence.

	MEADOW	TW3_115
TWAREA3	4.45	5.37
MEADOW		4.58

and Groves (1997) reported that 62 of the samples contained measurable ring sequences. 15 samples were cross-matched to produce a 181-year reference curve, named MEADOW, these samples probably represented data from *c*. 7 individual trees. There was a complete absence of sapwood or bark edge amongst the cross-matched material

The dating potential of the Meadow Lake oak assemblage appeared to have been adversely affected by the presence of a number of periodic, severe growth retardation events in many of the samples. At the time of their analysis there was no contemporaneous dated material from southern English archaeological structures.

The Testwood Lake evaluation assemblage

As part of the evaluation of the Testwood Lake site a group of six timbers were examined in 1998. One of these was an oak timber with sufficient rings to be suitable for dendrochronological analysis. This analysis identified that this timber matched the composite tree-ring series from Meadow Lake (Wessex Archaeology 2000, 17). Material from this timber were submitted for radiocarbon analysis and these results confirmed that this was of middle Bronze Age date (*ibid*., 17–18). This timber is unique amongst the dated timbers from any of these sites in retaining complete sapwood and bark-edge.

The Testwood Lake (Area 3) assemblage

A total of 116 samples from the timbers excavated at the Testwood Lake bridge structure were submitted for dendrochronological analysis. Of these, 43 were found to contain measurable ring sequences and these were analysed. Four groups of 8, 4, 4 and 3 samples respectively were found to comprise timbers derived from individual trees. These four 'tree' groups and six other individual timbers were found to cross-match with each other to yield a single 206-year mean chronology derived from 25 individual timbers, this composite chronology was called TWAREA3.

Relative and absolute dating of the Testwood and Somerset chronologies

The TWAREA3 sequence was compared with the original Meadow Lake sequence (MEADOW) and the single analysed sample from the Testwood Lake structure evaluation (TW3_115). This identified that these three sequences matched (Table 36).

Table 37. Correlation t-values (Baillie and Pilcher 1973) between the three series used to construct the SEngMBA chronology.

	Meare Heath	Tinney's A
TESTWOOD	5.87	4.52
Meare Heath		9.28

Table 38. Correlation t-values (Baillie and Pilcher 1973) between SEngMBA at its dating position and a number of external reference chronologies.

Reference series	***SEngMBA***
Netherlands bog oaks (Jansma 1995)	3.71
England later Prehistoric: 14 sites (Hillam pers. comm.)	4.46
England Humberside Hasholme bog oak (Hillam 1987)	4.65
Ireland Corlona Co Leitrim (Brown pers. comm.)	4.52
Ireland mid-Bronze Age: 7 sites (Brown pers. comm.)	5.46
Ireland Timahoe Co Kildare (Brown pers. comm.)	6.22

Note that the 'England later Prehistoric' master sequence is not independent of the Hasholme sequence, and the Corlona and Timahoe sequences are not independent of the Ireland mid-Bronze Age series. Due to the paucity of co-eval material from England the number of comparable datasets is low. Each sub-component gives support for this dating position

A single 227-year sequence was constructed from all the Testwood Lakes material, named TESTWOOD, and this was compared with dated and undated reference chronologies from around the British Isles and northern Europe. A strong correlation was identified between TESTWOOD and the undated but matched tree-ring data from the Meare Heath trackway and the Tinney's A track (Table 37). Furthermore a replicated correlation was found that dated the TESTWOOD sequence to 1688–1462 BC inclusive against contemporaneous tree-ring data from northern England, Ireland and the Netherlands. The TESTWOOD sequence and the Meare Heath and Tinney's A sequences were combined into a single composite 261-year sequence, dubbed SEngMBA, which at the equivalent dating position (1722–1462 BC inclusive) matches the same contemporaneous reference data (Table 38).

This allowed absolute dates to be assigned to all the cross-matched sequences obtained from the Testwood

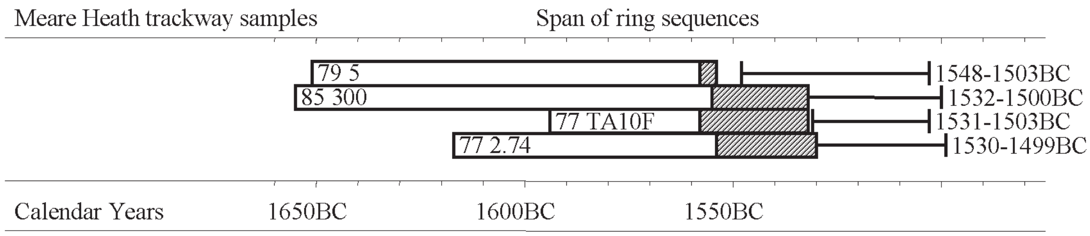


Figure 54. Bar diagram of the relative and absolute positions of the 4 matched and dated samples retaining sapwood from the Meare Heath track, with felling date ranges for each sample. White bars heartwood, shaded bars sapwood.

and Meadow Lakes bridge structures and for the 2 Somerset trackways.

The date of the Meare Heath track and the Tinney's A trackway timbers.

The composite tree-ring chronology for the Meare Heath track is dated to 1722–1532 BC inclusive. This represents the period through which the tree-ring sequences obtained from the dated samples actually lived. The archaeologically significant date is when the trees were felled. Four of the 66 dated timbers from the trackway include some sapwood, applying a sapwood estimate of 10–55 years to these four samples yields a combined felling date of 1530–1503 BC (Figure 54). This calculation makes three key assumptions; that the dated timbers represent the primary structure of the trackway, that the sapwood data appended to the data series were correctly recorded and that the Meare Heath track was the product of a single rapid construction programme.

The composite tree-ring chronology for Tinney's A track dates to 1703–1478 BC inclusive. This represents the period through which the tree-ring sequences obtained from the dated samples actually lived. The archaeologically significant date is when the trees were felled. None of the nine dated timbers from this trackway include any sapwood, applying a minimum sapwood value of 10 years to the latest datable tree-ring indicates the material was felled after 1468 BC. This calculation indicates the Tinney's A oak timbers were felled at least 35 years after the construction of the Meare Heath track, and more probably a little later than that. It has already been noted that the dated Tinney's A timbers may not have been felled directly for use on the trackway and may represent a re-used assemblage of timbers.

Conclusions

Absolute tree-ring dates obtained for Testwood Lake, Hampshire, simultaneously enabled absolute dates to be applied to hitherto undated timbers from nearby Meadow Lake as well as the hitherto undated assemblages of data from the Meare Heath track and Tinney's A track on the Somerset Levels. The interpreted construction dates for each structure are somewhat imprecise due to the lack of surviving sapwood.

Hitherto the only datable tree-ring material available around the middle Bronze Age period has been naturally deposited trees, mostly from the northern and eastern parts of England (Figure 55). The four sites discussed here have produced a series of replicated tree-ring sequences that cover an otherwise sparse period for reference data, in this case derived entirely from archaeological structures.

Baillie and Brown (2002) analysed clustering within the tree-ring dated archaeological features in Ireland (typically trackways). This analysis identified that their results were not randomly distributed through time, (*ibid.*, fig. 1). Tree-ring dated archaeological features between 2000 BC and 1 BC dates form two very strong clusters, and two or three lesser ones. One of their major clusters is at around 1500 BC, composed of around 20 structures. They suggested the following conditions produce such clusters; 'there were only narrow time windows when people were felling mature oak trees in order to build structures in wet contexts, wherein those timbers might survive to the present' (*ibid.*, 499).

Tree-ring dates obtained from the Meare Heath track, the Tinney's A track, and the Meadow Lake and Testwood Lake bridge structures appear to all fall into this *c.* 1500 BC cluster. This alignment suggests that at least one of the clusters identified from the more extensive Irish material also occurs in southern England.

The scale, form, and topographical location of each of these structures suggest that each was built in response to rising water levels. If this is correct it might be the case that this condition was occurring simultaneously in the Somerset Levels, the Hampshire basin, and in Ireland.

Fieldwork conclusion

Two of the Tinney's Tracks were located in the assessment excavation, demonstrating that they continued on the

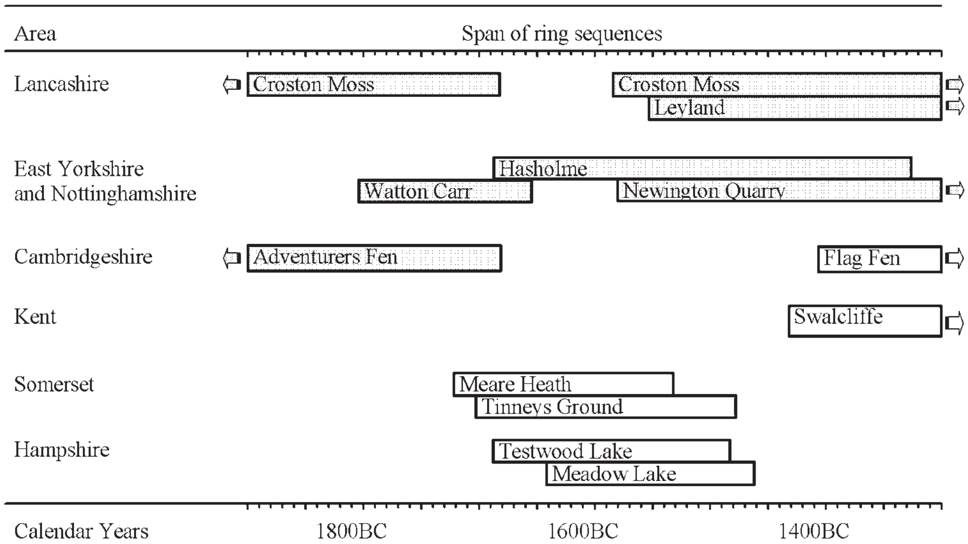


Figure 55. Bar diagram showing the temporal distribution of the component elements of the English oak tree-ring series 1900–1300 BC. Elements derived from naturally deposited trees are shaded.

Table 39. Tinney's Tracks: moisture content and state of degradation.

Timber no.	% Moisture content	Timber condition
1	1063	Heavily degraded
4	577	Heavily degraded
43	961	Heavily degraded
45	644	Heavily degraded

Table 40. Tinney's Tracks: wood species, % moisture content (MC) and density values.

Timber no.	Wood species	% MC	Original density	Present density
1	Alder	1063	0.48	0.08
4	Willow	577	0.42	0.15
43	Alder	961	0.48	0.09
45	Willow	644	0.42	0.14

known line towards the Polden hills. This has helped to allow a more precise prediction of their landfall. The superimposition of two trackways supports the evidence from previous excavations for the reuse of a similar route over a prolonged period of time. The existence of peat between the two trackways suggests that the second trackway was not a simple repair, but rather represents a complete rebuild along the same route.

Tinney's Tracks assessment and monitoring

Assessment of preservation

Visual assessment of wood

The wooden remains were visibly suffering from desiccation, with observable shrinkage and cracking and deterioration of surface condition. The western group and the lower trackway material both displayed the effects of significant compression. The less compressed character of the upper trackway suggests that the compression of the lower trackway stems may have occurred after a period of decay had occurred, degrading their cellular structure and making them more prone to compression by pedestrians using it or the upper track. The less compressed character of the upper trackway suggests that such a point of decay was not reached during its active life. A major desiccation crack runs down the centre of the trackways.

Detailed examination of wood structure

Mark Jones

Moisture content values recorded for timbers excavated at Tinney's tracks are listed in Table 39. Values obtained range from 577 to 1063%. The state of degradation of all timbers, based upon moisture content can be classified as heavily degraded.

Both alder and willow samples have density values, which are less than the original density for recent wood. Both wood species have lost considerable amounts of original cell wall material. At this site alder was found to be extremely decayed with little residual strength (Table 40). Previously examined alder (e.g. Harter's Hill site) was found in a better state of preservation. This indicates variations in the state of preservation of similar wood species at the different sites in Somerset.

All timber samples examined under the SEM showed extensive damage to most of the wood cell wall layers (middle lamella still well preserved) (Figure 56). The secondary wall layers of both alder and willow were extensively degraded by microbial attack during burial. FT-IR analysis (Figure 57) confirms this picture of decay. The lignin to holocellulose ratios has increased indicating massive degradation to the carbohydrates. Hemicellulose has been totally lost leaving a network of lignin.

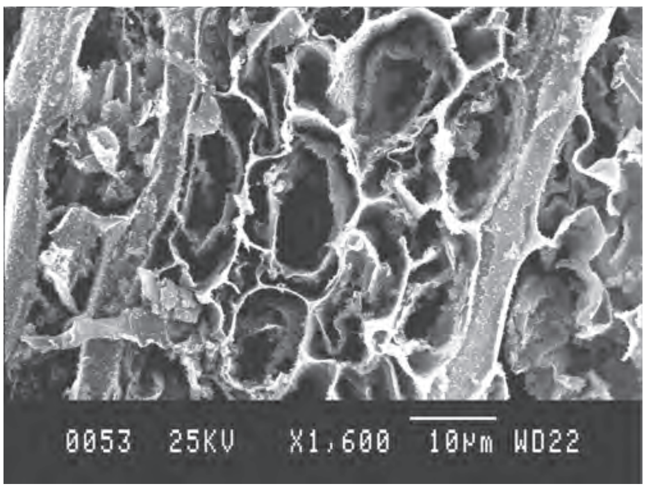


Figure 56. SEM of ancient alder (1).

Pollen evidence

Heather Tinsley

The excavation at the Tinney's site revealed two brushwood tracks, the upper about 0.8m below the ground surface, separated from the lower track by just a few centimetres of peat. The lower track was laid on dark brown, coarsely fibrous peat with obvious remains of *Eriophorum* (cotton grass). At the level of the tracks this changed to a well-humified moss peat some 0.45m thick, which became less well humified above the wood remains. Between 0.21m and 0.18m above the upper track, there was a marked stratigraphic change to a light yellow-brown poorly humified moss peat, which formed a prominent, undulating band between 0.09m and 0.12m thick. This was overlaid by around 0.15m of dark brown, dry, very compact, well-humified peat, on top of which 0.28–0.30m of clay extended up to the ground surface. Samples were assessed from below the lower track at 2.59–60m OD in the *Eriophorum* peat, from the level of the lower track at 2.69–2.70m OD, from between the tracks at 2.80–2.81m OD and from above the upper track at 2.90–2.91m OD. One sample was assessed from the yellow brown, poorly humified moss peat at 3.12–3.13m OD and the upper sample was from the compact well-humified peat at 3.23–3.24m OD.

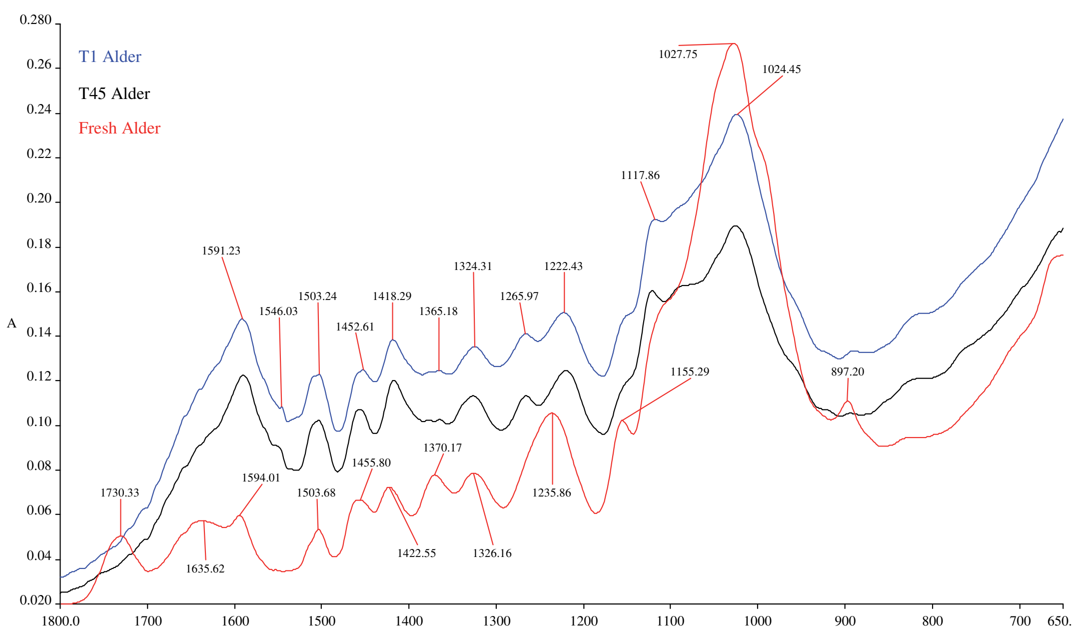


Figure 57. FT-IR spectra of timbers 1,45 (both alder) and modern alder Tinney's Tracks.

Palaeoenvironment

2.59–2.60m OD, 2.69–2.70m OD, 2.80–2.81m OD, 2.90–2.91m OD. Tree pollen: 54–80% TP, dominated by *Corylus*-type with some *Quercus* and *Alnus* and occasional grains of *Ulmus*, *Betula, Fagus, Pinus* and *Salix*. Herbaceous pollen: 20–46% TP, dominated by *Calluna vulgaris* with occasional grains of pollen taxa associated with disturbance from 2.69m OD upwards (the level of the lowest track). Occasional fern spores and spores of *Sphagnum*.

3.12–3.13m OD. Tree pollen: 40% TP, dominated by *Corylus*-type with a little *Alnus* and *Quercus* and occasional grains of *Pinus, Fraxinus, Fagus* and *Betula.* Herbaceous pollen: 60% TP, dominated by *Calluna vulgaris* with occasional *Vaccinium*-type, Poaceae and Cyperaceae. 45 spores of undifferentiated ferns, 1 of Polypodiaceae, 1 of *Pteridium aquilinum*, and 40 of *Thelypteris palustris*. 19 spores of *Sphagnum* moss and 2 of *Tilletia sphagni*.

3.23–3.24m OD. Tree pollen: 22% TP, dominated by *Corylus*-type with occasional grains of *Pinus*, *Quercus, Fagus, Betula* and *Alnus.* Herbaceous pollen: 88% TP dominated by Cyperaceae (73%) with occasional grains of Poaceae, *Typha latifolia, Plantago lanceolata* and *Calluna*. 18 spores of undifferentiated ferns and 2 of *Thelypteris palustris.*

Prior to the construction of the lower track, and throughout the period in which both lower and upper tracks were constructed, the vegetation at the site appears to have been dominated by heather, probably growing as part of a raised bog community. Bog moss was also present, presumably in wetter hollows. The stratigraphic evidence indicates tussock forming cotton grass at 2.59m OD. A dry-land woodland dominated by hazel and oak with a little elm, beech and alder appears to have grown close by the site before the track-building phase. Microscopic charcoal occurred frequently at 2.59–2.60m OD, suggesting human activity in the wider environment. The contribution of alder to the local woodlands increased at the level of the lower track, perhaps linked to increasing wetness on the woodland margins.

From 2.69m OD there is a continuous pollen record for taxa characteristic of disturbed habitats including ribwort plantain, sorrel/dock, mugwort, goosefoot family and daisy (or related Asteraceae), and this is likely to be linked to the anthropogenic activity associated with the track-building phase. The marked stratigraphic change at 3.09m OD, to very poorly humified moss peat, is reflected in the pollen assemblage from 3.12–3.13m OD, where the presence of quite high numbers of bog moss spores suggests increasingly wet conditions. The poor humification at this level indicates rapid accumulation of peat and this is borne out by the relatively low pollen concentration. Heather continued to be established in the area.

By the time the yellow moss peat at 3.12m OD was forming the extent or density of surrounding woodland appears to have been reduced. Fern spores, particularly the distinctive, spiky spores of marsh fern (*Thelypteris palustris*) (Plate 20: Appendix 3), were frequent at this level and sporangia occurred in the pollen preparations, indicating marsh ferns were growing close to the site. *Thelypteris* is characteristic today of certain tall herb and swamp communities typical of meso or eutrophic fens (Rodwell, 1995), rather than raised bog peat. The ecological significance of the *Thelypteris* spores is therefore not clear. It is possible that peat has been extracted at this site and that the yellow moss peat, which was very poorly humified and fresh-looking, formed rapidly in the base of a flooded cutting which possibly also provided a habitat for marsh fern. At 3.23–3.24m OD there was a further change, the local vegetation appears to have become dominated by sedges and surrounding woodland was further reduced, prior to the deposition of the upper clay. Microscopic charcoal was again frequent in this sample. Full pollen analysis is required to gain a clear understanding of the changing plant communities at this site.

Pollen preservation

In the basal pollen sample from Tinney's, from 2.59–2.60m OD, 42% of grains were well preserved; there were four indeterminable grains which were fragmented. 16% of identified grains were poorly preserved principally due to extensive corrosion, which was particularly developed on *Corylus*-type grains (Table 41). Partial corrosion affected 36% of all grains, degradation was less apparent. Some limited etching was observed on the fern spores. This sample has some unique preservational characteristics, not seen elsewhere in the MARISP sediments. The pollen preparation contained very abundant fine dark coloured 'hairs', without any internal structure visible, these wrapped around the pollen grains, sometimes partially obscuring them. In some cases these 'hairs' appeared to protrude from the surface of pollen grains. In addition, the pollen grains in this sample appeared somewhat shrunken. The biochemical preservation index was 0.83 and the mechanical preservation index was 0.26.

The pollen preservation characteristics of the samples from 2.69–2.70m OD, 2.80–2.81m OD and 2.90–2.91m OD were very similar. Well-preserved grains ranged from 58–69% of identified grains, with 0–4 indeterminable grains. The numbers of identified grains with poor preservation were low, just 4–6%. Partial corrosion and degradation was observed, but only to a limited extent. Biochemical preservation indices ranged from 0.25–0.28

Table 41. Tinney's Tracks: pollen preservation summary.

	2.59–60m OD	2.69–70m OD	2.80–81m OD	2.90–91m OD	3.12–13m OD	3.23–24m OD
Total identified pollen grains	100	100	100	100	100	100
Pollen concentration	84,000	2,782,000	231,000	556,000	55,000	30,000
Number of pollen taxa	6	11	11	12	11	11
Total indeterminable grains	4	0	4	4	4	0
Total identified extensively corroded grains (a)	8	2	0	1	2	4
Total identified extensively degraded grains (b)	5	2	3	0	5	8
Total identified extensively crumpled grains (c)	1	0	0	1	0	0
Total identified extensively broken grains (d)	2	2	2	2	5	0
Total identified grains with poor preservation (a+b+c+d)	16	6	5	4	12	12
Total well-preserved grains	42	69	60	58	52	25
Total grains of resistant taxa	0	1	1	3	0	0
Total ferns	8	0	4	9	93	20
Biochemical preservation index	0.83	0.25	0.28	0.28	0.57	0.9
Mechanical preservation index	0.26	0.29	0.27	0.42	0.3	0.15

and mechanical preservation indices from 0.29–0.42. Fern spores were in a good state of preservation.

At 3.12–3.13m OD, pollen preservation was slightly less good, with 52% of grains well preserved, 4 indeterminable grains and 12% of identified grains with poor preservation, principally due to extensive degradation. As with the samples immediately below, partial corrosion and degradation was very limited. The biochemical preservation index was 0.57 and the mechanical preservation index was 0.30. The majority of fern spores were in a good state of preservation.

In the upper sample examined, at 3.23–3.24m OD, the overall state of pollen preservation had deteriorated a little further. Only 25% of grains were well preserved, though no indeterminable grains were recorded. 12% of identified grains were poorly preserved (the same percentage as the sample below) and this was largely due to extensive degradation. However, partial degradation was extensive in this sample, particularly affecting the Cyperaceae, which were dominant in the assemblage. The biochemical preservation index was 0.90 though the mechanical preservation index was only 0.15. The fern spores tended to be somewhat thin, but did not show etching on their surfaces.

On the whole, pollen preservation is good in the samples from the Tinney's tracks. The unusual characteristics of the lowest sample from 2.59–2.60m OD, do tend to somewhat obscure the pollen grains, but not to the extent that identification is prevented. It seems likely that the masses of 'hairs' are in fact a fungal mycelium, though the 'hairs' are considerably finer than the fungal hyphae more commonly observed in pollen preparations. It is tempting to suggest that this mycelium could be the remains of a mycorrhiza associated with *Calluna vulgaris*, a species which supports mycorrhizal associations (Gimmingham 1960; Webb 1986) and which is well represented in the pollen assemblages at Tinney's. However, the 'hairs' are only apparent in the basal sample, whereas *Calluna* pollen occurs throughout.

The rather shrunken appearance of the pollen grains is also intriguing; it may be related to the occurrence of the 'hairs'/mycelium through some biochemical interaction, or it could be a result of lack of expansion of grains during the acetolysis process, but no other samples in the processing batch were affected in this way. The principal deterioration type in this sample was corrosion, in samples higher up the stratigraphy the incidence of corrosion declined. There could, therefore, be a link between the relatively high numbers of corroded pollen grains at 2.59–2.60m OD and possible fungal activity. Further investigations would be needed to attempt to resolve these points. The good pollen preservation between 2.69m OD and 2.90m OD must reflect constant saturation. It seems likely that the slight deterioration in preservation at 3.12–3.13m OD, which becomes more marked in the upper dry peat, is a result of recent water table fluctuation.

All the samples from the Tinney's tracks have the potential for full pollen analysis, the relatively low

Table 42. Tinney's Tracks: stratigraphy.

Stratigraphy	Plant macrofossil/beetle samples
3.18–3.33m OD Dark brown, very compact, dry peat with occasional modern roots	3.21–3.26m
3.09 (06)–3.18m OD Light yellow brown, poorly humified moss peat of variable thickness. Very undulating boundary	3.10–3.15m
2.83–3.09 (06) Brown, moderately humified moss peat. Top of upper trackway at 2.88m OD	
2.62–2.83m OD Brown, well humified moss peat. Lower trackway level at 2.65–2.73m OD	2.78–2.83m (between trackways) 2.66–2.71m (lower trackway
2.53–2.62m OD Dark brown fibrous *Eriophorum* peat.	2.57–2.62m

numbers of indeterminable grains and of identified grains with poor preservation means that such analysis could proceed with confidence, without concerns regarding bias due to differential preservation of less robust types. This applies even to the basal sample from 2.59–2.60m, despite the unusual characteristics of the pollen preparation, which require further investigation. The field observations of the uppermost peat at 3.23–3.24m OD ('very compact and dry') might lead to the assumption that pollen would be very poorly preserved, this is not the case; though preservation is not as good as lower down the section, overall it remains reasonable and full analysis would be worthwhile.

Plant macrofossils

Julie Jones

Five bulk samples were recovered, one from the fibrous peat below the level of the lower track, one from the level of the lower track, one from the peat between the tracks, one from the lighter moss peat above the upper track and one from the darker dry peat at the top of the sequence (Table 42). Overlying the peat is a layer of *c*. 30cm of clay, which may be the remains of a flood bank from the adjacent rhyne.

Palaeoenvironment

The basal sample from the fibrous peat included abundant wood and twig fragments, likely to be heather, as the bulk of the other macrofossils recovered were heather seeds and flowers. Cotton-grass spindles occurred with several fruits also present and abundant moss, including some *Sphagnum*. This heath/bog community persists in the two overlying samples from the level of the lower track and the peat between the two tracks. Rush are also common and other marsh taxa, including marsh pennywort, gipsywort and celery-leaved buttercup (*Ranunculus sceleratus*) suggest areas of damp ground. Pools or wetter areas of the bog would have supported water-crowfoot and bog-bean (*Menyanthes trifoliata*). Several taxa more typical of disturbed habitats, like fool's parsley (*Aethusa cynapium*), chickweed (*Cerastium*) and orache (*Atriplex*) may indicate areas of drier ground. The band of yellow, brown moss peat above the upper track consists predominantly of *Sphagnum* leaves suggesting colonisation by bog moss perhaps due to increasingly wet conditions. The uppermost sample had a more restricted assemblage although wet conditions appear to continue with communities of great fen-sedge, which prefers shallow water zones usually <40cm deep, bulrush, pondweed and other marsh taxa. However, there continues to be a disturbed ground element with orache, common chickweed and fat-hen (*Chenopodium album*).

Preservation

2.57–2.62m OD: Remains of heather form the bulk of this sample, with woody fragments, as well as seeds, flowers and small branches with several *Calluna* leaves attached. A third of the heather seeds are whole the remainder showing not only fragmentation but also degradation of the testa resulting in the epidermal cells being less clearly visible. The remaining fragments of the flowers were largely fragmented although some retained leaf fragments at the base of the capsules. Moss also frequently occurred in the sample with branches containing no leaves as well as individual un-branched leaves; occasional individual *Sphagnum* leaves also occurred. Although a scan of the entire sample estimated that a total of *c*. 300 seeds occurred no additional taxa were noted.

Preservation index 2.16. Four taxa in 100 counted. Analysis not recommended.

Table 43. Tinney's Tracks: plant macrofossil preservation.

Fibrous peat below lower track								
		Fragmentation				**Erosion**		
2.57–2.62m OD (71–76cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Calluna vulgaris (seed)	63	21	16	19	7	23	13	6
Calluna vulgaris (flower)	34	0	8	15	11	0	0	0
Erica sp (flower)	1	0	1	0	0	0	0	0
Eriophorum sp.	2	0	2	0	0	0	0	0
Other macrofossils: frequent wood/twigs ? *Calluna*, occasional moss, *Eriophorum* spindles, and *Calluna* leaf								
Peat at level of lower track								
		Fragmentation				**Erosion**		
2.66–2.71m OD (62–67cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Aethusa cynapium	*1*	0	0	0	1	1	0	0
Alchemilla sp.	2	1	0	1	0	0	0	0
Calluna vulgaris (seed)	16	7	7	0	2	5	5	0
Calluna vulgaris (flower)	2	0	1	1	0	0	0	0
Cerastium sp.	5	2	2	0	1	0	1	0
Eleocharis palustris/uniglumis	5	2	1	1	1	2	1	0
Erica sp (flower)	1	0	1	0	0	0	0	0
Hydrocotyle vulgaris	5	3	1	0	1	3	1	0
Juncus spp.	45	23	14	5	3	24	14	1
Menyanthes trifoliata	1	0	0	0	1	0	0	0
Ranunculus subg. *Batrachium*	2	0	0	0	2	0	0	0
Ranunculus sceleratus	1	1	0	0	0	0	0	0
Sagina spp.	7	1	1	4	1	1	6	0
Urtica dioica	1	1	0	0	0	1	0	0
Other macrofossils: frequent wood fragmentss, occasional moss, *Sphagnum*, and *Eriophorum* spindles								
Peat between trackways								
		Fragmentation				**Erosion**		
2.78–2.83m OD 50–55cm	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alisma sp.	1	0	0	0	1	0	0	1
Atriplex sp.	1	0	0	1	0	0	0	0
Alchemilla sp.	2	2	0	0	0	0	0	0
Calluna vulgaris (seed)	2	2	0	0	0	0	0	0
Carex paniculata	3	0	2	1	0	0	3	0
Carex spp.	2	1	1	0	0	1	1	0
Cerastium sp.	3	1	2	0	0	0	0	0
Eleocharis palustris/uniglumis	11	4	2	1	4	3	3	1
Hydrocotyle vulgaris	15	11	2	0	2	6	4	1
Juncus spp.	39	24	8	4	3	12	11	7
Lycopus europaeus	1	0	0	0	1	0	0	0
Mentha sp.	1	0	1	0	0	1	0	0
Montia sp.	1	0	1	0	0	0	0	0
Potentilla erecta	3	3	0	0	0	0	0	0
Potentilla sp.	1	0	0	0	1	1	0	0
Ranunculus acris/repens/bulbosus	1	0	0	0	1	0	1	0
Ranunculus lingua	2	0	0	0	2	0	0	0
Rubus sect. *Glandulosus*	1	1	0	0	0	0	0	0
Sagina spp.	1	1	0	0	0	1	0	0
Urtica dioica	2	2	0	0	0	2	0	0
Other macrofossils: frequent wood fragments, occasional *Eriophorum* spindles, rare charcoal								
Peat above upper trackway								
3.10–3.15m OD	Other macrofossils: abundant *Sphagnum* leaves and capsule lids, occasional wood frags and bark							
Peat at top of sequence								
		Fragmentation				**Erosion**		
3.21–3.26m OD (7–12cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Atriplex sp.	1	1	0	0	0	0	0	0
Calluna vulgaris (seed)	1	1	0	0	0	0	1	0
Chara spp.	12	11	0	1	0	0	0	0
Chenopodium album	2	0	1	1	0	0	0	0
Cladium mariscus	35	0	17	5	13	12	0	0
Hydrocotyle vulgaris	5	4	1	0	0	2	1	1
Poaceae indet	1	1	0	0	0	0	0	0
Potamogeton spp.	9	6	0	1	2	0	0	0
c.f. *Silene* sp.	1	0	0	0	1	1	0	0
Stellaria media	1	0	1	0	0	1	0	0
Typha sp.	1	0	1	0	0	0	1	0
Other macrofossils: occasional wood fragments, *Sphagnum* leaves, and charcoal								

2.66–2.71m OD: A count of only 94 seeds, from 13 taxa was possible from this sample. Several species that occur most frequently have small flimsy seeds. About half of the *Calluna* seeds were whole and half <25% fragmented, with some degradation of the epidermal cells. Over half of the pale flimsy *Juncus* seeds were also whole, although in many examples (84%) the clarity of the surface cell patterning was degraded by <25–50%. Seeds of *Sagina* (pearlwort) are even smaller than many *Juncus* seeds, approximately 0.4 × 0.3mm. They are more or less kidney-shaped with a pattern of slightly domed cells on the otherwise smooth seed coat, but despite the degree of fragmentation and erosion of this surface sculpturing, identification of this genus is still possible.

Preservation index 1.98. Thirteen taxa in 94 counted. Analysis would be possible, larger sample may add more taxa.

2.78–2.83m OD: Twenty taxa were recorded in this sample although the overall number of macrofossils was similar to the underlying peat. *Juncus* seeds were again fairly well preserved with over 60% whole examples and *c*. 60% <50% eroded. Marsh pennywort fruits were largely complete although most examples had suffered some deterioration of the slender ribs along the flat side of the seed. In the sample overall 55% of fruits were entire, exceptions include both buttercup and lesser spearwort (*Ranunculus lingua*), both >50% fragmented, with a single u-shaped embryo of *Alisma* and a tiny fragment of gipsywort (*Lycopus europaeus*). Gipsywort seeds are quadrangular in shape with a flat dorsal side and roof-shaped ventral side with a characteristic thickened margin of whiter tissue and as is the case with the example in this sample, it is still possible to identify this species from a surprisingly tiny fragment.

Preservation index 1.90. Twenty taxa in 93 counted. Analysis would be possible, larger sample may add more taxa.

3.10–3.15m OD: This sample from above the upper track comprised almost 95% individual *Sphagnum* leaves and capsule lids, in an excellent state of preservation, with abundant tiny fibres and occasional small woody fragments. No other seeds/fruits were recorded.

Preservation index 0. No seeds/fruits present. Analysis of a larger sample would seem unlikely to add more taxa, although identification of the *Sphagna* would be possible.

3.21–3.26m OD: From the uppermost dry compact peat, *c*. 60% of the sample float comprised unbroken down sediment and only 69 individual macrofossils were counted from 11 taxa. There were none of the leathery elliptic fruits of great fen-sedge, many of the examples were of the well-preserved (<25% fragmented) urn-shaped nutlets, although some were in a fragmentary state and about a third had suffered slight (<25%) deterioration of the woody nut wall.

The oospores of *Chara* were largely complete with no deterioration to the spiral surface sculpturing, marsh pennywort were similarly well preserved with the surface ribbing mostly clear. The single orache was complete and well-preserved, the circular to slightly oval seeds with black shiny surfaces seem very resistant to decay.

Preservation index 1.53. Eleven taxa in 69 counted. Analysis would be possible, larger sample may add more taxa.

Recommendations

Species diversity was low in the basal *Eriophorum* peat at Tinney's Track with the sample dominated by remains of heather, the level of fragmentation and erosion resulting in the highest preservation index of the sequence. In view of the restricted nature of the assemblage, due in part to the characteristics of this type of bog/heathland community, further analysis is not recommended.

The peat at the level of the lower track (2.66–2.71m OD) and the peat between the tracks (2.78–2.83m OD) gave similar results with preservation indexes of 1.98 and 1.90 respectively (Tables 43–45). Although macrofossil abundance was relatively low with just under 100 counted, processing of larger samples would allow analysis and fuller environmental interpretation. Preservation of *Sphagnum* at the level of the upper track was excellent although no other macrofossils were recorded and in view of this further analysis is not recommended. Larger samples would also be required to increase counts from the uppermost peat at the top of the sequence although preservation of those macrofossils recorded suggest that this would be worthwhile.

Coleoptera

Harry Kenward

Five samples were assessed from this site (Tables 46 and 47). The upper sample (3.21–3.26m OD) was from a dry humified peat, the next (3.10–3.15m OD) from a poorly humified yellow moss peat and the third from a well humified moss peat between the two trackways (2.78–2.83m OD). The fourth sample (2.66–2.71m OD) was taken beside the lower trackway and the lowest sample (2.57–2.62m OD) from a lower fibrous peat. One deposit, at 3.10–3.15m OD, contained too few fossils for a full preservation record, although the few remains seen were in quite good condition. Dilution by plant remains in a rather sterile environment is likely, since this was described as a 'moss peat'. The uppermost sampled layer (3.21–3.26m OD) contained

Table 44. Tinney's Tracks: macrofossil summary table.

	2.57–2.62m OD	2.66–2.71m OD	2.78–2.83m OD	3.10–3.15m OD	3.21–3.26m OD
Total macrofossils counted	100	94	93	0	69
Estimated total in sample	300	94	93	0	69
Total taxa	4	13	20	0	11
Total well preserved	21	41	52	0	24
Total <25% fragmented	27	28	19	0	21
Total 25%–50% fragmented	34	12	7	0	8
Total >50% fragmented	18	13	15	0	16
Total <25% erosion	23	37	27	0	16
Total 25%–50% erosion	13	28	22	0	3
Total >50% erosion	6	1	10	0	1
Preservation index	**2.16**	**1.98**	**1.90**	**0**	**1.53**

Table 45. Tinney's Tracks: properties of 250g unprocessed samples.

	Dry weight	0.25mm	0.5mm	1mm	2mm	4mm	Organic matter %
2.57–2.62m OD	44.93g	8.5g	7.4g	5.6g	3g		54%
2.66–2.71m OD	56.03g	4.1g	5.2g	4.3g	3.7g	4.6g	39%
2.78–2.83m OD	62.32g	4.1g	4.9g	4.1g	3.1g		27%
3.10–3.15m OD	40.46g	10.6g	14.2g	7.9g	4.7g		92%
3.21–3.26m OD	77.31g	4.1g	4.7g	3.1g			15%

Table 46. Tinney's Tracks: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
3.21–3.26	Small flot, plant detritus and crumbs of organic sediment. Few insects: mostly aquatics, others swmp forms.	Little potential even using a very large sub-sample. P3
3.10–3.15	Very large flot with abundant moss leaves and stems. Mites moderately numerous but almost no insects.	No significant potential even using a very large sub-sample; immensely time-consuming to sort. P3
2.78–2.83	Small flot with twig fragments, crumbs of humic sediment and rootlets. Very limited fauna of aquatic and swamp-tolerant forms.	Little potential even using a large sub-sample. P3
2.66–2.71	Small flot with lumps of humic sediment, plant fibres and some insect fragments. Mostly aquatic and marsh taxa, a single dung beetle (*Aphodius*).	Very limited potential unless to address some specific question. Large sub-sample (3–5kg) needed. P2
2.57–2.62	Very large flot of plant fibres. Mites quite common. Few insects, aquatic and marshland.	Evan a large sub-sample would probably not give useful numbers of remains. Very difficult to sort. P3

Table 47. Tinney's Tracks: preservation condition of invertebrate (principally insect) remains.

m OD	Chemical Erosion				Fragmentation				Colour change					Other properties
	range		mode	str	range		mode	str	To	range		mode	str	
3.21–3.26	4.0	5.0	4.0	W	2.5	4.0	3.0	W	–	–	–	–	–	Local decay spots on some fossils
3.10–3.15	–	–	–	–	–	–	–	–	–	–	–	–	–	Too few fossils; E ?2.0
2.78–2.83	2.5	5.0	4.0	W	2.5	5.0	3.5	W	Pale via	2	4	3	D	Some shrivelled fossils
2.66–2.71	2.0	5.0	4.0	D	2.0	5.0	3.5	D	Pale via brown	1	4	3	W	
2.57–2.62	1.5	3.5	2.5	W	1.5	3.0	2.5	W	–	–	–	–	–	

Table 48. Tinney's Tracks: Station 1.

Depth (cm)	Description
0–20	Pale brown (10YR 6/3) silty clay with common medium faint mottles of strong brown (7.5YR 5/6)
20–35	Very dark greyish brown (10YR 3/2) moist humose silty clay loam with common fine mottles of yellowish red (5YR 4/6)
35–70	Black (5YR 2/1) moist greasy amorphous peat (H9)
70–200+	Dark reddish brown (5YR 2/2) semi-fibrous grass-sedge peat (H6); moist becoming wet below 120cm depth.

Table 49. Tinney's Tracks: Station 2.

Depth (cm)	Description
0–25	Brown to dark brown (7.5YR 4/2) fine crumbly, slightly moist silty clay loam
25–35	Greyish brown (10YR 5/2) moist silty clay loam with common fine mottles of yellowish red (5YR 5/6)
35–120	Dark reddish brown (5YR 2/2) moist semi-fibrous grass-sedge peat (H6) containing occasional birch twigs
120–160+	Dark reddish brown (5YR 3/2) semi-fibrous grass-sedge peat (H5), and containing some mossy layers (raised moss remnant?)

Table 50. Tinney's Tracks: Station 3.

Depth (cm)	Description
0–25	Dark reddish brown (5YR 3/2) crumbly humose silty clay loam; contains occasional limestone fragments (presumably from past liming of the field)
25–35	Reddish grey (5YR 5/2) moist silty clay loam with few fine faint mottles of yellowish red (5YR 4/6)
35–45	Dark reddish brown (5YR 2/2) amorphous peat (H7) with some remains of *Sphagnum* discernible, and with some more fibrous layers evident; very moist
45–55	Dark reddish brown (5YR 3/2) wet semi-fibrous peat (H5) with *Sphagnum* remains
55–130	Black (5YR 2/1) amorphous peat with grass-sedge fragments
130–160+	Dark reddish brown (5YR 3/3) wet semi-fibrous grass-sedge peat (H5); smell of hydrogen sulphide

Table 51. Tinney's Tracks: Station 4.

Depth (cm)	Description
0–30	Brown to dark brown (7.5YR 4/2) moist crumbly silty clay loam
30–40	Greyish brown (10YR 5/2) silty clay with common fine mottles of strong brown (7.5YR 5/8) and some patches of dark material
40–52	Black (5YR 2/1) moist amorphous peat (H9)
52–63	Dark brown (7.5YR 3/2) wet semi-fibrous peat (H5) with *Sphagnum* remains
63–125	Black (5YR 2/1) amorphous peat (H8) with a few grass-sedge fragments
125–150+	Dark reddish brown (5YR 2/2) wet semi-fibrous grass-sedge peat (H6), with mostly roots and a few leaves

well decayed fossils (E 4.0–5.0), although fragmentation was not extreme. Some remains showed local decay spots, perhaps the result of assault by aerobic micro-organisms in the rhizosphere of the 'occasional modern roots'. Two of the sampled layers (2.78–2.83m OD and 2.66–2.71m OD) contained assemblages of insects with a substantial range of erosional states (worst fossils at E 5.0, and modes high at 4.0). These two also showed colour change (to pale via brownish), and there were some shrivelled fossils at 2.78–2.83m OD. These changes may be the result of recent de-watering, although both layers were 'moss peats', and the effect of the chemical regime within deposits of this kind (perhaps very acid?) is not known. Preservation in the lowest sampled layer (2.57–2.62m OD, an *Eriophorum* peat) was substantially better than in those above, with some fossils in good condition (E 1.5).

Monitoring of burial environment

David Hogan

Site descriptions

Transect: Northwards from ditch towards bushes, beginning 40m west from SE corner of field. Stations 1–3 at 5m, 20m and 40m. Station 4 is close to the excavation, 55m along South Drain SE corner, and 7m in from drain.

Land use: Maize stubble.

Station 1 (Table 48). Instrumentation: piezometers at 50cm, 100cm and 150cm depth.

Station 2 (Table 49). Instrumentation: piezometers at 50cm, 100cm and 150cm depth.

Station 3 (Table 50). Instrumentation: piezometers at 50cm, 100cm and 150cm, redox probes at 40cm, 75cmand 95cm depth.

Station 4 Table 51). Instrumentation: piezometers at 50cm, 100cm and 150cm depth

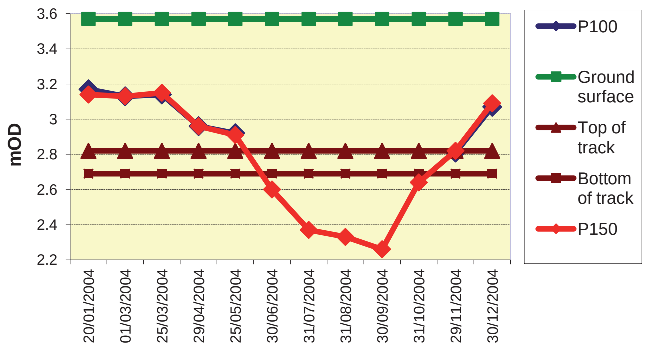


Figure 58. Water table at Station 4.

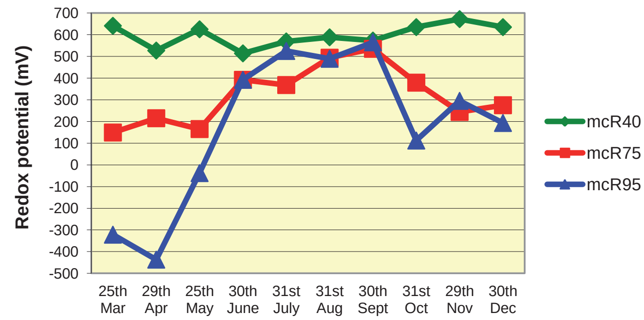


Figure 59. Redox potential at Station 4.

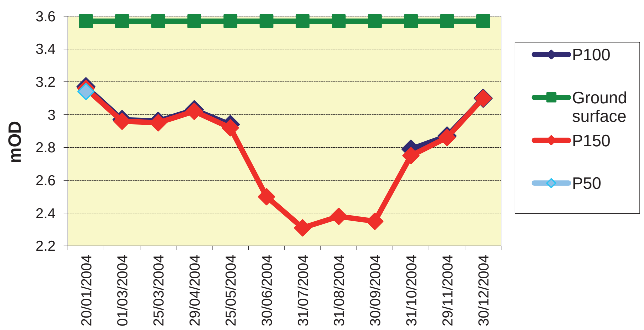


Figure 60. Water table at Station 1.

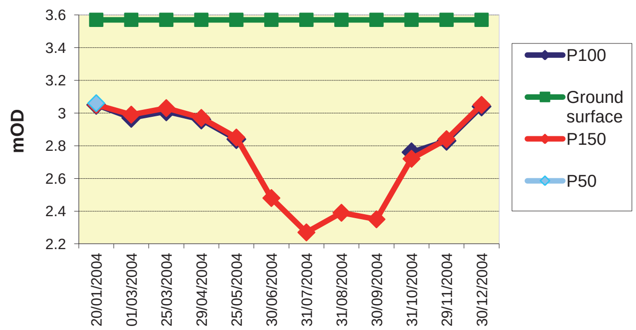


Figure 61. Water table at Station 2.

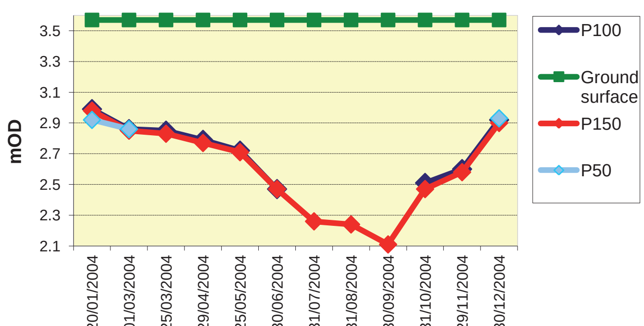


Figure 62. Water table at Station 3.

Results

Figure 58 illustrates the relationship between the layer containing the archaeology and the seasonal variations in soil water level at Station 4. From the end of June until the end of October, the water table was below the archaeological remains. Redox potential indicated a general lack of highly anoxic conditions (Figure 59). The R40 probe, just within the peat (overlain by 35cm of clay) indicated permanently *oxidised* conditions. The R75 probe, at an equivalent depth to the remains, recorded *slightly reduced* conditions throughout the year except one *oxidised* reading in the autumn. A clear seasonal pattern was evident, with a long gradual increase in oxidation from early spring through to autumn, until the trend reversed on the start of rewetting in October. The R90 probe, set deeper than the remains, showed the most reduced conditions, though with a similar pattern to R75. Conditions became *moderately reduced* in the late spring, though still became *oxidised* in the summer and autumn.

The seasonal pattern of fluctuation in the water table depth was also seen at the other stations (Figures 60–2), where the summer draw-down was sufficiently large that a complete record of the water table position could be obtained only from the deepest (1.5m) piezometer. Groundwater sampled from piezometers beside the trackway had a pH of 7.0 and water from the South Drain at the northern side of the field had a pH of 7.7.

Conclusions

The substantial period when the water table fell below the level of the archaeology together with the record of only *slightly reduced* conditions throughout most of the year are unlikely to be sufficiently anoxic to prevent continued degradation of the organic remains under present environmental conditions.

Preservation conclusion

The wooden components of the trackways were in a partially decayed condition but archaeological

Figure 63. Excavation of the Chilton 4 Track by the Somerset Levels Project.

information in the form of toolmarks and species identifications were still recordable. The hydrological regime suggests that the structure could be at risk of desiccation and oxidising conditions during the summer months despite its comparatively deep burial depth.

4. Chilton Tracks fieldwork

HER 10938; SM 27976

Previous fieldwork

The first mention of trackways on Chilton Moor was made by Dymond (1880, 108) who had been informed of some running between Burtle Island and the Polden hills. In 1933 Bulleid followed up on the report and interviewed local people who provided some further confirmation of their existence, which resulted in one trackway being named the Tidball Track after a local man had discovered it in his orchard (Bulleid 1933). The Tidball track is likely to be a southerly extension of one of the Chilton Tracks.

In 1968 Colin Clements tried to relocate the trackways without success until in the same year the Somerset River authority widened the old Glastonbury Canal and created supplementary drainage ditches. This allowed the discovery of numerous trackways, including thirteen trackways in the Chilton complex over a 500m width. Slightly further to the east the Burtle Bridge complex consisted of at least another 12 trackways of broadly similar date to the Chilton ones.

John Coles undertook the only excavations on the Chilton tracks in 1969 (Coles *et al*. 1970). These excavations examined short stretches (up to 5m long and 2m wide) of trackways 1, 2, 4 and 5 (Figure 63). Pollen analysis was undertaken from samples beside trackways 1, 4 and 5. In the case of trackway 1 the sampling reached the bottom of the peat at a depth of 0.95cm below ground (*ibid*., 134) where it rested on the blue-grey estuarine clay that underlies the peat across the whole of the central Brue valley.

The Chilton tracks are formed of longitudinally laid brushwood pegged down over transverse rods. Track 1 was made of straight hazel rods 2–3m long, with average diameters of 40mm. These poles may have been derived from coppiced woodland. The substructure consisted of birch roundwood transverse members augmented by patches of birch brushwood in wetter areas.

Tracks 2–6 were very similar in their construction. The brushwood was almost exclusively birch roundwood of 40–100mm diameter, up to 3m long. The material was laid in bundles 15–20cm deep over transverse birch roundwood of *c*. 40mm diameter and average length of 1m. The mass of wood was held in place by small roundwood pegs of birch and hazel.

Track 4 has been dated to 3660–3370 cal BC (Lu-327, 4760±65 BP) and track 1 has a date of 3700–3360 cal BC (HAR-649, 4760±80 BP). The trackways are therefore

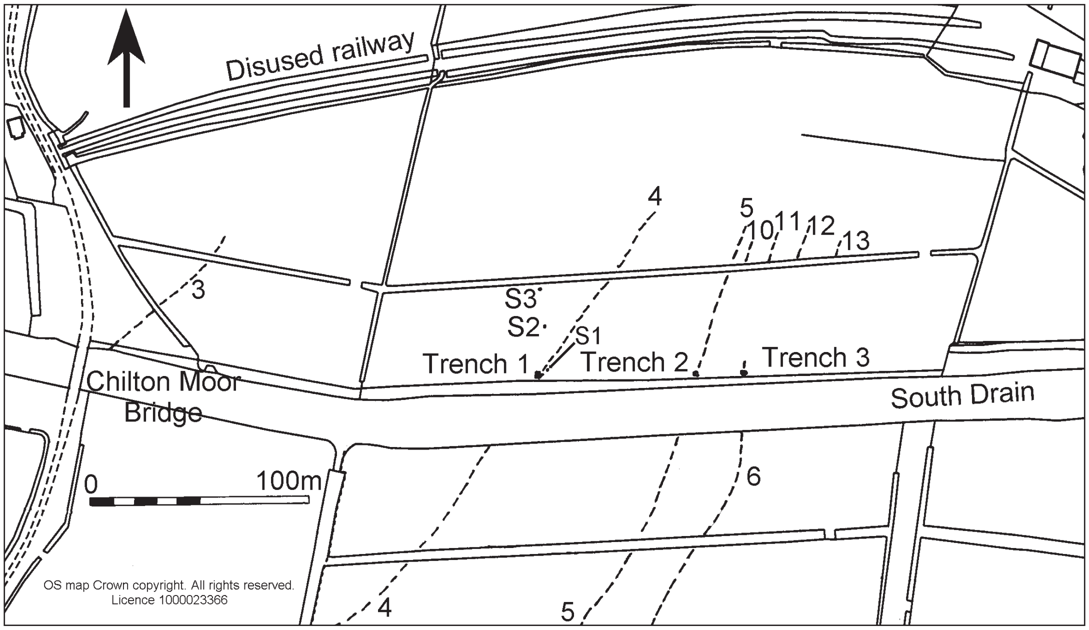


Figure 64. Location map of Chilton Tracks.

broadly contemporary although their close proximity suggests that at any one time only one track may have been in existence, to be replaced by another on a nearby line after a few years.

The environment that the trackways crossed consisted of extensive fen woodland with patches of reeds in the wetter areas (Coles *et al*. 1970). This palaeoenvironmental information was derived from a location relatively close to Burtle island. It is therefore possible that slightly different conditions prevailed further south along the route of the trackways.

Turbary rights on Chilton Moor can be traced back to at least AD 1199 (Somerset Record Society, vol. 68, 55) and peat from the moor appears to have been used as the fuel for the extensive Romano-British salt industry located on the western edge of the area (Brunning and Farr-Cox 2006). Extensive peat cutting continued into the 20th century. It is therefore not surprising that only the peat of the early Neolithic period still survives over most of the moor, all subsequent deposits having been cut away. One benefit of this destruction is that the water table remains very close to the ground surface, even during the summer months, because of the low level of the moor.

The Chilton tracks have been traced across Chilton Moor by Colin Clements for a distance of roughly 500m but this was very difficult because the structures were below the water table for most of the year (Coles *et al.* 1970, 127). This suggests that the trackways may still survive over virtually their whole original route of *c*. 2km between Burtle island and the Polden hills.

MARISP excavation results

The MARISP fieldwork was designed to examine some of the trackways John Coles had previously examined in 1968 in a field at ST388427 (Figure 64). Trench 1 (2 × 2m with a 0.5 × 1m extension to the east) was located across the line of Chilton track 4. The track was located under *c*. 40cm of black, well humified, peat and existed across the whole 2m length of the trench. The ground surface was 1.82m OD and the top of the trackway was between 1.4m and 1.6m OD. In one area it had been badly damaged by a 10cm wide clay filled cut that ran obliquely across the trench. This may have been a shallow drainage feature.

The structure consisted of numerous straight roundwood stems laid along the line of the route directly on the raised bog surface. These formed a walkway surface 0.8–1.1m wide. The structure was not very thick, in the main part formed of only one or two layers of brushwood. The diameters of the roundwood varied from 10mm to 60mm with the vast majority of 20–30mm (Figures 65 and 66).

No vertical pegs were recorded but the peg tops may have been hidden by the spread of the horizontal brushwood, so their absence could only have been proved if all the brushwood had been lifted. A few individual stems existed either side of the trackway suggesting the discarding of some material during construction or the slight disintegration of the trackway during or after its active life.

Fifteen samples were taken at random from the

Figure 65. Excavation of Chilton Track 4 in Trench 1, looking south. Scale 1m.

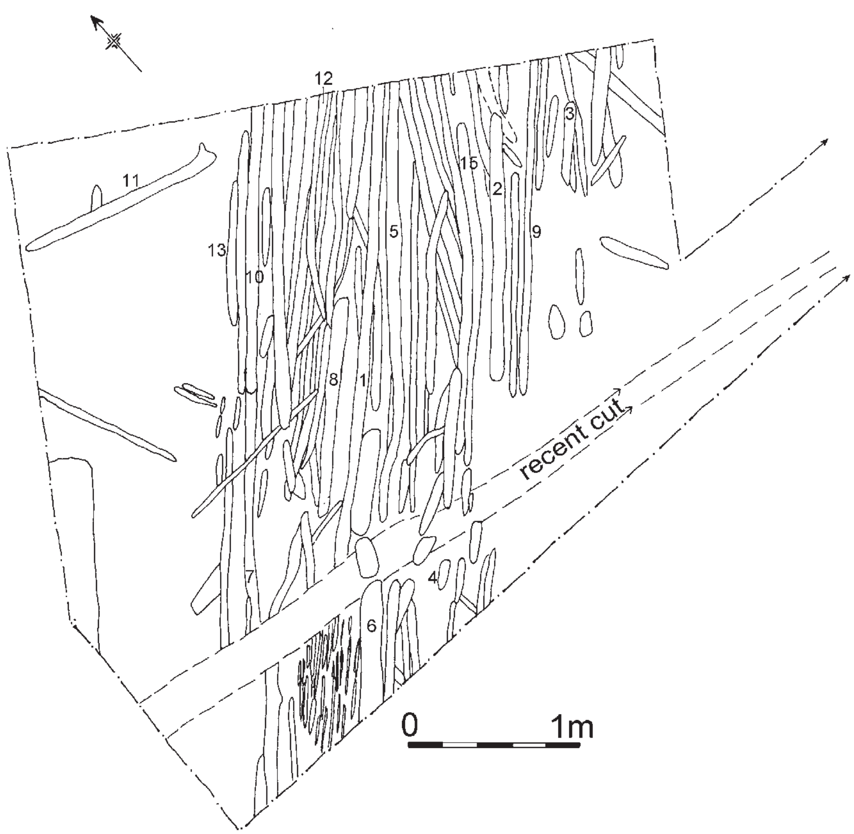


Figure 66. Trench 1 plan. Chilton Track 4.

Figure 67. Excavation of Chilton Track 5 in Trench 2 showing recent damage, looking north. Scale 1m.

structure for species identification by Rowena Gale. Two of the samples were too degraded for identification. Of the remainder three were hazel stems, 8–10 years old, and 10 were birch between 7 and 22 years of age. The palaeoenvironmental assessment samples were taken from the northern corner of the trench immediately beside the trackway.

Trench 2 (1 × 1.6m with an eastern extension of 0.3 × 0.3m) was located over Chilton track 5. The remains of the trackway were present running obliquely across the trench (Figure 67). The structure was present in a fragmentary condition under 27cm of black, well humified, peat. It was almost completely destroyed over a distance of 0.6m from the southern edge of the trench. In this area all that remained was an area of disturbed peat and wood fragments. This probably represents the previous excavation area from 1968.

In the northern part of the trench the trackway had also been damaged in three places where only wood fragments remained amongst disturbed peat. The heavy machinery used on the adjoining South Drain in the 1970s may have caused this damage. One possibility is that the stabiliser pads of a JCB sinking into the soft peat caused the roughly square patches of disturbance.

Where it survived the structure consisted of roundwood of 10–30mm diameter, laid along the line of the trackway. Only one layer of wood was present and the brushwood was more dispersed over the 1.0m wide trackway than was the case with track 4. No pegs were noted anywhere in the excavation. The only piece sampled was identified as birch roundwood.

As the first two trenches had been completed quickly, a third trench was opened further to the east where decayed brushwood was visible in the bank of the South Drain. The trench was 0.6m wide and 4m long. The western 0.5m of the trench contained a mixture of disturbed peat, clay and stone that was not bottomed. A layer of bark fragments occurred 1–2m from the western end of the trench at a depth of 22–27cm below the ground surface. The overlying material consisted of black, well humified peat. Only a few traces of wood survived adhering to the bark. The bark itself was orientated in many different directions although the layer clearly crossed the trench in the direction of Burtle island. This deposit is likely to represent the remains of a very poorly preserved trackway where the wood has almost completely decayed leaving just bark fragments. This pattern of decay is what may be expected from birch wood that is very easily decayed, often leaving just the bark surviving. This decay could have occurred recently (see below) or may have taken place in the Neolithic because this part of the track crossed a slightly drier hummock where decay was more advanced before the structure entered a more stable burial environment.

The ground surfaces at Trenches 2 and 3 were recorded at 2.30m OD and 2.36m OD respectively. These are significantly higher (54–57cm) than the ground surface at Trench 1. This difference in surface height was not readily apparent in the field, suggesting that an error in levelling is a possibility. However, the edge of Burtle island projects southwards into the moor in the field to the east of the excavations so the greater height of the ground surface in Trenches 2 and 3 would be consistent with a rise in the underlying geology. The palaeoenvironmental assessment undertaken in 1968 suggested that Chilton 5 was created significantly earlier than Chilton 4 and 1 (Coles *et al*. 1970, 139). Unfortunately the published excavation of 1968 contained no OD heights. The rising ground surface around trenches 2 and 3 would also explain the much poorer state of preservation of the wooden remains.

Dating

No dating was undertaken because the existing radiocarbon dates were thought sufficient.

Palaeoenvironmental analysis

No analysis was undertaken because the previously published work provided sufficient landscape setting for the monument.

Fieldwork conclusion

The MARISP excavations only recorded two very short sections of the Chilton tracks, one of which was in a very poor condition. A good record of the Chilton 4 structure was made and analysis of the species used in its construction provides reinforcement for the composition of the brushwood suggested from previous work.

Chilton Tracks assessment and monitoring

Assessment of preservation

Visual assessment of wood

All the wooden remains were vertically compressed. This may have been caused by the weight of the overlying peat deposits (now removed) or by tractors and Environment Agency machines tracking over the structures. The wooden remains in Trenches 2 and 3 were in a very poor state of preservation with significant deterioration visible and very poor surface condition. The wood in Trench 3 had almost totally decayed, just leaving the bark.

The wood in Trench 1 was in a better condition and retained its shape and form. Surface condition was moderate. No cut ends were lifted so the quality of toolmark evidence was not recorded. The condition of the wood was sufficiently good to identify 13 out of 15 samples from the structure.

Table 52. Chilton Tracks: moisture content values and the state of degradation.

Timber no.	% Moisture content	Timber condition
1	354	Medium degraded
2	914	Heavily degraded
7	638	Heavily degraded
8	623	Heavily degraded
9	722	Heavily degraded
Track 5	468	Heavily degraded

Table 53. Chilton Tracks: wood species, % moisture content (MC) and density.

Timber no.	Wood species	%MC	Original density	Present density
1	Hazel	354	0.58	0.23
2	Hazel	914	0.58	0.10
7	Birch	638	0.62	0.14
8	Birch	623	0.62	0.14
9	Birch	722	0.62	0.12
Track 5	Birch	468	0.62	0.18

Detailed examination of wood structure

Mark Jones

The state of degradation, as given by the moisture content and taken from an average of three samples from each of the timber supplied is presented in Table 52. The condition of timber samples excavated from this site range from medium to heavily degrade. There are some variations in the degree of degradation between each timber sample. None of the timbers examined had moisture contents below 185% (slightly degraded).

Table 53 lists the range in density values of each wood species. All recorded density values of Chilton trackway timbers are low (between 0.23 and 0.10) indicating substantial losses of original cell wall material.

Wood from the Chilton site has been identified as hazel and birch. All birch samples were highly decayed and different stages of degradation were apparent. In the outer surface, secondary wall layers were extensively degraded and patterns of decay suggest attack by erosion bacteria. These bacteria have been reported to be the most common type of bacterial degraders in wood, which has been exposed to oxygen limiting environments. With the exception of timber 2 (hazel, class II), all timbers at this site were extensively degraded throughout. However, micro-morphological observations of deteriorated hazel and birch from this site showed the anatomical characteristics of these

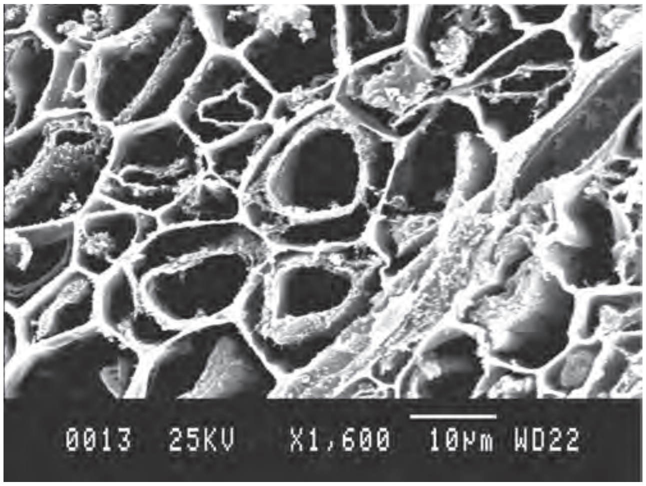


Figure 68. Transverse section through hazel (CT03–1).

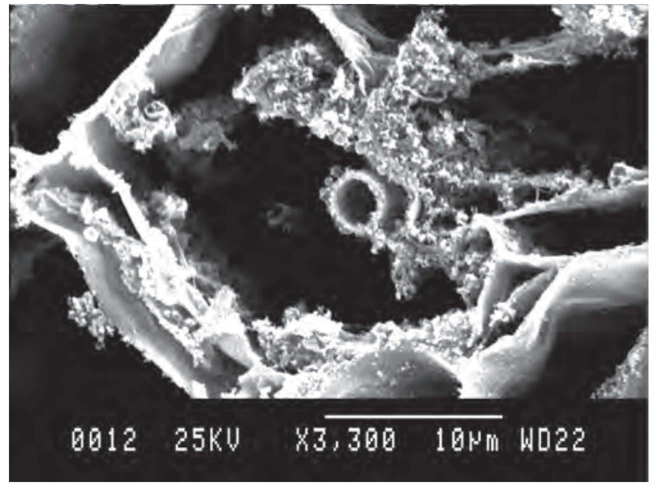


Figure 69. SEM of hazel (1).

wood species were still clearly evident. Figure 68 is a transverse section through timber 1 (archaeological hazel). Cells are medium grade with residual secondary wall layers intact. Middle lamella is the best-preserved cell wall layer. Close examination of the secondary wall layer indicates ancient attack by bacteria and fungi both groups of microbes capable of utilising carbohydrates for energy (Figure 69).

Although, the middle lamellae remained relatively intact, this thin, lignified framework does not provide binding strength to the cell wall and results in wood that is exceedingly weak. In many regions, particularly in the outer surface layers, the cells were collapsed suggesting that timbers buried at this site had been subjected to partial dehydration during burial.

Bacterial attack of hazel and birch samples at this site is fundamentally a chemical process that often leads to selective alteration of specific compounds and structures. Thus, to understand fully the changes to valuable archaeological samples, it is essential to investigate chemical changes to this complex solid mixture.

FT-IR spectra obtained for recent and archaeological hazel and birch are shown in Figures 70–1. The spectra for fresh hazel (Figure 70) is dominated by absorptions due to cellulose, however there are additional peaks characteristic of hemicellulose (1732 cm^{-1}) and 1506 cm^{-1} (lignin). The lignin peak in archaeological hazel (1) is very prominent, whilst the hemicellulose signal has been lost through degradation. Other changes include decreased absorptions at 897cm^{-1} and 1370cm^{-1}. These are variously taken as indicators of amorphous/ordered cellulose suggesting that the degree of crystallinity and holocellulose content has been reduced in the ancient hazel sample.

Figure 71 shows the spectra for archaeological birch (7 and 9) and modern birch. Once again we have prominent lignin peaks for the ancient birch samples whilst the hemicellulose peak at 1731cm^{-1} has been lost. Another notable change to ancient birch is the decreased absorption at peaks 1371 cm^{-1} and 897cm^{-1} indicating a loss of cellulose content. The condition of wood found at this site would irreversibly collapse upon drying.

Pollen evidence

Heather Tinsley

Three samples were assessed, the basal one at 1.03–1.04m OD was from below the track in wet, well-humified peat with few plant remains visible. The peat became drier higher up the section, and a second sample was assessed from the level of the track at 1.29–1.30m OD. Above this, the peat had further dried out and desiccation cracks were visible extending down from the ground surface. The upper sample assessed was from 1.32–1.33m OD, just above the track.

Palaeoenvironment

1.03–1.04m OD. Tree pollen: 61% TP, principally *Corylus*-type and *Betula*, with *Quercus* and some *Alnus* with occasional grains of *Fraxinus*, *Ulmus*, *Tilia*, and *Salix*. Herbaceous pollen: 39% TP, dominated by Cyperaceae and Poaceae with occasional *Sparganium emersum*-type (bur reed of lesser bulrush) and *Typha latifolia* (bulrush). 2 grains of *Calluna vulgaris*. 58 undifferentiated fern spores and 40 spores of *Thelypteris palustris* (marsh fern).

1.29–1.30m OD, 1.32–1.33m OD. Tree pollen: 80–87% TP, dominated by *Corylus*-type, with *Alnus*, *Quercus*

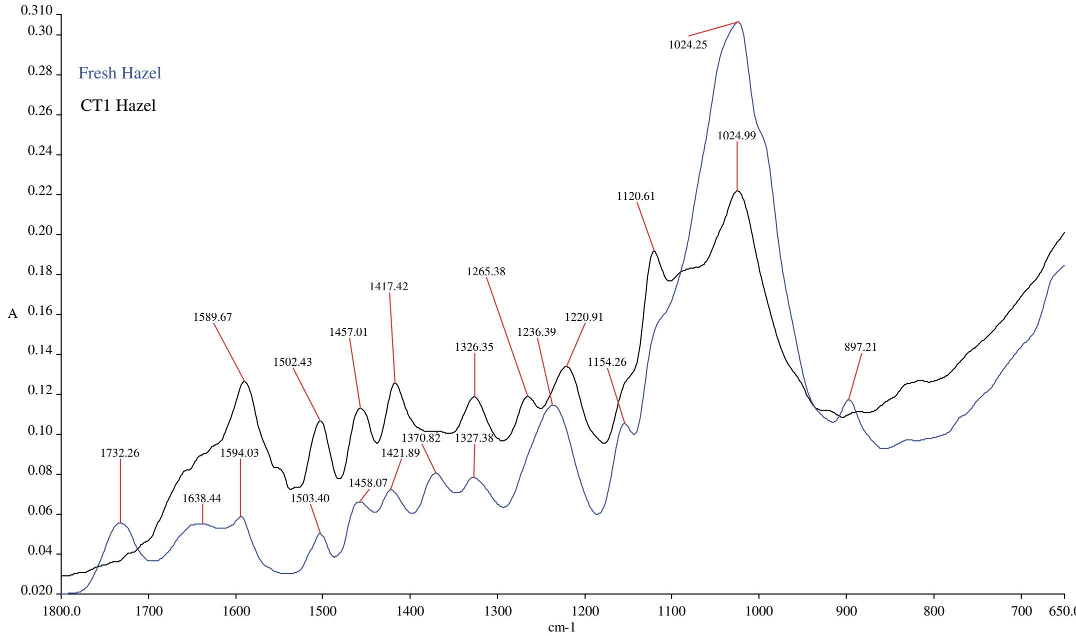


Figure 70. FT-IR spectra (1800–600cm^{-1}) of Chiltern Brushwood timber sample 1 (hazel) and modern hazel.

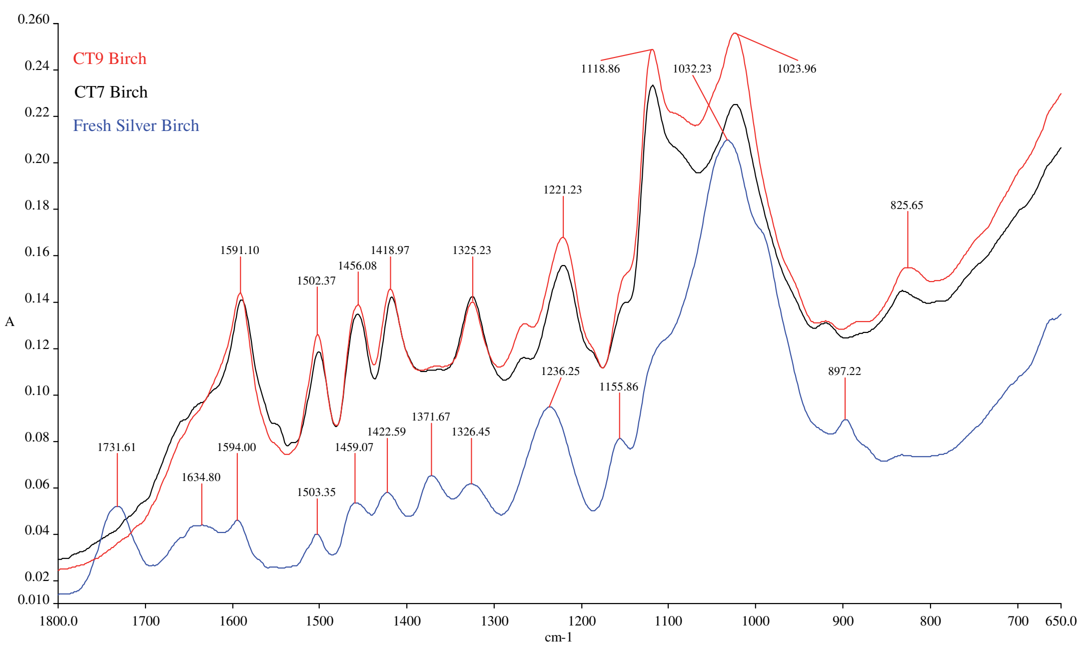


Figure 71. FT-IR spectra of Chilton Brush timber samples 7, 9 (both birch) and modern birch.

and some *Betula* with occasional grains of *Pinus, Ulmus, Tilia* and *Fraxinus*. Herbaceous pollen 20–13% TP, mainly Cyperaceae, with occasional grains of Poaceae, *Sparganium emersum*-type and *Typha latifolia*. In the upper sample there were occasional grains of herb taxa indicative of disturbance, including *Plantago lanceolata* (ribwort plantain), *Artemisia*-type (mugwort), and *Urtica* (nettle). Undifferentiated fern spores were very frequent, (540–1419) with occasional spores of Polypodiaceae and *Pteridium aquilinum*.

Prior to the construction of the track at 1.03–1.04m OD, the environment at the site appears to have been dry fen woodland, dominated by birch and hazel with some alder and willow, and oak on the higher

Table 54. Chilton Track: pollen preservation summary.

	1.03–1.04m OD	1.29–1.30m OD	1.32–1.33m OD
Total identified pollen grains	100	100	100
Pollen concentration	121,000	46,400	77,300
Number of pollen taxa	13	13	13
Total indeterminable grains	4	5	17
Total identified extensively corroded grains (a)	14	20	18
Total identified extensively degraded grains (b)	10	40	28
Total identified extensively crumpled grains (c)			
Total identified extensively broken grains (d)	1	2	1
Total identified grains with poor preservation (a+b+c+d)	25	62	48
Total well-preserved grains	30	10	15
Total grains of resistant taxa	3	6	3
Total ferns			
Biochemical preservation index			
Mechanical preservation index			

land. The ground flora was dominated by sedges with grasses (the stratigraphy suggests that common reed was present) and ferns, including the marsh fern, *Thelypteris palustris*. Higher up the stratigraphic sequence alder became increasingly important in the fen woodland, apparently at the expense of birch. Possibly this reflects wetter conditions on the surface of the peat which precipitated the building of the track. Ferns continued to make a major contribution to the ground flora; the huge numbers of fern spores present reflect fern dominated communities on-site, as sporangia were frequent in the pollen preparations. The influence of disturbance due to human activity in the area is suggested by the presence of occasional pollen of ribwort plantain, mugwort and nettle at 1.32–1.33m OD, towards the top of the section.

Pollen preservation

The pollen preservation at this site was best in the sample from below the track at 1.03–1.04m OD where 30% of all grains were well preserved and only 4 were indeterminable (Table 54). 25% of grains identified had poor preservation, of these 14 suffered from extensive corrosion, principally *Betula* and *Corylus*-type, and 10 were extensively degraded. 23% of all grains identified suffered from partial corrosion and at least 8% from partial degradation. 15% of grains showed some mechanical damage. The biochemical preservation index was 1.16 and the mechanical preservation index was 0.29. Many of the fern spores present were partially split and whereas some were well preserved, others showed some etching of the surface.

Higher up the stratigraphic sequence, at 1.29–1.30m OD, pollen preservation was markedly worse, with only 10% of grains well-preserved and five indeterminable grains. 62% of all identified grains had poor preservation, with extensive corrosion again affecting the grains with smooth exines such as *Corylus*-type, *Betula* and *Alnus* and extensive degradation occurring across a wide range of taxa. 14% of all identified grains were partially corroded and >10% of identified grains were partially degraded. 19% of all grains showed some mechanical damage. The biochemical preservation index was 1.99 and the mechanical preservation index was 0.32. Fern spore preservation was very variable, some were well preserved, but others were very thin and/or badly etched (Plate 17: Appendix 3).

Preservation of identified grains appeared slightly better at 1.32–1.33m OD with 15% of grains well-preserved, and 48% with poor preservation. However, there was a substantial number of indeterminable grains (17%), of which the majority were very extensively corroded. Of the grains identified, 7% showed partial corrosion and >14% were partially degraded. Mechanical damage was apparent in 17% of grains. The biochemical preservation index was 1.75 and the mechanical preservation index was 0.30. The majority of the fern spores were highly etched.

Pollen preservation in the Chilton Track samples varied from poor to moderately good. At this site, corrosion was quite marked at all depths, suggesting relatively high biological activity, either currently or in the past. However, compared with other MARISP locations, this site had particularly high numbers of pollen grains of taxa with smooth exines (*Betula, Alnus, Corylus*-type), and it may be that the high incidence of corrosion is simply a reflection of the taxonomic composition of the assemblage, rather than a 'real' difference in processes operating in the sediment.

Table 55. Chilton Tracks: stratigraphy.

Stratigraphy	Plant macrofossil/beetle samples
1.31–1.49m OD Black well humified peat. Modern roots visible. Desiccation cracks	1.31–1.36m
1.31m OD Level of trackway surface	
0.99–1.31m OD Black well humified peat becoming increasingly wet with depth. Some modern roots, but these cease by 1.05m OD. Water table at 1.00m OD.	1.26–1.31m 1.00–1.05m

The best preservation was found in the lowest sample assessed (1.03–1.04m OD), where the peat appeared waterlogged, however, even here preservation was only moderately good.

Higher up in the stratigraphy, where the peat became drier, preservation was poorer, undoubtedly due to drying out, and desiccation cracks were visible in the upper peat. The two samples from the dry peat contained very large numbers of fern spores, and, as with the Bell Track, the presence of sporangia in the pollen preparations indicates that ferns were growing on the peat and decaying *in situ*, with the possibility of subsequent differential decay of more susceptible pollen taxa resulting in further concentration of spores. The worst preservation was at 1.29–1.30m OD, at the level of the track, though the difference between the preservation indices in this sample and those from the peat 0.03m above is probably not significant. There was no evidence to suggest any serious contamination by modern pollen resulting from the desiccation cracks, though the occasional pollen grains of ribwort plantain and nettle at 1.32–1.33m OD might have washed down the profile, as both these plants were recorded as growing close to the sampling site.

The basal sample assessed from the Chilton Track, 1.03–1.04m OD, sequence has the potential for full pollen analysis. The sample from 1.29–1.30m OD should be rejected on the grounds of the very high number of grains with poor preservation; almost certainly less resistant taxa will have been differentially lost from this assemblage. The upper sample from 1.32–1.33m OD is also of marginal value for full analysis.

Plant macrofossils

Julie Jones

Three samples were taken (Table 55), one from the peat below the track (1.00–1.05m OD), one from the level of the track (1.26–1.31m OD) and one from above the track (1.31–1.36m OD).

Palaeoenvironment

A birch dominated environment is suggested from the macrofossils recorded in the peat below the trackway with both downy birch and silver birch. Downy birch is more typical of damper peaty soils and is likely to have grown in association with greater tussock-sedge and other sedges, with bulrush (*Typha*) suggesting some areas of standing water. In contrast silver birch prefers lighter, drier soils than downy birch so these may have colonised woodland nearby where the ground surface was drier, with the light wind-borne seeds being deposited at this location. The assemblages recovered from both the level of the track and the overlying peats were small although birch and sedge continues to occur. Seeds of bog bean (*Menyanthes trifoliata*) suggest areas of shallow water in wetter parts of the fen, which would also have provided a habitat for the abundant *Sphagnum* leaves in the peat above the level of the track.

Preservation

The preservation results are shown in Tables 56–58.

1–1.05m OD: The best preservation occurred in the peat below the track, with an estimated 500+ seeds/fruits in the sample, although species diversity was low with only seven taxa recorded. Small wood fragments, frequent bud scales and moss branches devoid of their leaves also occurred. Birch fruits dominate the sample, the majority lacking wings, therefore determined as *Betula* sp and showing up to 25% fragmentation with only slight deterioration of the fruit epidermis. Some well preserved fruits allowed identification of both downy and silver birch. In silver birch fruits the wings are more than twice as wide as the body and extend well beyond the stigmas at the apex (Figure 4: Appendix 4). There were several well preserved achenes of greater tussock-sedge although many of the other sedges (*Carex*) were not only fragmented but showed erosion of the epidermal cell pattern; therefore identification to species may not be possible.

Table 56. Chilton Track: preservation of plant macrofossils.

Below level of trackway								
		Fragmentation				**Erosion**		
1.00–1.05m OD (44–49cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula pendula	16	16	0	0	0	0	0	0
Betula c.f. *pendula*	5	5	0	0	0	0	0	0
Betula pubescens	5	5	0	0	0	0	0	0
Betula sp	54	0	43	7	4	4	3	0
Carex paniculata	2	2	0	0	0	0	0	0
Carex spp	15	5	5	0	5	4	3	4
Poaceae indet	1	0	1	0	0	0	0	0
Typha sp	2	0	2	0	0	0	0	0
Other macrofossils: occasional wood/stems, frequent bud scales and moss branches – no attached leaves								
Level of trackway								
		Fragmentation				**Erosion**		
1.26–1.31m OD (18–23cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula sp	3	0	2	1	0	1	0	0
Menyanthes trifoliata	29	2	0	7	20	13	3	11
Typha sp	1	0	1	0	0	0	1	0
Other macrofossils: frequent wood/twigs/bark, occasional buds and leaf abscission pads								
Above level of trackway								
		Fragmentation				**Erosion**		
1.31–1.36m OD (13–18cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula sp	4	0	3	1	0	0	0	1
Carex spp	7	6	1	0	0	1	0	0
Menyanthes trifoliata	9	0	0	2	7	5	3	1
Ranunculus lingua	2	2	0	0	0	0	0	0
Other macrofossils: occasional wood/stems and charcoal, abundant *Sphagnum* leaves and capsule lids								

Table 57. Chilton Track: macrofossil summary table.

	1.00–1.05m OD	**1.26–1.31m OD**	**1.31–1.36m OD**
Total macrofossils counted	100	33	22
Estimated total in sample	500	33	22
Total taxa	7	3	4
Total well preserved	33	2	8
Total <25% fragmented	51	3	4
Total 25%–50% fragmented	7	8	3
Total >50% fragmented	9	20	7
Total <25% erosion	8	14	6
Total 25%–50% erosion	6	4	3
Total >50% erosion	4	11	2
Preservation index	**1.25**	**4.06**	**2.18**

Table 58. Chilton Track: properties of 250g unprocessed samples.

	Dry weight	**0.25mm**	**0.5mm**	**1mm**	**2mm**	**Organic matter %**
1.00–1.05m OD	30.71g	5.7g	5.2g	3.9g	3.2g	59%
1.26–1.31m OD	49.02g	4.2g	4.8g	7.2g	5g	44%
1.31–1.36m OD	47.6g	5.3g	4.8g	7g	4.4g	45%

Preservation index 1.25. 7 taxa in 100 counted. Analysis possible. Larger sample may increase species diversity.

1.26–1.31m OD: Species diversity was low at trackway level with only three taxa out of 33 macrofossils counted. The bulk of the sample float was composed of wood fragments, although up to 50% of the float <2mm was unbroken down sediment. Although 29 counts were recorded for bog bean, 20 of these were from small fragments (>50%), but were still recognisable from the smooth shiny surface and may represent only a few whole seeds. As a result the preservation index for this level (4.06) is high.

Preservation index 4.06. 3 taxa in 33 counted. Analysis not recommended

1.31–1.36m OD: Species diversity and abundance was also low in the peat overlying the trackway with four taxa out of 22 macrofossils counted. Occasional wood fragments occurred although 50–60% of the <2mm float comprised individual *Sphagnum* leaves with abundant capsule lids. Bog bean seeds were again fragmented, none of the birch fruits retained wings and most of the sedge fruits were entire showing little deterioration, although these were not identified to species level.

Preservation index 2.18. 4 taxa in 22 counted. Analysis not recommended.

Recommendations

Macrofossil preservation was variable at Chilton with the best preserved remains below the level of the track. Species diversity was however relatively low and although the 250g sample contained an estimated 500+ fruits/seeds no additional taxa were noted in addition to those in the 100 assessment count. The preservation index was low at 1.25, accounted for partly by the well-preserved fruits of *Betula pendula* and *Betula pubescens* with the majority of other *Betula* suffering only loss of the delicate wings but with the rest of the fruit entire. Sedges suffered a greater degree of deterioration and many are unlikely to be identifiable to species. There is some potential for further analysis with the processing of a larger sample.

The two samples at the level of and above the trackway are not recommended for further analysis. Species diversity and abundance were low. The many fragmented remains of bog bean are thought likely to represent only a few individual seeds and accounts for the high preservation index for the peat sample at trackway level.

Coleoptera

Harry Kenward

Three samples were assessed, one from immediately above the trackway (1.31–1.36m OD), one from immediately below (1.26–1.31m OD) and one further down the profile (1.00–1.05m OD). Preservation varied within a fairly tight range (best and worst values of both E and F fell in the range 2.0–3.5), though there was appreciable colour change in the middle sample (mode 3 – 'strong' change), and some in the lowest sample (Tables 59 and 60). That these changes were seen in the lower layers may indicate ancient decay rather than the effect of recent dewatering.

Table 59. Chilton Track: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
1.31–1.36	Flot of moderate size, herbaceous detritus. Limited number of insects, some aquatics but predominantly from moist semi-terrestrial conditions.	Large (3–5kg) sub-sample would give useful group and clarify local ecology. Difficult identifications. P1B
1.26–1.31	Quite small flot, mostly herbaceous detritus, perhaps some rhizome fragments. Rather few insects, predominantly aquatics (e.g. *Ochthebius* sp., *Hydraena*, *Hydroporus* spp.) and waterside taxa.	Very large sub-sample needed to determine water quality in detail; difficult identifications; limited potential. P2
1.00–1.05	Very large flot, herbaceous detritus. Moderately large numbers of insects, dominated by aquatics (e.g. Hydroporinae spp., *Ochthebius* sp., *Limnebius* sp., various Hydrophilinae, *Microvelia* sp.). Remaining fauna all able to utilise swamp litter or emergent vegetation.	Larger sub-sample (3kg) would give good fauna; refined data concerning water quality obtainable, but little beyond this. Difficult identifications. P1B

Table 60. Chilton Track: preservation condition of invertebrate (principally insect) remains.

m OD	Chemical Erosion				Fragmentation				Colour change					Other properties
				str				str	To				str	
1.31–1.36	2.0	3.5	2.5	W	2.0	3.5	2.5	W	–	–	–	–	–	
1.26–1.31	3.0	3.5	3.0	W	2.0	3.0	2.5	W	Orange, pale	2	3	3	D	
1.00–1.05	2.5	3.5	2.5	D	2.0	3.5	2.5	W	Pale	1	1	1	S	

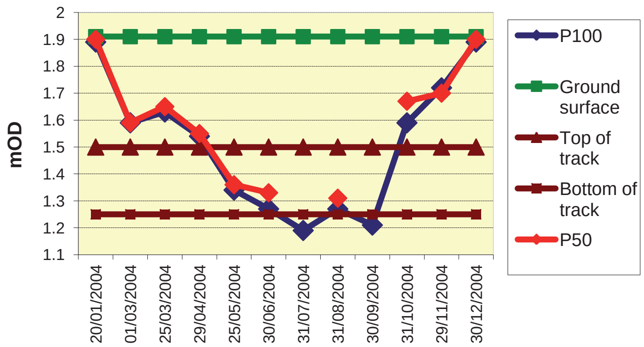


Figure 72. Water table at Station 1.

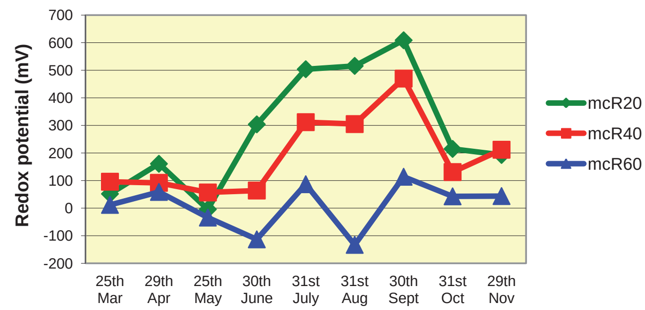


Figure 73. Redox potential at Station 1.

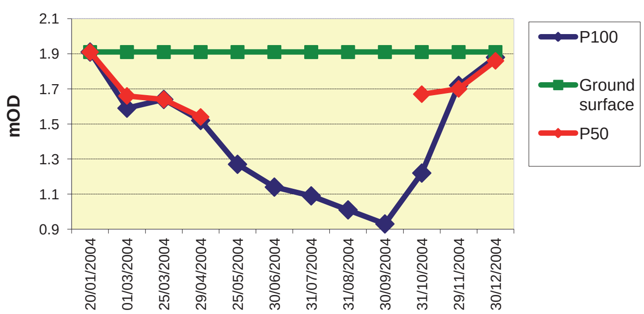


Figure 74. Water table at Station 2.

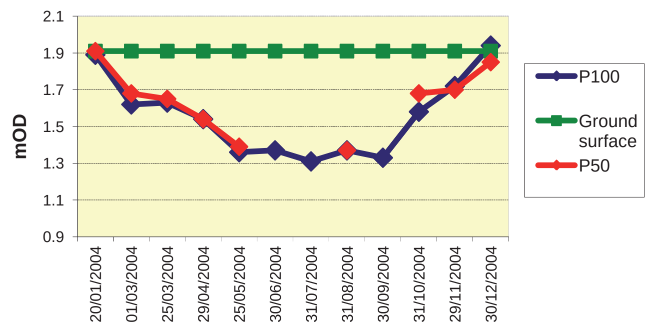


Figure 75. Water table at Station 3.

Monitoring of burial environment

David Hogan

Site description

Transect: Begins 5m east of excavation with three stations at 5m, 25m and 45m from South Drain running north towards small bramble patch (Figure 64).

Land use: Permanent pasture of mesotrophic grassland.

Station 1 (Table 61): piezometers at 50cm and 100cm, redox probes at 20cm, 40cm and 60cm depth.

Station 2 (Table 62): piezometers at 50cm and 100cm.

Station 3 (table 63): piezometers at 50cm and 100 cm.

Results

Water levels fluctuated from standing more or less at the surface in winter to between 70cm and 100cm depth in the summer (Figures 72, 74 and 75). Archaeological material occupies a very thin layer at about 50cm depth. Figure 72 indicates that the water table drops below the level of the wood from late May until mid-October, falling during that period some 20cm below the remains. Redox measurements (Figure 73) indicate conditions at the depth of the archaeology to move from *moderately reduced* in the spring and early summer to *slightly reduced* from later summer through to the end of the year, when it appeared that pre-summer conditions were becoming re-established. Groundwater from piezometers beside the trackway had a pH of 7.7, while a pH of 7.5 was recorded from a ditch on the east side of the field.

Conclusions

Prospects for preservation are moderate, since truly *oxidised* conditions did not appear to develop during the monitoring period, despite the water table falling below the level of the remains, though not substantially. It is likely that the archaeology remained within the zone of a wetting front, enabling *slightly reduced* conditions to be maintained. However, the maintenance of adequately reduced environmental conditions during this period is likely to be dependent on adequate local rainfall amounts during the summer period, which is likely to vary from year to year.

Preservation conclusion

Chilton tracks 4 and 5 were successfully located. Trackway 5 had suffered from significant mechanical damage in the recent past, either from machinery or previous excavation. Trackway 5 was very close to the surface and was in a very poor state of preservation. Trackway 4 was also quite close to the ground surface but was visually in a much better condition.

Hydrological monitoring recorded that, although

Table 61. Chilton track: Station 1.

Depth (cm)	Description
0–28	Black (5YR 2/1) hard and crumbly humified peat (H9); water table at 5cm depth
28–54	Dark reddish brown (5YR 2/2) semi-fibrous grass-sedge peat (H6), darkens on exposure
54–84	Dark reddish brown (5YR 2/2) semi-fibrous peat (H5) with much root material and some Typha
84–120	Dark reddish brown (5YR 2/2) amorphous peat (H8) with very few remains visible
120–200+	Bluish grey clay with occasional fragments of *Phragmites* and *Typha*

Table 62. Chilton Track: Station 2.

Depth (cm)	Description
0–25	Black (5YR 2/1) hard and crumbly humified peat (H9); water table at 10cm depth: earthworms present in topsoil; basal 3–4cm contains grey clay (could be old surface layer incorporated by ploughing).
25–46	Dark reddish brown (5YR 2/2) hard humified peat (H9)
46–80	Dark reddish brown (5YR 2/2) humified peat (H7)
80–130	Dark brown (7.5YR 3/2) semi-fibrous peat (H5) with a few Typha remains
130+	Grey silty clay

the water table remained very high throughout the year, there was a risk of trackway 4 drying out and entering aerobic conditions during the summer months. Palaeoenvironmental remains at the level of the track 4 were already not considered sutable for analysis. This suggests that seasonal desiccation was already having an adverse effect on the monument.

Table 63. Chilton Track: Station 3

Depth (cm)	Description
0–20	Black (5YR 2/1) hard, granular humified peat (H9); moist
20–52	Black (5YR 2/1) humified peat (H8) moist with occasional grass-sedge remains
52–120	Dark reddish brown (5YR 2/2) semi-fibrous peat (H6)
120+	Grey silty clay with occasional fragments of *Typha*

5. Viper's and Nidon's Tracks Fieldwork

Somerset HER 10735 and 10736: SM 27989

Previous fieldwork

The Nidon's and Viper's Tracks are two late prehistoric trackways that headed northwards across Shapwick Heath from the Polden hills, possibly forming part of a routeway towards Meare 'island' or possibly to access a series of platforms beside the 'Platform Track' that may have had a hunting or ritual function (Godwin 1960; Dewar and Godwin 1963; Coles 1972). They were chiefly recorded in the area of peat extraction on the Heath where they no longer survive except possibly under a single surviving drove road.

Dewar first saw Nidon's Track in 1949 running 240ft (73.15m) east of Viper's Track, upon whose line it apparently converges south of Shapwick Moor Rhyne. In 1953 further peat digging again exposed the trackway, prompting a small excavation by Dewar. He opened a further section in 1955 and in 1959 the track was recognised in another peat face, and a large pile extracted (Godwin 1960; Dewar and Godwin 1963). Viper's Trackway had been recorded in four peat cutting exposures south of Decoy Pool Drove, towards Shapwick Moor Rhyne. It was first exposed east of Decoy Pool Wood in June 1947, and a section of c. 3m was excavated by Dewar in 1949. The trackway was again seen exposed in peat cuttings in 1955 and 1959.

The Nidon's Track was built in the late Bronze Age or early Iron Age somewhere between 910 and 410 cal BC (Q-313, 2585±100 BP). It was in a poor state of preservation when excavated but consisted of longitudinal brushwood and planks in a cradle formed by planks driven in obliquely. The vertical and horizontal planks were all oak and many appear to have been reused as they had mortise holes that served no purpose in the trackway structure (Godwin 1960).

Viper's track was formed of double pairs of vertical stakes with oval holes towards their tops, through which transverse rods, 45 × 65mm in size, were inserted (Figure 76). These in turn supported longitudinal stems 10–45mm in diameter that formed a walkway surface generally 0.7m wide but up to 3m wide in one particularly wet patch. The paired verticals comprised half split birch and field maple and squared oak timbers. In addition stakes of *c.* 40mm diameter were inserted at the edges of (and within) the track and around the outer ones were woven 'twisted bundles of slender rods' (Godwin 1960). It has two radiocarbon dates of 1050–410 cal BC (Q-312, 2630±110 BP) and 900–350 cal BC (Q-7, 2520±110 BP) suggesting that it is broadly contemporary with the Nidon's track.

Both trackways were associated with an increasingly wet raised bog surface immediately preceding the establishment of sedge fen conditions (Godwin 1960). The increasingly wet conditions on the bog surface may have been the reason for their creation.

The trackways' southern ends head towards a large

Figure 76. Godwin's excavation of the Viper's Track.

roughly circular enclosure recorded as a cropmark on aerial photographs and partially on geophysical survey in the field to the south. The southern side of the enclosure is overlain by a Roman villa and the presence of Late Iron Age pottery (Adby *et al.* 2001) suggests that the enclosure may be of this date, placing it slightly later than the construction of the trackways.

MARISP fieldwork results

The southern terminal of the tracks (ST427398) was thought to be the only place where they still survived so that was chosen as the location for the MARISP fieldwork (Figure 77). A coring survey on 0.5m grid spacing was undertaken to locate these features on the projection of their known course using a small diameter gouge auger. No convincing remains were encountered so linear trenches (10 × 0.5m and 10 × 0.8m) were opened across the presumed line of the tracks, to a depth of *c*. 0.9m.

No substantial remains were revealed, the small pieces of wood encountered displaying no signs of working by humans and probably representing entirely natural deposits of small branches and roots. Subsequent dating of samples from the top of the peat from trench 2 suggests that both trackways have been destroyed. Several pieces of oak heartwood were recovered from the ploughsoil and may represent the more resilient elements of the trackways.

Dendrochronological dating

Cathy Tyers and Christine Locatelli

Both samples, 16 and 17, were suitable for measurement (Table 64) and their ring sequences were found to cross-match (Table 65). The very high *t*-value produced and the excellent visual match suggests that these two timbers are likely to have been derived from the same tree (Figure 78; Table 65). The ring sequences from these two matching samples were combined to produce a mean sequence for this site (Table 66). This site mean sequence, Dew-S2, was compared with a range of dated reference chronologies from Britain and elsewhere in northern Europe spanning the last 7000 years. No conclusive results were obtained, thus the two timbers from the Dewar's B (Nidon's) tracks site remain undated by dendrochronology.

The analysis failed to successfully date the two timbers from one of the trackways but has shown that they are both likely to have been derived from a single tree. The lack of absolute dating is not particularly surprising as single tree sequences have a significantly reduced chance of reliable dating compared to a site master sequence that incorporates data from several different trees. In addition whilst the chronological network for the historic period is strong both temporally and geographically, thereby increasing the likelihood of successful analysis, for the prehistoric period the network is far less well replicated.

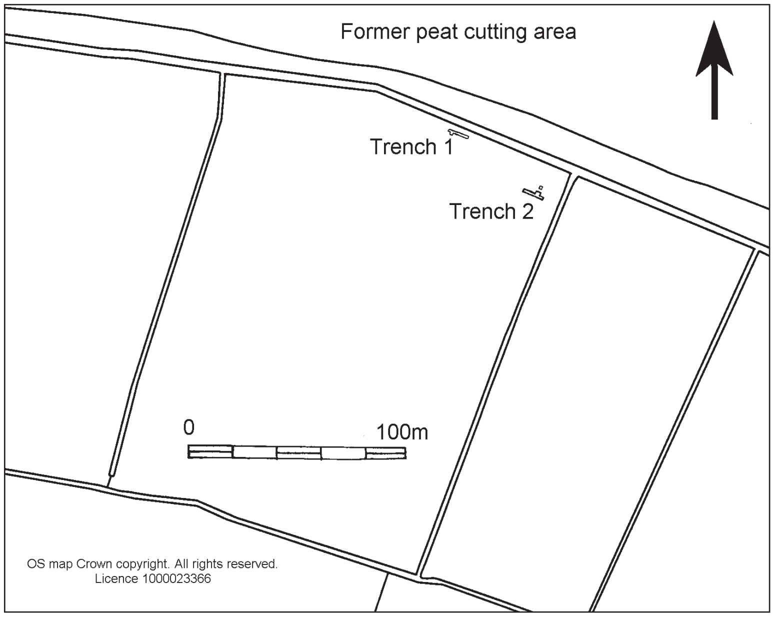


Figure 77. Viper's and Nidon's location map.

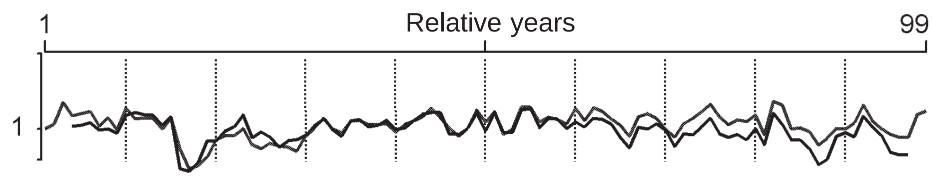


Figure 78. Diagram showing the similarity between the ring sequences derived from samples 16 and 17 from Dewar's B (Nidons) tracks. These two timbers are thought to have been derived from the same-tree.

Table 64. Details of the dendrochronological samples from Viper's site.

Wood No.	Sample description	No. Rings	Sap-wood rings	ARW	Cross-section type	Cross-section (mm)	Date of measured sequence	Comments
Dewar's B (Nidons) tracks								
16	?trackway	99	–	1.12	quartered	110 × 70	–	same tree as 17
17	?trackway	94	–	0.99	quartered	90 × 55	–	same tree as 16

No. rings: total number of measured rings including both heartwood and sapwood; sapwood rings: number of measured sapwood rings only; ARW – average ring width in millimetres

Table 65. Matrix showing the t-values obtained between the matching ring sequences from Dewar's B (Nidons) tracks included in the site master chronology Dew-S2

	17
16	14.79

Table 66. Ring width data from the undated site master chronology Dew-S2

Ring widths (units of 0.01mm)									
100	110	173	118	122	129	101	112	94	143
131	130	129	103	127	54	42	47	66	78
90	95	118	77	80	79	69	73	71	86
105	125	98	88	118	120	106	108	115	96
105	118	132	147	133	95	87	101	143	105
142	90	95	153	155	108	125	122	105	135
111	140	133	116	95	76	115	118	118	98
76	100	106	123	146	109	96	104	98	117
79	158	136	89	90	80	59	67	93	95
99	147	110	94	75	70	70	135	145	

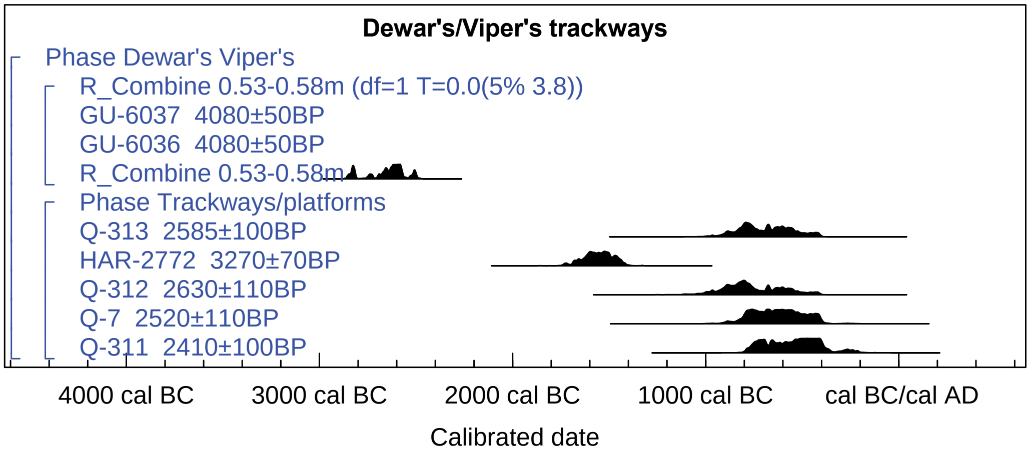


Figure 79. Probability distributions of dates from Dewar's/Viper's trackways. Each distribution represents the relative probability that an event occurred at a particular time. These distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993).

Table 67. Dewar's/Viper's trackway: radiocarbon results.

Lab. no.	Sample ID	Material	‰^{13}C	Radiocarbon Age (BP)	Weighted mean	Calibrated date (95% confidence)
GU-6037	0.53–0.58m	Peat, humic acid	-27.9	4080±50	4080±35 BP (T′=0.0; T′ (5%)=3.8; ν=1),	2860–2490 cal BC
GU-6036	0.53–0.58m	Peat, humin fraction	-27.3	4080±50		

It was decided that radiocarbon dating would be largely pointless because their unstratified location in the ploughsoil and the absence of sapwood.

Radiocarbon dating

P. D. Marshall, W. D. Hamilton, R. Brunning, G. Cook and C. Bronk Ramsey

Sequence

The single sample of black, partly humified moss peat came from 0.53–0.58m below the ground surface. This was below the limit of ploughing and the well humified and desiccated peat soils that existed above it. The two measurements (GU-6036 and GU-6037) are statistically consistent (T′=0.0; T′ (5%)=3.8; ν=1; Ward and Wilson, 1978) and allow a weighted mean to be calculated (4080 ± 35 BP).

Results

The date (Figure 79; Table 67) of the peat below the plough destruction layer (2860–2490 cal BC) shows that the trackways and associated sediments will almost certainly have been destroyed due to peat wastage.

Fieldwork conclusion

It seems clear that the southern terminals of all the trackways that once existed in the Scheduled field have been destroyed by rapid peat wastage associated with arable agriculture. The oak heartwood timbers recovered from the ploughsoil may represent the more resilient, last vestiges of the structure. The only possible area where some remains may still exist is under the narrow band of colluvium at the southern edge of the field.

The northern limits of the trackways have not been conclusively established but it seems very likely that they have been destroyed by peat extraction. The only possible area where remains may exist to the north of their known extent, is under an old drove that is now surrounded by water on Shapwick Heath National Nature Reserve. The peat under this drove would have been subjected to prolonged desiccation during the peat extraction process, in addition to compression from the weight of traffic. It is therefore unlikely that it still exists in the area.

6. Meare Heath Track fieldwork

HER24809: SM27986

Previous fieldwork

Arthur Bullied first recorded the structure when it was uncovered during peat cutting (Bulleid 1933). It was seen again several decades later by Godwin (Godwin 1960), who carried out some palaeoenvironmental analysis. The Somerset Levels Project excavated several stretches of the structure and undertook additional palaeoenvironmental analysis (Coles and Orme 1976; 1978a, Coles *et al*. 1988).

The trackway consisted of a double plank walkway, laid over transverse planks that were held in place by pairs of stakes at 0.5–1m intervals (Figure 80). A brushwood and timber substructure was used in wetter areas, sometimes with occasional longitudinal timbers under the transverses to give added support. The structure was 1m across but the planked walkway surface was only 0.4–0.5m wide. It probably ran for a distance of 2200m between the Polden ridge and Meare Island.

The planks were radially and tangentially split oak, 100–250mm (av. 20) wide, 50–150mm (av. 100) thick and possibly 5–10m long. The transverse beams were split oak, 0.70–2.50m long (av. 1.7m), 100–300mm wide (av. 160mm) and 25–300mm thick (av. 100) and were perforated with one to three rectangular holes. The stakes were split oak, 0.4–1.4m long, in two clusters averaging 0.5m and 1.3m long. The brushwood was mostly hazel and alder with smaller quantities of willow, ash, oak, fruitwood, field maple, birch, dogwood, Pomaceous fruitwood, elm, rowan, yew and buckthorn.

The trackway had been built across a very wet raised bog shortly before the partial flooding of the bog surface its replacement by sedge fen. Its construction has been dated by dendrochronology to sometime between 1530 and 1503 BC (see the dendrochronology report in the Tinney's Tracks section).

MARISP fieldwork results

The MARISP fieldwork was centered on the southern terminal of the trackway (ST437392). A series of 40 cores failed to identify the presence of the trackway. A 1m by 0.5m trench was opened over an anomalous core but this turned out to be a recent animal burial. Based on the depth of peat over the blue grey clay and the date from Viper's/Dewar's field it is likely the trackway may have been destroyed in this (Scheduled) field by a process of slow peat wastage.

Fieldwork conclusion

The inability to find the trackway at its southern terminal suggests that it may no longer exist, if it ever crossed the lagg area, which fringed the raised bog. As the northern end of the trackway appeared to continue to dry land, it seems probable that the southern one did too. Radiocarbon dating the top of the peat surviving below the topsoil will help to prove whether it is likely that any remains of the structure still survive. The field is in permanent pasture but it may be that draw down from the adjoining area of peat extraction caused significant peat wastage over many decades.

Figure 80. Excavation of the Meare Heath Track by the Somerset Levels Project.

7. Withy Bed Copse Track fieldwork

HER10755: SM27986

Previous fieldwork

The site was discovered and excavated by the Somerset Levels Project in one field where it was revealed by peat extraction (Coles *et al.* 1975b). It was an intermittent structure used to facilitate passage over the wetter areas of the bog (Figure 81). The character of the structure varied considerably in each location.

Site A consisted of six tangentially split planks (4 ash, 1 oak, 1 alder) all with mortises that seemed to perform no function within the structure. These timbers were clearly reused from some other structure that had been dismantled. Site B was far less substantial, simply formed of two spreads of brushwood, *c*. 1.5m wide and 1m apart. The longitudinal roundwood was a mixture of alder, hazel, willow, field maple and whitebeam, of diameters from 10–50mm, mostly in the 20–40mm range. At one end were the remains of a possible broken hurdle, again suggesting reuse of material from a previous structure. Occasional roundwood stakes held the material in place. Site D consisted of a broken hurdle fragment, that may have had a prior use elsewhere, before being taken onto the bog.

Figure 81. Excavation of the Withy Bed Copse Track by the Somerset Levels Project.

The trackway was built immediately before the raised bog surface was subjected to surface inundation that led to the widespread establishment of sedge fen conditions. It has been dated to 1060–790 cal BC (HAR-944, 2740±70 BP) and 980–510 cal BC (HAR-3446, 2630±80 BP), placing it in the very late Bronze Age.

MARISP fieldwork results

Richard Brunning

The MARISP fieldwork was centered on the southern terminal of the trackway (ST435393). A series of 23 cores failed to identify the presence of the trackway. A 12m by 2m trench was opened along its projected route but failed to identify the structure. Based on the depth of peat over the blue grey clay and the date from the Viper's/Dewar's field it is likely the trackway may be destroyed in this (Scheduled) field.

Fieldwork conclusion

As the Withy Bed Copse structure was very intermittent it may never have extended beyond the area excavated by the Somerset Levels Project. The lagg area, presumed to fringe the southern edge of the bog, may have been too wet for such a structure. If the trackway did extend into the field that contains its possible southern landfall, it appears that it may no longer exist in that area. The field is in permanent pasture but it may be that draw down from the adjoining area of peat extraction caused significant peat wastage over many decades.

4. Platforms and Pile Alignments

Richard Brunning

8. Saul Platform, Sharpham Park fieldwork

Somerset HER 15525

Previous fieldwork

The site was discovered in May 2002 when worked wood was discovered and reported during the excavation of a trench for an electricity cable at ST46840 37463. Archaeological inspection of the *c*. 40cm wide trench the following stratigraphy was revealed:

0–30 cm	topsoil
30–64 cm	dry black humified peat with many visible wood fragments between 50–64 cm
64–87 cm	organic rich silt layer containing reed, sedge and wood fragments
87–100cm	fen wood peat with occasional clusters of snail shells.

In the lowest layer, just above the water table, some worked wood was visible over *c*. 5m from the northwest end of the trench by a electricity pole. This included split and cut roundwood. Other split timbers, including one with a groove cut in it, were also recovered from further along the trench up to 20m from the end by the electricity pole. This distance corresponds with the edge of the wetland, which is visible on the ground surface as a clear change in slope. The narrow, partly water filled, trench prevented a definitive explanation of the worked material, especially since much natural fenwood was also present including beaver chewed material. The wood was identified as alder with the exception of one piece of ash. One piece of worked wood was dated to 1260–910 cal BC (Wk-11329). The details of this previous intervention are recorded in the Somerset HER file 15525.

MARISP excavation results

A trench 3m by 1.2m was excavated beside the previous small excavation (Figure 82). The stratigraphy varied slightly in its OD heights across the length of the trench. The base consisted of Lias bedrock overlain by creamy coloured tufa deposits (contexts 13, 12 and 11) from 4.25m OD to *c*. 4.91m OD. These basal deposits have been interpreted as the location of a seasonal spring (see below). The tufa graded into a darker organic detrital mud (context 10), with frequent snail shells throughout and occasional small pieces of lias. The mud was being deposited from the middle Bronze Age as shown by a weighted mean of two radiocarbon dates of 1680–1520 cal BC from its base.

From roughly 5.02m OD the detrital mud was replaced by a woody peat deposit (Context 7), which was composed of a dense twiggy layer over its lowest 0.1m. This change has been dated to 1200–940 cal BC (see below for details). A layer of large logs and stems existed within context 7 between 5.11m OD and 5.39m OD (Figure 83), seemingly resting on the dense twiggy layer and within a fibrous peat with wood fragments. The material was not carefully laid to form a coherent platform but was a more irregular dump of material (Figures 84 and 85).

The material consisted of a mixture of small roundwood stems, larger logs and woodchips. The larger material comprised seven alder and one ash log, with diameters between 120mm and 272mm. Many of the logs appeared to be eroded on their bottom sides, with significant decay. One log (40) may represent a half split log but the decay exhibited on one side raises the possibility that it is decayed away rather than split by humans. The total length of the logs was only known in one case (timber 33) where the log extended for

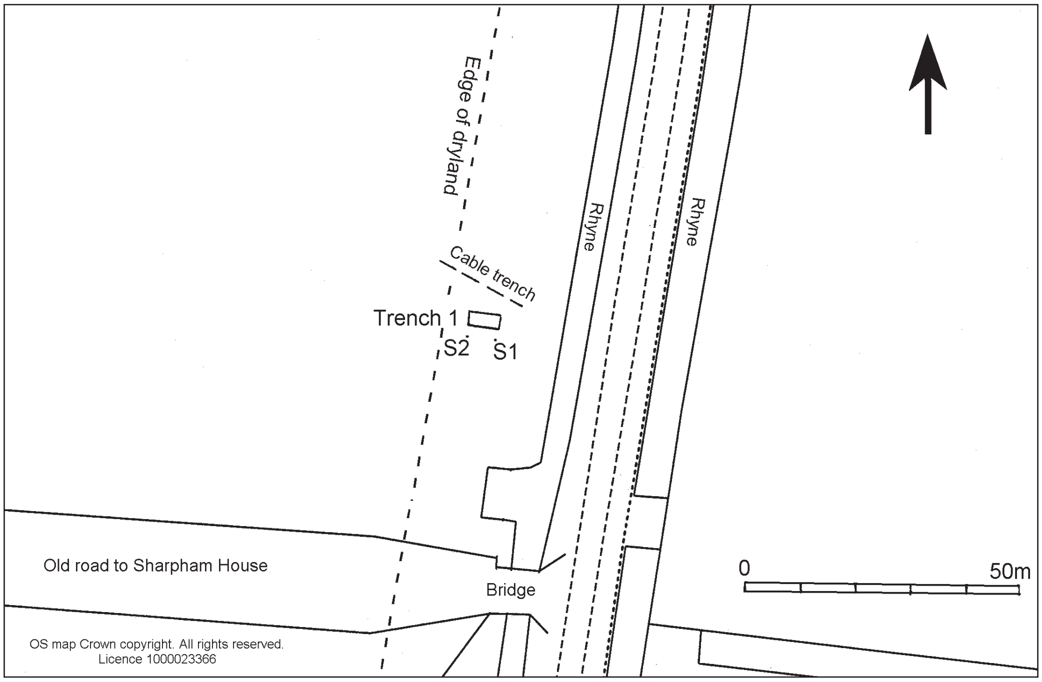


Figure 82. Location plan of Saul Platform trench and monitoring stations.

Figure 83. Logs in context 7, Saul Platform, looking west. Scales 1m.

Figure 84. Upper wood layers, Saul Platform, looking east. Scales 1m.

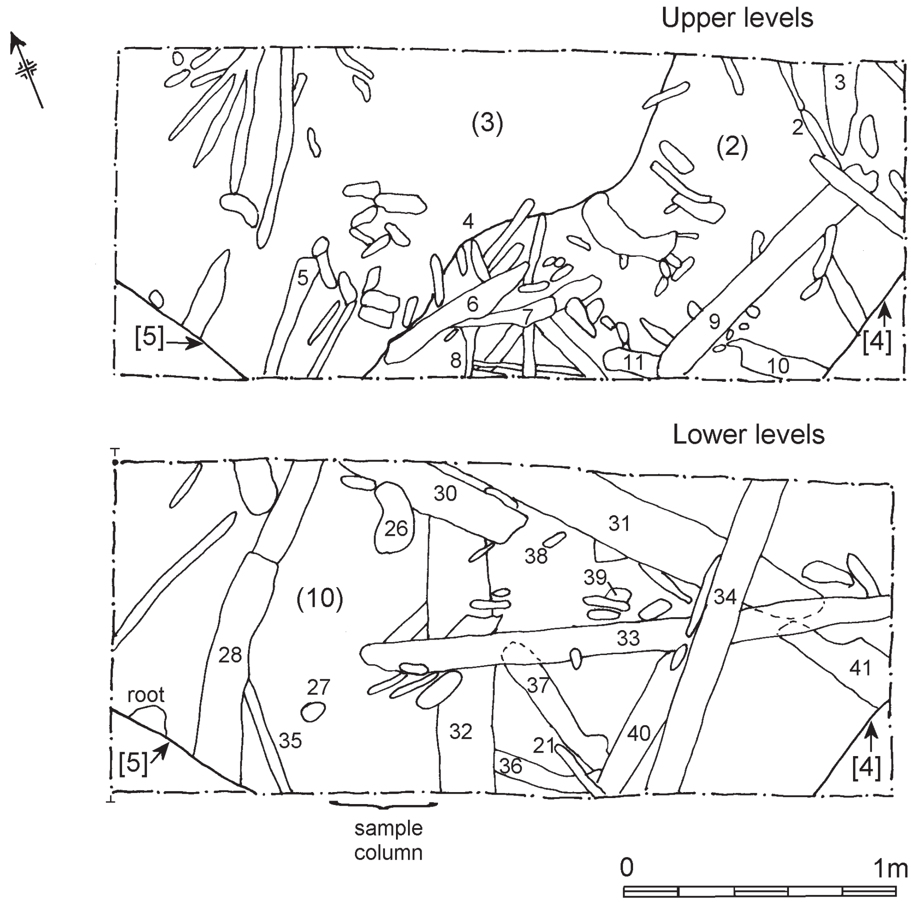


Figure 85. Plan of wood layers, Saul Platform.

2.17m, both ends being broken. The smaller roundwood consisted of four pieces of alder of lengths between 174mm and over 590mm and diameters between 33mm and 96mm. One piece (37) had two broken ends and another (22) had a possible cut end. The only vertical element was a straight piece of 28mm diameter hazel roundwood (38), 250mm long, which had no evidence of a cut at its lower end. The other vertical elements were three large tree roots, one alder (26), one ash (27) and one unknown (28). All the roundwood and logs retained their bark.

Amongst the roundwood elements were fifteen woodchips and one larger offcut. These were all alder with the exception of two ash woodchips (17 and 27). The larger fragment (39) was 180mm long, 75mm wide and 35mm thick and had been split or axed tangentially from a log. The woodchips were a mixture of radial and tangential pieces. Their dimensions shown on Table 68. They could have been produced by felling trees of the sizes represented by the logs with which they are associated. Two of the woodchips (21 and 24) retained evidence of toolmarks created by axe blows delivered at *c.* 30° to vertical. The axe that created the toolmark must have been a minimum of 56mm wide in the case of woodchip 21.

Table 68. Split wood from the Saul Platform.

Wood No.	Conversion	Length (mm)	Width (mm)	Depth (mm)
11	radial	47	27	8
13	radial	46	34	13
14	radial	48	27	11
16	radial	60	25	9
12	intermediate	52	30	6
17	intermediate	47	19	6
15	tangential	61	21	5
18	tangential	45	19	6
19	tangential	30	18	4
20	tangential	57	43	17
21	tangential	62	56	14
24	tangential	38	42	10
25	tangential	46	19	4

One piece of beaver chewed roundwood was found just above this main wood layer. Over the western 1.2m of the trench an organic peaty deposit existed containing a great concentration (*c.* 35%) of small

Figure 86. Brushwood patch context 9, Saul Platform, looking south-west. Scale 0.5m.

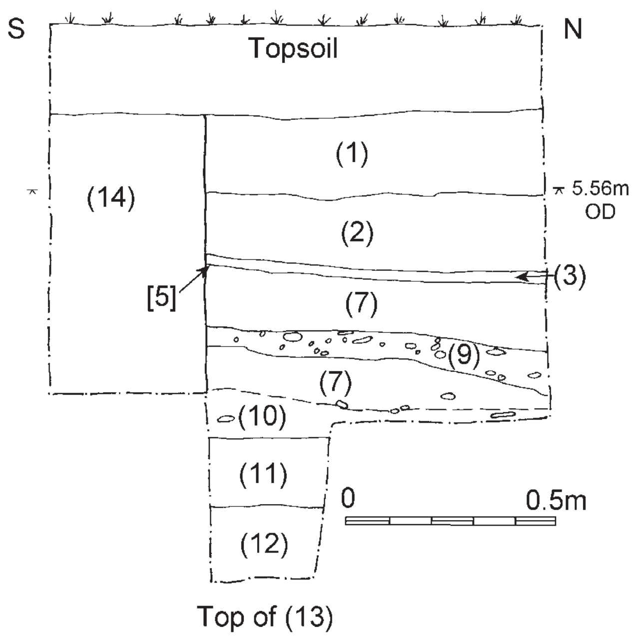


Figure 87. Saul Platform section (west end of Trench 1).

roundwood (context 9). This layer was only *c.* 0.6–0.8m deep and dipped down slightly to the north, the bottom being between 5.10m OD and 5.17m OD and the top between 5.21m OD and 5.18m OD (Figures 86 and 87). No cut ends were visible on the roundwood but a single woodchip was identified. This deposit effectively immediately overlay the larger material below and provided a fairly even surface.

Roughly 0.1m above context 9 was a small patch of willow or poplar brushwood (context 8) that only appeared in the southwest corner of the trench where it had been truncated by a recent drainage trench (cut 5). It ran for 0.75m along the southern edge of the trench and was up to 25cm wide. It was composed of tightly packed roundwood stems of 15–20mm diameter. The stems were laid respecting a tree stump (28) in that corner of the trench. No evidence of cut ends was recorded and one piece had definitely been beaver chewed.

A band of light grey clay (context 3) of variable thickness was found above context 7, between 5.34 and 5.40m OD, being highest in the northwest corner where its organic content was greatest. The top layer of context 7 has been dated to 1025–905 cal BC (see below for details).

Above the clay layer was a highly organic silt (context 2) containing woody remains that were especially densely packed immediately above the boundary with the clay. The boundary between the two contexts undulated across the trench by up to 0.1m. This may be because the clay (3) had been incised by a shallow water feature of that depth before context 2 began accreting. The wood in context 2 was compressed small alder and ash roundwood with the bark still present. Context 2 began forming between 800–730 cal BC (31% probability) or 700–540 (64%) cal BC and ended at 410–350 cal BC (82%) or 290–230 (13%) cal BC (see below for details).

The woody peat (context 2) was replaced by yellowish-brown clay silt at *c*. 5.56m OD that extended to the ground surface at 5.94m OD. Two modern drainage trenches in the southeast and southwest corners (cuts 4 and 5) cut all the contexts below the topsoil.

Wood species identification

Rowena Gale

Context 2

Ten samples of roundwood were examined of which two were too degraded for identification. Four were ash (*Fraxinus excelsior*), three were alder (*Alnus glutinosa*) and one either alder or hazel (*Corylus avellana*).

Main wood layer in context 7

Fifteen woodchips were analysed of which thirteen were alder (*Alnus glutinosa*) and two ash (*Fraxinus excelsior*). Thirteen pieces of roundwood were examined of which eleven were alder (*Alnus glutinosa*), one hazel (*Corylus avellana*) and one ash (*Fraxinus excelsior*).

Context 8

Six samples of roundwood were examined, all of which were either willow (*Salix* sp.) or poplar (*Populus* sp.).

Radiocarbon dating

P. D. Marshall, W. D. Hamilton, R. Brunning, G. Cook and C. Bronk Ramsey

Sequence

The basal sample marks the onset of mud, silt and peat deposition at the site. The two measurements (OxA-16250 and OxA-16251) are statistically consistent (T′=0.3; T′ (5%)=3.8; ν=1; Ward and Wilson, 1978) and allow a weighted mean to be calculated (3325±25 BP). The sample of waterlogged plant macrofossils (SUERC-9830) from 5.03–5.04m equates to the onset of silty peat deposition and that from 5.34–5.35 with the end of this phase of deposition. The measurements from 5.34–5.35m (OxA-16248 and OxA-16249) are statistically consistent (T′=0.3; T′ (5%)=3.8; ν=1; Ward and Wilson, 1978) and allow a weighted mean to be calculated (2521±22 BP). The sample from 5.41–5.42m correlates to the onset of the most recent phase of peat deposition at the site, and the two measurements (SUERC-9835 and SUERC-9839) are statistically consistent (T′=0.5; T′ (5%)=3.8; ν=1; Ward and Wilson, 1978) and once again allow a weighted mean to be calculated (2528±25 BP). The uppermost sample in the sequence (5.52–5.53) comes from the top of the woody peat before the onset of clay silt deposit and therefore provides a date for the end of peat deposition. The two measurements (SUERC-9834 and SUERC-9838) are statistically consistent (T′=0.5; T′ (5%)=3.8; ν=1; Ward and Wilson, 1978) and thus allow a weighted mean to be calculated (2298 ± 25).

Results

The model shows good agreement between the radiocarbon results and their stratigraphic positions ($A_{overall}$=100.8%) and suggests that peat and environmental remains associated with the wooden platform do survive (Table 69 and Figure 88).

Palaeoenvironmental analysis

Heather Tinsley and Julie Jones

The MARISP trench revealed a complex sedimentary sequence. At the base of the trench a buff coloured tufa, with possibly some weathered Lias, was evident, overlaid by a creamy coloured tufa. This graded upwards into darker, increasingly organic sediments that had the character of an organic detrital mud above 4.91m OD, with frequent snail shells. These basal deposits have been interpreted as the location of a seasonal spring (P. Davies, pers. comm.). Above 5.02m OD there was a change to a well humified, twiggy peat some 0.1m thick. The top of the main layer of worked timbers forming the platform occurred between 5.19m and 5.27m OD, it appeared to rest on the twiggy peat, within a horizon of less well humified fibrous peat with wood fragments. A band of clay of variable thickness was found within this peat between 5.34m and 5.40m OD. Above 5.55m OD, the peat was replaced by a yellowish-brown clay silt that extended to the ground surface at 5.94m OD. Some of the wood recovered during the MARISP excavations also showed signs of beaver chewing. The stratigraphy and sampling scheme for pollen, plant macrofossils, insects, snails and radiocarbon dating is shown in Table 70.

The base of the detritus mud, at 4.91m OD, is dated to 1690–1520 cal BC; the pollen diagram extends from just below this level to 5.53m OD (0.41m below the ground surface) where peat is dated to 400–260 cal BC. Above 5.55m OD colluvial clays replace the organic sedimentation.

Pollen assemblage zones

Heather Tinsley

The pollen diagrams for these samples are shown in Figure 89.

SP 1 (Below 5.02m OD; 92–108cm below the ground surface)

Tree pollen forms <44% TP principally *Alnus* (4–24%

Table 69. Saul Platform, Sharpham Park: radiocarbon results.

Lab. no.	**Sample ID (m)**	**Material**	**δ^{13}C (‰)**	**Radiocarbon Age (BP)**	**Weighted mean**	**Calibrated date BC (95% confidence)**	***Posterior Density Estimate cal BC***
OxA-16250	4.91–4.92	Peat, humin	–28.0	3309±37	3325±25 BP (T′=0.3; T′(5%)=3.8; ν=1)	1690–1520	*1680–1520*
OxA-16251	4.91–4.92	Peat, humic	–27.9	3338±33			
SUERC-9830	5.03–5.04	Plant macro-fossils; *Oellathe aquatica x8; Alnus* glutinosa x11; *Carex* x1; *Cladium mariscus* x1, *Sparganium erectium* x1	–27.9	2970±35		1190–920	*1200–940*
OxA-16248	5.34–5.35	Peat, humin	–29.2	2835±33	2821±22 BP (T′=0.3; T′(5%)=3.8; ν=1)	1045–905	*1025–905*
OxA-16249	5.34–5.35	Peat, humic	–29.1	2809±30			
SUERC-9835	5.41–5.42	Peat, humic acid	–28.4	2510±35	2528 ± 25 BP (T′=0.5; T′(5%)=3.8; ν=1)	800–540	*800–730 (31%) or 700–540 (64%)*
SUERC-9839	5.41–5.42	Peat, humin fraction	–28.6	2545±35			
SUERC-9834	5.52–5.53	Peat, humic acid	–28.3	2325±35	2298 ± 25 BP (T′=1.2; T′(5%)=3.8; ν=1)	400–260	*410–350 (82%) or 290–230 (13%)*
SUERC-9838	5.52–5.53	Peat, humin fraction	-28.1	2270±35			

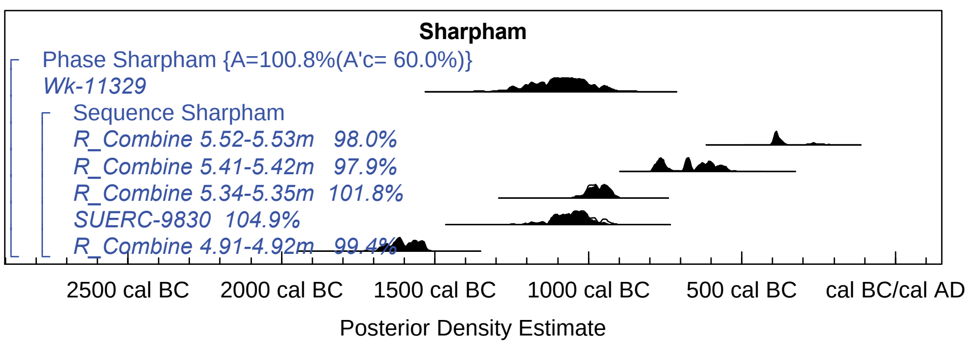


Figure 88. Probability distributions of dates from Saul Platform, Sharpham Park. Each distribution represents the relative probability that an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. The large square brackets down the left hand side along with the OxCal keywords define the model exactly.

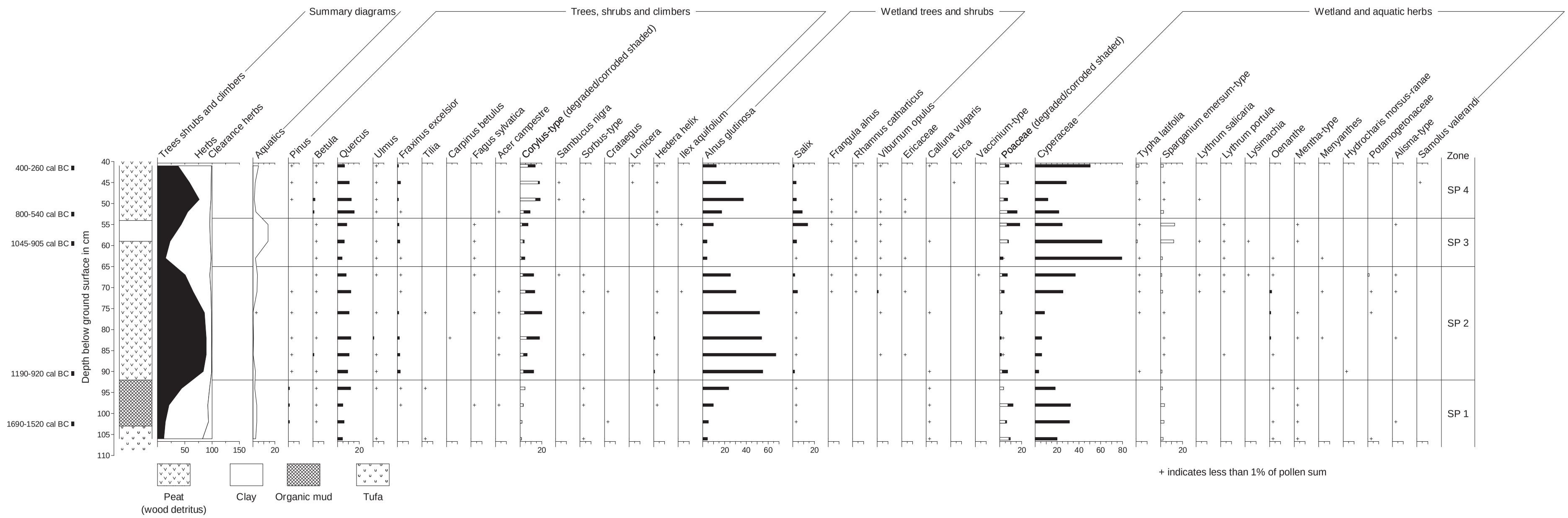
TP) and *Quercus* (5–12% TP). *Corylus*-type makes up <5% TP. Other tree pollen taxa are present as occasional grains. Of the herbaceous pollen taxa, Cyperaceae form 18–32% TP and Poaceae <12% TP, pollen of *Sparganium emersum*-type is present throughout at low frequencies. The most characteristic feature of the zone is the high percentages of some ruderal taxa, often associated with disturbed ground, particularly Lactuceae (15–27% TP), *Solidago virgaurea*-type (5–8% TP) and *Plantago lanceolata* (2–14% TP). There is quite a high diversity of other flowering herbs present as occasional grains. Spores of Pteropsida (undifferentiated) form 14–20% TP+ferns and spores of *Pteridium* form 7–13% TP+ferns. Unknown and indeterminable grains form up to 9% of TP+indeterminables; the majority of the *Corylus*-type and Poaceae grains show marked biochemical deterioration. The zone is characterised by very low pollen concentrations. The concentration of microscopic charcoal, which is initially quite high, declines during the zone.

SP 2 (5.02–5.29m OD; 92–65cm below the ground surface)
Tree pollen forms 50% TP. *Alnus* values rise initially reaching a peak of 67% TP at 5.09m OD, then gradually

Sharpham Park 2003

Part 1

Percentages of total pollen minus aquatics



Part 2

Percentages of total pollen minus aquatics

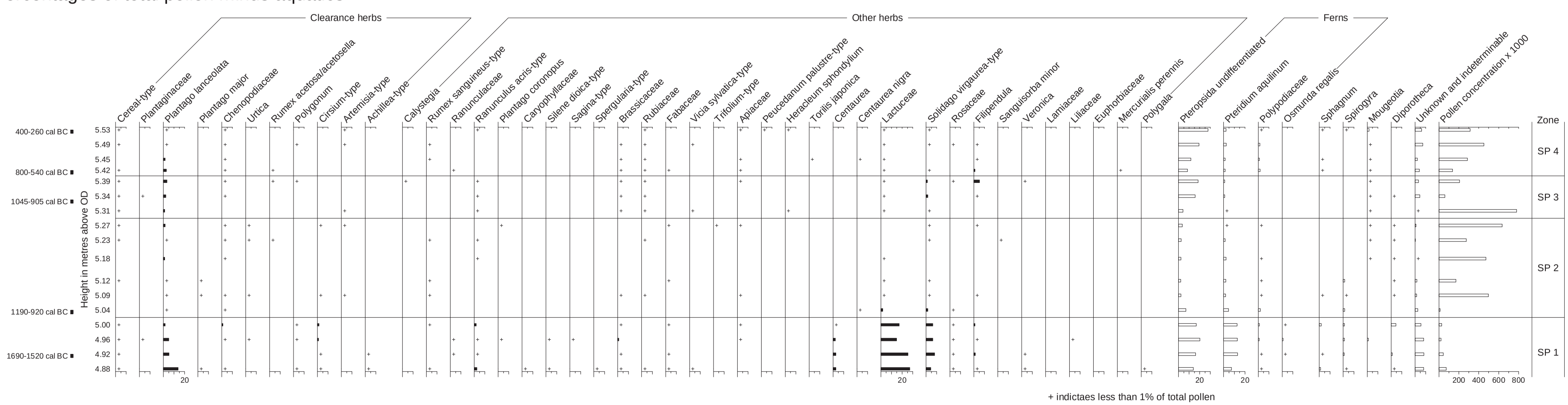


Figure 89. Saul Platform pollen diagram.

Table 70. Saul Platform, Sharpham Park: stratigraphy and dating.

Depth	Stratigraphy	Pollen	Macros snails beetles diatoms	Calibrated radiocarbon date range
Ground surface at 5.94m OD				
5.55–5.56	Yellow brown colluvium Gradual boundary (Context 1)			
5.40–5.55	Dark brown fibrous well-humified woody peat, with rare fragments of herbaceous and woody plants. Modern roots present Gradual boundary (Context 2)	5.52–5.53 5.48–5.49 5.44–5.45 5.41–5.42		5.52–.5.53 410–350 cal BC (82%) 290–230 cal BC (13%) 5.41–5.42 800–730 cal BC (31%) 700–540 cal BC (64%)
5.35–5.40	Grey brown alluvial clay band with fine organic laminae. Traces of woody plants. Gradual boundary (Context 3)	5.38–5.39	5.38–39 diatoms	
5.13–5.35	Dark grey-brown heterogenous peat with traces of woody plants. Traces of clay. Main timber layer 5.19–5.27m OD Very gradual boundary (Contexts 9 and 7)	5.33–5.34 5.30–5.31 5.26–5.27 5.22–5.23 5.17–5.18	5.30–5.35 macros	5.34–5.35 1025–905 cal BC
5.02–5.13	Very dark brown heterogenous granular peat with rare fragments of herbaceous and woody plants and twigs. With snails from 5.1m OD Very gradual boundary (Context 7)	5.11–5.12 5.08–5.09 5.03–5.04	5.09–5.14 macros, beetles, snails	5.03–5.04 1200–940 cal BC
4.91–5.02	Pale brown homogenous detrital mud with snails throughout. Occasional fine herbaceous plants. Gradual boundary (Context 10)	4.99–5.00 4.95–4.96 4.91–4.92	4.95–5.0 snails; macros assessed	4.91–4.92 1680–1520 cal BC
4.82–4.91	Grey calcareous tufa with organic detritus and rare fragments of herbaceous and woody plants. Occasional snails. Very gradual boundary (Context 11)	4.87–4.88		
4.72–4.82	Creamy buff homogenous tufa with some large wood fragments Very gradual boundary (Context 12)		4.73–4.83 snails; macros assessed	
4.66–4.72	Buff weathered tufa with orange mottles (Context 13)		4.67–4.73 snails	

decline to 27% TP at the zone boundary. *Corylus*-type varies between 6–20% TP; *Quercus* values are unchanged. Pollen of the wetland shrubs *Frangula alnus, Rhamnus catharticus* and *Viburnum opulus* occur occasionally. *Fraxinus* is continuously present and is at a maximum of <3% TP early in the zone. *Pinus, Betula,* and *Ulmus* are present as occasional grains. *Salix* reaches 4% TP towards the end of the zone. Cyperaceae pollen increases steadily from 4%–37% TP. There are occasional pollen grains of wetland and aquatic herbs; these also increase slightly in frequency towards the top of the zone. Lactuceae, *Solidago virgaurea*-type and *Plantago lanceolata* are all represented at <2% TP. Spores of all Pteropsida form less than 13% TP+ferns. Unknown and indeterminable grains form <3% TP+indeterminables. A relatively small proportion of grains of *Corylus*-type and Poaceae show biochemical deterioration. Pollen concentrations remain low at the start of the zone but then increase markedly. Microscopic charcoal concentrations are variable with small peaks in the earlier part of the zone, which later disappear.

SP 3 (5.29–5.40m OD; 65–54cm below the ground surface)
Tree pollen falls to 15% TP at the start of the zone, but later rises to 42% TP by the zone end, the decline is principally due to a fall in *Alnus* values which do not rise above 10% TP in this zone. *Quercus* forms 4–8% TP and *Corylus*-type 4–7% TP. *Salix* pollen increases to 14% TP at the zone end. Pollen of *Frangula alnus, Rhamnus catharticus* and *Viburnum opulus* continue to occur occasionally. *Betula, Fraxinus, Ulmus* and *Fagus* are represented at very low frequencies. Herbaceous pollen is dominated by Cyperaceae, Poaceae and *Sparganium emersum*-type which together form 83%

TP at the start of the zone, declining to 56% TP. Occasional pollen grains of other wetland and aquatic herbs continue to be represented. The diversity of other flowering herbs increases in this zone. Pollen of *Plantago lanceolata* forms 1–3% TP. There is a small increase in spores of Pteropsida (undifferentiated) to a maximum of 18% TP+ferns. Unknown and indeterminable grains from <5% TP+indeterminables. There is little evidence of biochemical deterioration of *Corylus*-type grains but some deterioration in the Poaceae. Pollen concentrations are very variable, falling markedly after initially high values. Microscopic charcoal concentrations are low.

SP 4 (5.40–5.5.53m OD; 41–54cm below the ground surface) Tree pollen values recover somewhat in this zone to form a maximum of 76% TP at 5.45m OD, before falling to just 38% TP at the zone end. *Alnus* values recover initially to reach 37% TP but then fall to 13% TP. *Quercus* forms 6–15% TP and *Corylus*-type 9–18% TP. *Salix* falls from 9% to 1% TP during the zone. *Betula, Fraxinus* and *Ulmus* are represented by occasional pollen grains throughout. Cyperaceae continue to dominate the herbaceous pollen forming 12–50% TP, with the highest values at the end of the zone where there is also a small increase in pollen of *Typha latifolia*. The frequency of pollen of *Plantago lanceolata* declines from 3%TP to <1% TP during the zone. Pteropsida (undifferentiated) form 8–28% TP+ferns. Unknown and indeterminable grains form <7% TP+indeterminables and numbers of biochemically deteriorated grains increase. Pollen concentrations increase again in this zone. Microscopic charcoal concentrations peak markedly mid-zone.

Plant macrofossils

Julie Jones

As well as the three samples examined at the initial assessment stage (Jones 2005) two additional samples, extracted from the pollen monolith tin, were assessed from the basal tufa (4.73–4.83m OD) and overlying detrital mud (4.95–5.0m OD) together with snail samples from the same levels, to assist in the interpretation of these deposits (Table 71).

4.73–4.83m OD: This sample from the tufa, which overlay the basal Lias/tufa was seen to include organic detritus although assessment of a sub-sample showed that this to be primarily unidentifiable small wood fragments and bark.

4.95–5.0m OD: This pale brown detrital mud included abundant snail shell fragments and again consisted primarily of soft wood and occasional charcoal fragments, with a few *Quercus* buds. The assessment showed a predominantly wetland marsh assemblage with several species of *Carex*, and *Juncus*, *Mentha aquatica*, *Eupatorium cannabinum* and *Ajuga reptans*.

5.09–5.14m OD: The peat overlying the detrital mud contained abundant wood fragments, twigs and bud scales. Although the wood was not identified, the dominance of *Alnus glutinosa* fruits, cones, male catkins and buds, forming 42% of the total macrofossil assemblage indicates that much of the wood is also likely to have derived from alder. Occasional *Salix* buds, *Carex paniculata* and *Carex pallescens*, typical of open woodland where water is always available, also suggest alder fen carr conditions. Aquatic taxa (25%), indicative of areas of open water, form 25% of the assemblage; these are mostly *Chara*, *Potamogeton* with occasional *Lemna* and *Alisma plantago-aquatica*. Swamp/bankside taxa (23%) include *Typha* and *Oenanthe aquatica*. Marsh taxa (9%) are mostly Cyperaceae. Indications of drier ground come from *Quercus* buds/scales, *Corylus avellana* nut fragments, *Rubus* sect. *Glandulosus* and *Rubus idaeus* and the herbaceous taxa *Solanum dulcamara* and *Sonchus asper*.

5.30–5.35m OD: Peat sampled from above the main timber layer (5.19–5.27m OD) shows a marked reduction in *Alnus* (2%) although there are still occasional fruits and buds plus occasional *Salix* buds. There is a reduction in aquatics (3%) with only a trace of *Chara*, *Potamogeton* and *Alisma plantago-aquatica* and a reduction in swamp/bankside taxa with less *Typha,* although *Sparganium erectum* now occurs. There is a marked increase in marsh taxa, principally Cyperaceae (76%).

Insect remains

Harry Kenward

5.09–5.14m OD: There was a moderately large and diverse assemblage of adult beetles and bugs (167 individuals of 93 taxa; alpha = 86, SE = 12), and a range of other invertebrates, among them immense numbers of fragments of immature insects, numerous mites, and some snails and caddis larvae (Table 72). The beetle and bug fauna was dominated by aquatic and waterside insects (53 individuals of 22 taxa of aquatics, almost a third of the assemblage; 36 individuals of nine waterside taxa, over a fifth of the assemblage). The more abundant among the former were *Tanysphyrus lemnae*, a weevil found on duckweeds (*Lemna*), and *Ochthebius minimus*. Waterside taxa included two *Cyphon* species (with 16 and 9 individuals; the latter was *C. padi*, very common in marshy environments), and *Cercyon tristis* (with five individuals). *T. lemnae* and others indicated a rich aquatic and emergent vegetation.

While much of the terrestrial component of the assemblage may have lived at the edge of water, there were indications of somewhat drier conditions, such as two species of *Cantharis* (soldier beetles), the dung

Table 71. Saul Platform, Sharpham Park: plant macrofossil remains.

	Height (m OD)	5.09–5.14	5.30–5.35	Habitat code
	Common name			
Characeae				
Chara spp.	Stonewort	180	1	A
Ranunculaceae				
Ranunculus subg. *Batrachium* (DC.) A. Gray	Water Crowfoot		1	APR
Fagaceae				
Quercus sp. (bud)	Oak	13 + 73 scales		HSW
Betulaceae				
Alnus glutinosa (L.) Gaertner (fruit)	Alder	400	5	RWw
Alnus glutinosa (L.) Gaertner (cone)	Alder	81	1	RWw
Alnus glutinosa (L.) Gaertner (male catkin)	Alder	12 f		RWw
Alnus glutinosa (L.) Gaertner (bud)	Alder	3 + 12 scales	2	RWw
Corylus avellana L (nut fragments)	Hazel	7		HSW
Polygonaceae				
Rumex sp.	Dock		1	DG
Salicaceae				
Salix spp (bud)	Willow	1	2	w
Rosaceae				
Crataegus monogyna Jacq	Hawthorn	2		HSW
Filipendula ulmaria (L.) Maxim	Meadowsweet		1	w
Rubus sect. *Glandulosus* Wimmer and Grab	Bramble	2f		DHSW
Rubus idaeus L.	Raspberry	1		EW
Lythraceae				
Lythrum salicaria L.	Purple-loosestrife		1	BMF
Apiaceae				
Hydrocotyle vulgaris L.	Marsh Pennywort		2	FM
Oenanthe aquatica (L.)Poiret	Fine-leaved Water-Dropwort	76	1	P
Solanaceae				
Solanum dulcamara L.	Bittersweet	1		DHS
Lamiaceae				
Ajuga reptans L.	Bugle	4		G(w) W (shady)
Lycopus europaeus L.	Gipsywort	4	32	FRw
Mentha aquatica L.	Water Mint	1	46	MPw
Mentha spp.	Mint		9	
Asteraceae				
Eupatorium cannabinum L.	Hemp-agrimony		3	w-shade/open
Sonchus asper (L.)Hill	Prickly Sow-thistle		2	CD
Alismataceae				
Alisma plantago-aquatica L.	Water Plantain	14	2	APR
Alisma sp.	Water Plantain	7	1	
Potamogetonaceae				
Potamogeton sp.	Pondweed	36	9	APR
Lemnaceae				
Lemna sp.	Duckweed	5		A
Cyperaceae				
Carex spp.	Sedge	14	75	GMPRW
Carex elata All.	Tufted-sedge	41	111	FPR, reedswamp
Carex pallescens L.	Pale Sedge	10	104	G (damp) R,W-clearings
Carex paniculata L.	Greater Tussock-sedge	5	2	BFMw,Ww
Carex pendula Hudson	Pendulous sedge	10	3	Whw
Carex riparia Curtis	Greater Pond-sedge	5	17	PMN, w

For habitat codes, see Appendix 1.

beetles *Aphodius* and *Onthophagus joannae*, and some species associated with dead wood. This last component included scolytid bark beetles (two *Hylesinus crenatus*, mostly attacking ash; and damaged fossils identified as *Scolytus ?multistriatus* and *S. ?rugulosus*, the former on a range of trees, the latter on various woody Rosaceae), remains which were probably of the click beetle *Melanotus*, two *Anaspis ?maculata*, and the woodworm beetles *Grynobius planus* and *Anobium ?punctatum*. Most *Rhynchaenus* (two individuals) are associated with trees, in this case living ones. *Polydrusus cervinus* normally occurs on broadleaf trees, and *Chilocorus renipustulatus* is found on trees, too. Among the bugs, *Aphrophora alni* is mainly found on trees and bushes and *Idiocerus* species are mostly found on poplars.

In summary, this deposit appears to have been formed in an ecologically rich swamp with open water and trees.

Molluscan remains

Paul Davies

Four samples were analysed from the Sharpham Park site. Three of the samples (4.67–4.73m OD, 4.73–7.83m OD and 4.95–5.00m OD) were provided as unprocessed sediment by Heather Tinsley. The other sample (5.09–5.14m OD) was provided as 'picked shells' by Julie Jones.

Shells were recovered from all four samples, although numbers in the lowermost two samples (4.67–4.73m OD and 4.73–4.83m OD) were very low and low respectively. The two upper samples both contained abundant shell (100+). The species recovered are given below.

From Table 73 it is evident that the number of species increases upwards through the profile. The two lowest samples contained only terrestrial species. The following sample contained mainly terrestrial species but also four 'amphibious species (*Lymaea peregra, Lymnaea truncatula, Pisidium personatum, Pisidium obtusale*) capable of living on wet soil. The uppermost sample contained a rich terrestrial and a rich aquatic assemblage, suggestive of a freshwater edge environment.

Environmental interpretation

The recovered assemblages varied within each of the four samples. Initially, therefore, each is interpreted in its own right

4.67–4.73m OD: Only four species were represented (*Aegopinalla nitidula, Carychium minimum, Discus rotundatus* and *Vertigo substriata*), all in very low numbers. While any interpretation based on such low numbers must be tentative they are all terrestrial, and consistent with a shaded environment (not necessarily wooded, possibly only well vegetated grassy/herbaceous conditions). *Vertigo substriata* is a

Table 72. Saul Platform, Sharpham Park: main statistics for assemblages of adult beetles and bugs (excluding aphids and scale insects).

Preservation code	5.09–5.14m OD	Preservation code	5.09–5.14m OD
S	93	PNP	22
N	167	SL	7
ALPHA	86	PSL	8
SEALPHA	12	NL	8
SOB	57	PNL	5
PSOB	61	SRT	11
NOB	123	PSRT	12
PNOB	74	NRT	16
ALPHAOB	41	PNRT	10
SEALPHAOB	6	SRD	1
SW	22	PSRD	1
PSW	24	NRD	5
NW	53	PNRD	3
PNW	32	SRF	2
SD	9	PSRF	2
PSD	10	NRF	3
ND	36	PNRF	2
PND	22	SSA	3
SP	19	PSSA	3
PSP	20	NSA	7
NP	36	PNSA	4
SSF	3	NSF	7
PSSF	3		

S	93	PNP	22
N	167	SL	7
ALPHA	86	PSL	8
SEALPHA	12	NL	8
SOB	57	PNL	5
PSOB	61	SRT	11
NOB	123	PSRT	12
PNOB	74	NRT	16
ALPHAOB	41	PNRT	10
SEALPHAOB	6	SRD	1
SW	22	PSRD	1
PSW	24	NRD	5
NW	53	PNRD	3
PNW	32	SRF	2
SD	9	PSRF	2
PSD	10	NRF	3
ND	36	PNRF	2
PND	22	SSA	3
SP	19	PSSA	3
PSP	20	NSA	7
NP	36	PNSA	4
SSF	3	NSF	7
PSSF	3		

For explanation of abbreviations, see Appendix 2.

Table 73. Saul Platform, Sharpham Park: Mollusca.

	sample height (m OD)			
species	**4.67–4.73**	**4.73–4.83**	**4.95–5.00**	**5.09–5.14**
Valvata cristata	–	–	–	29
Bithynia tentaculata	–	–	–	13
Bithynia operculae	–	–	–	43
Lymnaea truncatula	–	–	18	27
Lymnaea peregra	–	–	2	6
Planorbis planorbis	–	–	–	4
Bathyomphalus contortus	–	–	–	10
Gyraulus crista	–	–	–	1
Segmentina nitida	–	–	–	5
Acroluxus lacustris	–	–	–	1
Sphaerium corneum	–	–	–	2
Pisidium personatum	–	–	5R 3L	–
Pisidium obtusale	–	–	3R 4L	–
Pisidium spp.	–	–	2 (paired)	7
Pomatias elegans	–	2	–	1
Acicula fusca	–	–	–	2
Carychium minimum	2	–	52	64
Carychium tridentatum	–	3	6	18
Succineidae	–	–	3	3
Cochlicopa lubrica	–	1	6	7
Vertigo antivertigo	–	–	–	4
Vertigo substriata	1	1	–	–
Vertigo pygmaea	–	–	2	5
Vertigo moulinsiana	–	–	2	–
Vallonia costata	–	1	–	–
Acanthinula aculeata	–	–	1	1
Ena obscura	–	–	–	1
Punctum pygmaeum	–	–	1	2
Discus rotundatus	3	2	2	5
Vitrina pellucida	–	1	–	–
Vitrea spp.	–	1	4	8
Nesovitrea hammonis	–	–	1	7
Aegopinella pura	–	–	1	3
Aegopinella nitidula	1	1	9	10
Oxychilus spp.	–	1	–	5
Zonitoides nitidus	–	–	1	–
Euconulus spp.	–	–	1	–
Cochlodina laminata	–	2	–	1
Clausilia bidentata	–	2	1	1
Ashfordia granulata	–	–	30	30
Trichia hispida	–	–	–	8
Cepaea spp.	–	1	–	–

notable find, and is indicative of either marshy or wet-woodland conditions).

4.73–4.83m OD: At least 13 species are represented, all terrestrial. There is a strong shade-requiring element consisting of *Carychium tridentatum, Discus rotundatus, Aegopinella nitidula*, *Oxychilus* spp, and (particularly) *Clausilia bidentata* and *Cochlodina laminata*. Other species are more generalist (*Vitrina pellucida, Cochlicopa lubrica, Vitrea spp., Cepaea spp. Vertigo substriata*). Together these indicate a fairly dry wooded environment. The presence of *Pomatias elegans* is notable, the species favouring bare ground when present in woods.

4.95–5.00m OD: The assemblage contains a strong 'woodland' element (*Discus rotundatus, Carychiun tridentatum, Clausilia bidentata, Acanthinula aculeata, Punctum pygmaeum, Aegopinella* spp), but wet-ground species are also represented (*Vertigo moulinsiana, Carychium minimum*, *Euconulus* spp., Succineidae, *Ashfordia granulata, Zonitiodes nitidus*), as are amphibious species (*Lymnaea truncatula, L. peregra, Pisidium personatum, P.obtusale*). Another two paired bivalves (unident) were also recovered. These elements would be consistent with a wet woodland environment, probably with sedges at ground level.

5.09–5.14m OD: The terrestrial species continue to indicate wet woodland. Particularly noticeable are *Acicula fusca, Acanthinula aculeata* and *Cochlodina laminata*, which together would never be expected outside of a wooded environment. The wet-ground terrestrial and amphibious elements also remain well represented, although the presence of *Pomatias elegans* would also suggest some drier areas.

Freshwater species are also well represented. *Bithynia tentaculata, Acroluxus lacustris* and *Valvata cristata* all suggest a well-oxygenated permanent water body. The range of freshwater species present suggests a lacustrine rather than lotic system. In summary, the sample probably represents a woodland/lake edge.

Discussion

In general terms from base upwards the sequence shows the development of dry woodland conditions which subsequently become wetter, finally resulting in wet woodland adjacent to a lake edge. It is important to note that the term 'lake' as used here does not necessarily mean a very large water body, but the species represented do indicate a well-oxygenated water body of *at least* tens of metres in diameter.

The presence of *Discus rotundatus* throughout indicates that the sequence began sometime after *c.*7600 cal BC. In the topmost sample the presence of *Acicula fusca* together with *Cochlodina, Acanthinula* and other woodland species demonstrate that the woodland is most likely largely 'undisturbed', the assemblage being consistent with Preece and Bridgland's (1999) molluscan zone *d*, indicative of 'climax' woodland conditions.

This is an interesting sequence, particularly given the radiocarbon dates. The uppermost sample (5.09–5.14m OD) is after 1190–920 cal BC, but the terrestrial assemblage is strongly indicative of pre-disturbance woodland, of the type generally found somewhat earlier elsewhere. It is not possible to be tree-specific but similar modern woodland assemblages have been found in alder/hazel (with a bit of oak) type damp woodlands (damp meaning water table fairly near surface but seldom actually flooding). The key thing is that there are a number of species (*Acicula fusca, Cochlodina laminata*) that are really intolerant of woodland disturbance, and in snail circles are generally thought of as being indicative of climatic optimum wildwood. That said, it is rare to sample snails from later prehistoric woodland – there is no reason to think that the assemblages would not persist as long as the woodland remained undisturbed. The term climax woodland in wet-ground areas could also apply to alder-ash-others and does not necessarily suggest oak dominated woodland. The presence of *Pomatias elegans* is also interesting, as it indicates bare ground.

The basal minerogenic deposits in the Sharpham Park sequence were also briefly examined.

4.66–4.72m OD: this deposit resembles tufa rather than just weathered lias (although it may be a mixture) and contains snail shell.

4.72–4.82m OD: this deposit resembles tufa, although is marl-like (i.e. fine grained/creamy) and contains snails.

It appears from the snails present that these deposits were probably created by a very seasonal spring, since wetland species are not well represented in the tufaceous samples.

Environmental interpretation

Heather Tinsley and Julie Jones

In the lower part of the pollen diagram below 5.02m OD (LPAZ SP 1), from the detrital mud and underlying mixed organic/mineral deposit, pollen concentrations are extremely low because of poor preservation. Very high proportions of all *Corylus*-type and Poaceae grains show evidence of extensive biochemical alteration of the exine; and much pollen has probably completely decayed away.

No pollen at all was recovered from the tufa below 4.88m OD. The spores of ferns, which are generally more resistant to decay than pollen grains, are represented at relatively high frequencies in this zone. The pollen assemblage is heavily biased towards those taxa growing in the pollen source area that produce robust grains resistant to biochemical deterioration. This accounts for the high percentages of pollen of Lactuceae (dandelion and related Asteraceae) and, to a lesser extent, those of *Solidago virgaurea*-type (daisy, hemp-agrimony and related Asteraceae) and *Centaurea* (knapweeds). Lactuceae pollen grains in particular are extremely resistant (Havinga 1984) as they have a thick exine (pollen grain wall), and a very distinctive morphology making identification easy, even when preservation is poor. Lactuceae are included by Bunting and Tipping (2000) in a list of pollen taxa likely to accumulate differentially in conditions where preservation is poor. *Solidago virgaurea*-type and *Centaurea* are also thick-walled grains and have very distinct morphological features. Pollen of *Plantago lanceolata* one of the group of 'clearance herbs', which also appears to be over-represented in this assemblage, is not usually recognised as particularly resistant to decay, but again this taxon has very distinct morphological features enabling recognition even in a deteriorated state.

The numbers of indeterminable grains are greater in SP 1 than further up the profile though not markedly high, probably because most of the pollen has been lost. The poor preservation must have been influenced by the highly calcareous nature of the lower sediments; pollen preservation is generally not good in deposits with a high pH (Moore *et al.* 1991). The preservation of plant macrofossils was also poor at this level, although snail shells were preserved at low frequencies.

The snail assemblages recovered from the lower buff tufa deposits reflect the local nature of this environment thought to be associated with a spring-line. Initially these are indicative of a well-vegetated herbaceous cover providing a shaded environment, with other terrestrial species in the overlying creamy buff tufa more typical of a fairly dry wooded environment, with *Pomatias elegans* suggestive of areas of bare ground within the woodland. Higher in the sequence in the mixed organic detritus and tufa, the assemblage continues to have a woodland element although wetter conditions are indicated.

The bias towards robust pollen taxa in SP 1 means that this data cannot be reliably interpreted ecologically. The very low tree pollen percentages cannot necessarily be assumed to indicate an entirely open wetland landscape, or clearance of the adjacent dry land, nor can the high percentages of herbs often associated with disturbed ground necessarily be assumed to be linked with human activity, though this interpretation finds support in evidence from the series of Bronze Age trackways at Tinney's Ground, some 500–600m north of Sharpham Park, (Coles and Orme 1978b). At this site an undated pollen diagram from a monolith adjacent to one of the tracks showed high values for cereal pollen and ruderal taxa which were interpreted as indicating agriculture in the Sharpham area (Coles *et al.* 1975a). It is certain, however, that in SP 1 at Sharpham Park *Alnus* and *Salix* were present locally, with *Quercus, Corylus, Ulmus, Fraxinus* and *Tilia* on the drier land. No deductions regarding the proportions of woodland to open habitat can be made.

A wetland flora including Cyperaceae, *Juncus, Sparganium, Mentha aquatica* and *Ajuga reptans* (bugle) grew close to the spring and a ruderal community with Lactuceae, members of the taxon *Solidago virgaurea*-type, *Centaurea* and *Plantago lanceolata* was also present. These taxa typical of disturbed ground may have grown in cleared fields and the presence of *Pomatias elegans* could be significant in this context, however, another possible interpretation could link the community to ground kept open as a result of dynamic local hydrology with erosion by a seasonal spring.

Above 5.02m OD in LPAZ SP 2, the stratigraphy changes to a terrestrial peat as the site became drier, perhaps associated with the gradual movement of the seepage zone away from the immediate site. Pollen concentrations increase and the numbers of indeterminable grains fall; the contribution of Asteraceae pollen is greatly reduced, all indicating that preservation conditions improved, almost certainly associated with the decreased influence of base-rich water at the site. This transition occurred around 1190–920 cal BC (5.03–5.04m OD).

At the opening of SP 2, which coincides with the stratigraphic change, high values of *Alnus* pollen indicate that alder carr was established on the site, the trees had rooted into the detritus muds and underlying tufa as the water table fell. Fragments of woody roots occur below 5.02m OD in the stratigraphy and abundant fungal hyphae, which were observed on the pollen slides from the detritus muds, may represent the remains of associated mycorrhiza.

The pollen evidence suggests that the carr woodland was initially dense, reaching a peak at 5.09m OD. Terrestrial snails from this level (5.09–5.14m OD) continue to indicate wet woodland and plant macrofossils also show an abundance of alder fruits, cones and buds. Above this level the canopy gradually became more open, allowing the pollen of other shrubs growing nearby to reach the site; these included *Salix, Frangula alnus* (alder buckthorn), *Rhamnus cathartica* (buckthorn) and *Viburnum opulus* (guelder rose). There are also indications in the insect assemblage for drier conditions including some species associated with dead wood, including scolytid bark beetles, with, for example, *Hylesinus crenatus*, which mostly attacks ash and *Scolytus ?rugulosus* various woody Rosaceae. Evidence from bugs, such as *Aphrophora alni* suggest the presence of trees and bushes, with *Idiocerus* species occurring mostly on poplars.

The ground flora was dominated by Cyperaceae with some Poaceae, *Sparganium* and occasional *Typha latifolia* with the sedges in particular expanding towards the end of the zone as the carr canopy opened. Flowering herbs such as *Lythrum salicaria*, *Lythrum portula*, *Oenanthe* (water dropworts), *Mentha* and *Rumex sanguineus*-type (includes clustered dock and curled dock, both of which grow in damp places) were also part of the community.

Freshwater snails, including *Bithynia tentaculata* and *Valvata cristata*, suggest a well-oxygenated permanent water body and the beetle and bug fauna is dominated by aquatic and waterside taxa indicating a rich aquatic and emergent vegetation. The aquatic plant taxa also form a relatively high proportion of the macrofossil assemblage and also suggest the presence of open pools providing a habitat for *Potamogeton*, *Chara*, *Menyanthes trifoliate, Alisma plantago-aquatica* and *Lemna*, the latter with an associated weevil *Tanysphyrus lemnae.*

The horizon of wood, which makes up the Saul Platform, occurs within SP 2 with the top of the structure between 5.19 and 5.27m OD. The identified wood was principally *Alnus* along with some *Fraxinus*, indicating that both wetland and dry land wood was used in the construction (see above). The single date of 1260–910 cal BC on worked alder is consistent with the early part of LPAZ SP 2.

Above 5.29m OD the site appears to have become wetter again. Pollen and macrofossils of *Alnus* decline to low levels at the start of LPAZ SP 3 and Cyperaceae pollen expands markedly indicating the replacement of the carr community by sedge beds. There is a corresponding increase in macrofossils of Cyperaceae, including *Carex elata* (tufted sedge), which occurs in eutrophic mires such as reedswamps where at least seasonal flooding occurs, and *Carex riparia*, (greater pond-sedge) which can form large stands around pools in swamps or wet fen woods which are waterlogged for long periods in spring. Fruits of *Sparganium erectum* occur in addition to *Typha*, although the *Typha* is less frequent than in the peat below the timber platform.

Pollen of both *Sparganium emersum-type* (includes *S. erectum*) and Poaceae increase later in the zone and grasses (possibly common reed) may have spread into the sedge beds as the water table rose further. This phase culminated in flooding which produced minerogenic deposition in the form of the thin irregular band of grey clay between 5.35m and 5.40m OD. Organic material from just beneath this band is dated to 1045–905 cal BC, and minerogenic deposition ends just before 800–540 cal BC.

The dates link this flooding to events in the wider Brue valley, where evidence for periods of both freshwater and brackish water flooding occurred in the 1st millennium BC. On the raised bog area, to the north-west of Sharpham Park, phases of freshwater flooding were first recorded by Clapham and Godwin (1948) at Meare Heath in the form of horizons rich in macrofossils of *Cladium mariscus* (great fen-sedge) indicating a change from acidic to more base-rich conditions, with the first flooding horizon between 836–792 cal BC. To the north-east of Sharpham several metres of estuarine clay deposition (the Upper Wentlooge formation) have been recorded in the Godney Moor area (Godwin 1955; Housley 1988; Aalbersberg 1997). At Long Run Farm, just south of Godney island, Housley dated both regressive and transgressive boundaries associated with this formation. The calibrated dates of 1210–900 cal BC and 810–440 cal BC (Housley *et al*. 2000) are very similar to the dates which bracket the thin clay band at Sharpham Park. However, it seems likely that at this site the clay deposition was a result of freshwater flooding as there is no evidence of increases in halophytic taxa in the pollen diagram or the plant macrofossils. The horizon was assessed for diatoms, but none were preserved (Cameron 2007).

Following this period of higher water table associated with the deposition of the clay at Sharpham Park, the pollen data from the end of LPAZ SP 3 indicate that *Salix* expanded round the edges of the waterlogged beds of Cyperaceae and *Sparganium*. With the opening of SP 4 (dated to 800–540 cal BC), there was a short-lived re-expansion of *Alnus* around the site but by the end of the zone, at 400–260 cal BC, the wetland landscape was once again largely dominated by Cyperaceae with some Poaceae and *Typha*.

The evidence for the dry land vegetation on the slopes of the Poldens near the Sharpham Park site, throughout the period from 1690–1520 cal BC to 400–260 cal BC, indicates that it supported woodland dominated by *Quercus* with *Corylus*. *Fraxinus* was also present, with some *Ulmus* and occasional *Fagus.* Even in the base of the pollen diagram in SP 1, where pollen preservation is so poor, these dry land taxa are present. The presence of the *Alnus* carr at the site, from the start of SP 2, filtered out dry land pollen to some extent. Nevertheless, above this level the pollen curves for *Quercus* and *Corylus*-type fluctuate largely in parallel, strongly suggesting that the *Corylus*-type curve is primarily *Corylus* rather than *Myrica* (bog myrtle). This is supported by the presence of occasional hazel nut fragments and the lack of any *Myrica* fruits.

Both *Quercus* and *Corylus*-type pollen are somewhat reduced in SP 3, during the period of higher water table. Possibly the flooding which deposited the clay band had implications for the density of trees on the lower Polden slopes, immediately above the wetland proper. Pollen values for the dry land trees recover a little in SP 4, though decline again towards the top of the zone. The pollen record for *Fraxinus* is continuous throughout the diagram, but is at a maximum of 3% TP in SP 2, the zone associated with the platform, which included ash wood.

There are occasional cereal-type pollen grains throughout the diagram (no macrofossil remains of *Glyceria* were found). These cereal grains must have originated from fields on the adjacent slopes. If zone SP 1 is ignored, because of the problems of pollen preservation, the pollen curve for clearance herbs shows a small increase towards the end of SP 2, principally due to an increase in *Plantago lanceolata*. The curve for *P. lanceolata* peaks between the two dated horizons of 1045–905 cal BC and 800–540 cal BC in SP 3, before falling somewhat at the end of SP 4. The implication is that there was a period of increased human impact on the adjacent Polden ridge in the early part of the 1st millennium BC, with land used for both cultivation and pasture. Indeed there may well have been significant impact earlier in the Bronze Age, associated with the multiple trackways which were found at Tinney's Ground (Coles and Orme 1978b). However, the poor pollen preservation in the base of the Sharpham Park diagram means that evidence for this is equivocal. The phase of agricultural activity appears to have reduced by 400–260 cal BC.

Fieldwork conclusion

The limited excavations confirmed the evidence for humanly worked material on the site in the later Bronze Age but were unable to define the character of the activity it represented. The associated waterlogged deposits extend for less than 10m to the west but the other limits of the site are still unknown. The detailed environmental analysis has been able to show how the wetland edge of the Poldens in this location changed from a tufa forming spring into an alder carr by the late Bronze Age and then into a wetter sedge dominated swamp, overwhelmed by deeper flooding at the beginning of the 1st millennium cal BC. Alder carr re-established itself briefly in the middle Iron Age before sedge swamp with open pools of water again covered the area. The snail evidence showed that the local oak and hazel dominated woodland remain relatively unmodified until the later prehistoric period although arable farming was taking place nearby. Agricultural activity in the local area appears to have peaked in the late Bronze Age before declining again by the middle Iron Age.

Saul Platform assessment and monitoring

Assessment of preservation

Visual assessment of wood

Visually the wood appeared to be in good condition with little or no signs of desiccation cracks. Bark was often still in place on the roundwood and surface condition was good.

Detailed examination of wood structure

Mark Jones

The state of degradation, as given by the moisture content is shown in Table 74. All samples have moisture content values above 400%. Alder samples have moisture content values above 461% and range up

Table 74. Saul Platform, Sharpham Park: moisture content values and state of degradation.

Timber no.	% Moisture Content	Timber Condition
29	670	Heavily degraded
30	698	Heavily degraded
32	832	Heavily degraded
33	461	Heavily degraded
34	790	Heavily degraded
39	810	Heavily degraded

Table 75. Saul Platform, Sharpham Park: wood species, moisture content (MC) and density values.

Timber no.	Wood species	%MC	Original density	Present density
29	Alder	670	0.48	0.13
30	Alder	698	0.48	0.13
32	Alder	832	0.48	0.11
33	Alder	461	0.48	0.19
34	Ash	790	0.67	0.11
39	Alder	810	0.48	0.11

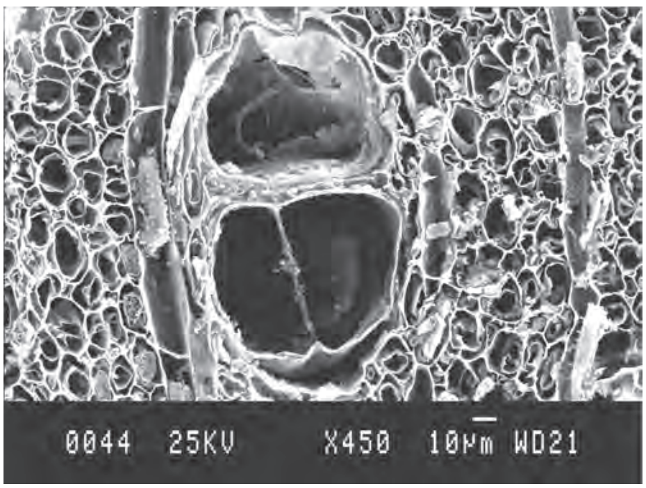


Figure 90. SEM of ancient ash 43.

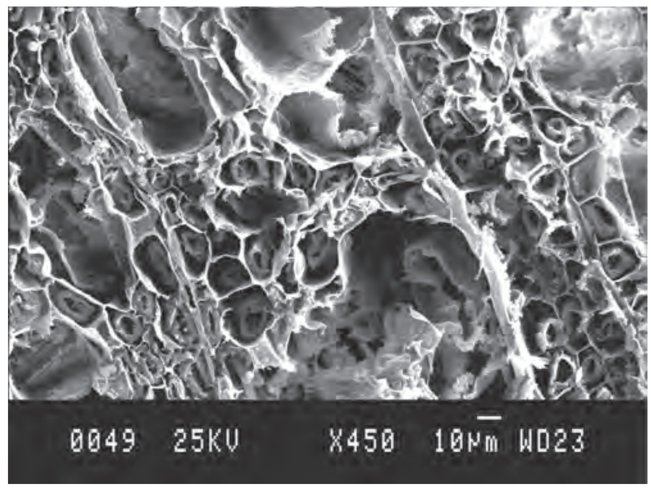


Figure 91. SEM of ancient alder 32.

to 832%. The solitary ash sample had high moisture content values (790%). The state of degradation as given by moisture content of the timber samples fall into the class of heavily degraded (Figures 90 and 91).

Table 75 lists the density values obtained for the samples excavated at this site. All samples were much lower than the original density values. This indicates a loss of original cell wall material. Density values obtained for alder samples range from 0.19 to 0.11. Ash sample (34) had a density value of 0.11.

Ash (34) sample analysed under the SEM showed different stages of attack (Figure 90). This sample was highly decayed with moisture content of 790%. In the outer surface the fibre cells, rays and vessels were extensively degraded.

Changes to the chemistry of alder and ash samples can be seen in Figure 92. The spectra indicate that the ratio of lignin to cellulose has increased, indicating degradation of the carbohydrate and selective preservation of the lignin in the wood matrix. The hemicellulose peak (1730cm^{-1}) has been lost in the spectra for ancient ash and alder indicating total degradation of this polyose. The recorded condition of the wood found at the Saul Platform means irreversibly collapse would be inevitable if the wood dried out.

Pollen evidence

Heather Tinsley

The six samples assessed from this site extended over a varied stratigraphy as previously described. Samples were assessed from the detrital mud at 4.95–4.96m OD, and from the peat at 5.03–5.04m, 5.12–5.13m, 5.34–5.35m and 5.41–5.42m OD. The upper sample was from 5.52–5.53m OD, just below the junction of the peat with the overlying clay-silt.

Pollen preservation

Preservation varies quite markedly at this site (Table 76). At 4.95–4.96m OD, in the basal sample examined from the detrital mud, 23% of pollen grains were well preserved. There were 14 indeterminable grains, some amorphous, five with heavy corrosion, and some mechanically damaged. 23% of identified grains were poorly preserved, principally due to degradation (exine thinning). Around 30% of identified grains showed

Table 76. Saul Platform, Sharpham Park: pollen preservation summary.

	4.95–4.96m OD	**5.03–5.04m OD**	**5.11–5.12m OD**	**5.33–5.34m OD**	**5.41–5.42m OD**	**5.52–5.53m OD**
Total identified pollen grains	100	100	100	100	100	100
Pollen concentration	18,300	13,900	126,500	48,800	99,400	695,600
Number of pollen taxa	17	15	12	16	14	9
Total indeterminable grains	14	20	5	4	13	10
Total identified extensively corroded grains (a)	1	9	12	5	5	9
Total identified extensively degraded grains (b)	18	42	3	1	4	19
Total identified extensively crumpled grains (c)	1	2	2	0	0	0
Total identified extensively broken grains (d)	3	1	1	0	3	0
Total identified grains with poor preservation (a+b+c+d)	23	54	18	6	12	28
Total well-preserved grains	23	1	42	48	49	24
Total grains of resistant taxa	17	3	0	2	0	0
Total ferns	54	28	4	22	9	54
Biochemical preservation index	0.93	1.94	0.98	0.63	0.61	1.23
Mechanical preservation index	0.68	0.37	0.23	0.26	0.36	0.14

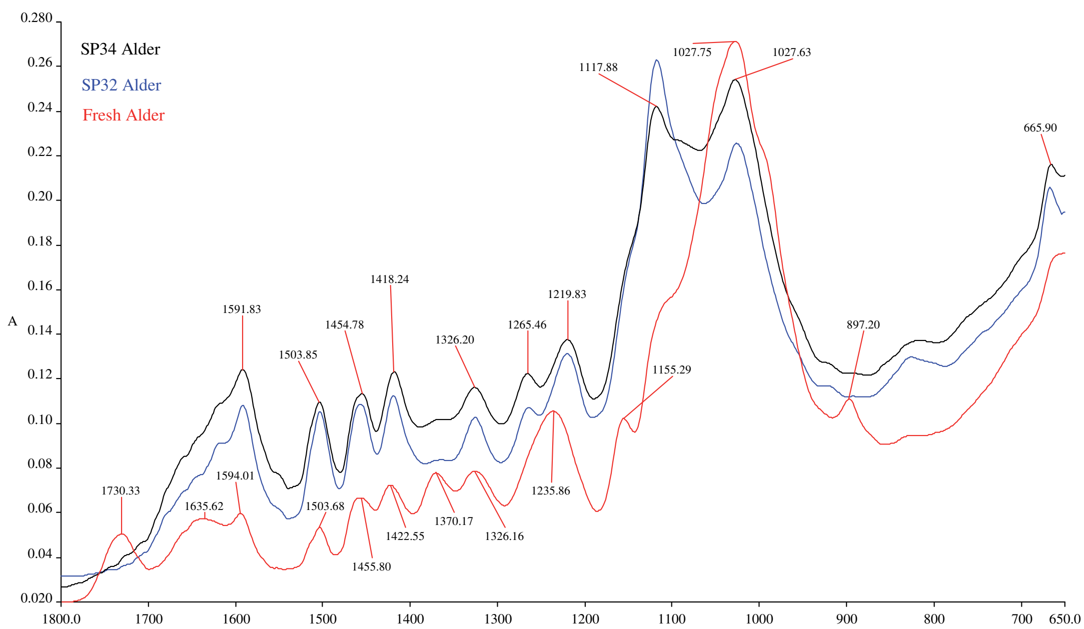


Figure 92. FT-IR spectra of timbers 32 (alder) 34 (ash) and modern alder, Saul Platform.

partial degradation. Nine grains of *Solidago virgaurea*-type were identified and all appeared partly shrunken, the reason for this is not known, but it may possibly be a result of degradation and partial collapse of the grain. The biochemical preservation index was 0.93 and the mechanical preservation index was 0.63. Around half of all the fern spores had some surface etching.

Preservation was significantly worse at 5.03–5.04m OD, at the base of the silty peat, where only 11% of grains were well preserved. Twenty indeterminable grains were counted; the majority of these were amorphous. 54% of all identified grains were poorly preserved, principally due to extensive degradation and nearly 30% of grains showed partial degradation. Corrosion was not a major factor in this assemblage, only 1 out of the 15 *Corylus*-type grains showed evidence of this type of deterioration. The biochemical preservation index was 1.94 and the mechanical preservation index was 0.37. The preservation of the fern spores was very mixed ranging from well preserved to very thin and etched.

Overall preservation characteristics at 5.11–5.12m OD, 5.34–5.35m OD and 5.41–5.42m OD were fairly similar, and markedly better than at 5.03–5.04m OD. The total of well preserved grains ranged from 42–49%, with 4–13 indeterminable grains. The number of grains with poor preservation was variable ranging from 18% at 5.12–5.13m OD to only 6% at 5.34–5.35m OD. Far fewer grains showed partial degradation in these samples, though corrosion increased somewhat. Biochemical preservation indices ranged from 0.61 to 0.98 and mechanical preservation indices 0.23–0.36. Fern spores were generally well preserved with the exception of those at 5.41–5.42m OD, where half showed some surface etching.

In the uppermost sample, from the top of the well-humified wood peat at 5.52–5.53m OD, preservation was less good. 24% of grains were well preserved, with 10 indeterminable, 4 amorphous, 3 corroded and 4 fragmented grains. 28% of identified grains were poorly preserved, 19% due to extensive degradation. Cyperaceae formed 57% of pollen counted and more than half of these grains were degraded to some extent. Corrosion was most apparent on the *Corylus*-type grains with 10 out of 12 grains showing this deterioration type. The biochemical preservation index was 1.23 and the mechanical preservation index was 0.14. Of the 49 undifferentiated fern spores noted, the majority were etched on the surface, some extensively.

The variability in pollen preservation noted in this section cannot simply be a product of water table variation. Preservation was only moderately good in the basal sample examined, and markedly poorer in the well-humified silty peat above this at 5.03–5.04m OD. Both these samples contained fungal hyphae and indeterminate fungal spores, and it is possible that there may have been a hiatus in sediment deposition around this level, allowing the basal sediments to dry out somewhat and become subject to biological activity and subsequent pollen deterioration. However, there is no obvious stratigraphic evidence to support this suggestion and indeed the dominant deterioration type observed was degradation, not corrosion.

Other factors connected with pH may well be implicated; pollen preservation is generally not good in sediments of high pH (Moore *et al.* 1991). The marl at the base of this section is highly calcareous; a sample was processed but it contained no pollen, and this must be a result of lack of preservation. It is certainly possible that calcareous water influenced the lower sediments, which accumulated during the early part of the hydrosere at this site, and as a result pollen deteriorated, primarily due to degradation, although this does not explain the presence of the fungal material.

The high numbers of Lactuceae, and to a lesser extent *Solidago virgaurea*-type grains, found in the basal sample are also of interest. Lactuceae pollen grains are particularly robust (Plate 19: Appendix 3) and are extremely resistant to decay (Havinga 1984), consequently these could be a consequence of differential accumulation, following selective decay of less robust types. However, the biochemical preservation index was only 0.93 and pollen preservation was moderately good, though the mechanical preservation index was 0.63. It appears that a community with abundant Asteraceae must have been established when the peat at 4.95–4.96m OD was forming. Full analysis of this assemblage is needed to further investigate this.

Preservation was much better in the three samples from 5.11–5.12m, 5.34–5.35m and 5.41–5.42m OD, though numbers of indeterminable grains increased in the higher samples. These sediments appeared to have remained consistently waterlogged. As they accumulated, and the height of the fen peat was raised, the influence of the more strongly calcareous water probably diminished. Preservation was less good in the uppermost sample at 5.52–5.53m OD, where both degradation and corrosion was apparent, almost certainly this is due to the rather drier conditions at the top of the section which have promoted oxidation; the modern roots, which were noted in the field, suggest that biological activity by bacteria and fungi may be currently active at this level.

Of the six samples assessed at this previously unstudied site, five have the potential for full pollen analysis; the sample from 5.03–5.04m OD should be rejected, on the grounds of the numbers of indeterminable grains (17% TP+indeterminables) and the very large numbers of grains with poor preservation (54%). It is likely that there will have been differential losses of the least robust pollen taxa from this sample and therefore the pollen assemblage may well be biased. Any future pollen diagram prepared from the Sharpham Park site would therefore have a hiatus around this stratigraphic level. The upper sample from the sequence, where pollen is potentially at the greatest risk of deterioration due to recent fluctuations in the water table, is suitable for full analysis.

Plant macrofossils

Julie Jones

Preservation

The preservation results are summarised in Tables 77–80.

Table 77. Saul Platform, Sharpham Park: plant macrofossil samples and stratigraphy.

Stratigraphy	**Plant macrofossil/ beetle samples**
5.55–5.56m OD Clay silt (colluvium)	
5.40–5.55m OD Well–humified woody peat. Modern roots present	5.41–5.46m
5.35–5.40m OD Blue grey clay, the band is variable in thickness, 5cm maximum	
5.02–5.35m OD Well humified silty peat, with snails from 5.16m OD No modern roots present	5.30–5.35m 5.09–5.14m
4.92–5.02m OD Brown detrital mud with wood fragments	
4.92m Grey calcareous marl	

Table 78. Saul Platform, Sharpham Park: plant macrofossil preservation.

Well humified silty peat								
		Fragmentation				**Erosion**		
5.09–5.14m OD (42–47cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alisma plantago–aquatica	4	0	4	0	0	3	1	0
Alnus glutinosa	59	32	24	3	0	7	9	0
Carex spp.	12	5	4	1	2	4	3	0
Chara spp.	8	4	4	0	0	4	0	0
Hypericum sp.	1	1	0	0	0	0	0	0
Mentha aquatica	1	1	0	0	0	1	0	0
Oenanthe aquatica	11	3	6	1	1	4	4	1
Potamogeton spp.	4	1	1	0	2	0	2	0
Other macrofossils: abundant wood fragmentss, frequent *Alnus glutinosa* cones and buds/scales, occasional moss, land and water snails								
Well humified silty peat								
		Fragmentation				**Erosion**		
5.30–5.35m OD (21–26cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alisma sp	1	0	0	0	1	0	1	0
Carex paniculata	1	1	0	0	0	0	0	0
Carex spp	34	18	10	2	4	8	10	2
Lycopus europaeus	5	1	0	3	1	0	0	0
Mentha aquatica	8	8	0	0	0	7	0	0
Potamogeton spp	4	3	0	1	0	1	0	0
Potentilla sp	1	1	0	0	0	0	0	0
Sparganium erectum	17	10	2	1	4	12	2	1
Typha spp	6	1	3	0	2	3	2	0
Urtica dioica	1	1	0	0	0	1	0	0
Other macrofossils: abundant wood/twigs, occasional caddis fly larvae								
Well humified woody peat								
		Fragmentation				**Erosion**		
5.41–5.46m OD (10–15cm)	**Total counted**	**whole**	**<25%**	**25–50%**	**>50%**	**<25%**	**25–50%**	**>50%**
Ranunculus subg. *Batrachium*	1	0	0	0	1	1	0	0
Stellaria media	1	0	0	1	0	1	0	0
Other macrofossils: abundant wood fragments								

5.09–5.14m OD: The bulk of this sample was soft wood fragments with well preserved alder cones, buds/scales as well as moss branches, some with leaves attached and frequent mollusca, both land and water species. Alder fruits were most common, accounting for 59% of macrofossils assessed. The flat fruits (Figures 2 and 3: Appendix 4) approximately 2.5 × 2mm, are rounded pentagonal in outline with a blunt tip, the dorsal face often with one faint longitudinal keel and two lateral ones. The fruit wall is thick and corky and appears to be very resilient. In this sample there are >50% complete examples and a further 40% <25% fragmented. There was some abrasion to the surface structure, but generally the fruits were in good condition.

The water-plantain showed some fragmentation of the flat wedge-shaped fruits (Figure 1: Appendix 4), with some erosion of the testa making the darker brown U-shaped embryo inside clearly visible.

Fine-leaved water-dropwort (*Oenanthe aquatica*) is typical of slow-flowing or stagnant water and its fruits are oblong to ovate in outline with a flat ventral side and domed dorsal side (Figure 14: Appendix 4). Preservation was variable with degrees of fragmentation and only three complete examples. There was also noticeable degradation to the longitudinal ribs on the domed dorsal side of the fruit. In well-preserved examples, there are five ribs of spongy tissue, the lateral ones somewhat thicker than the inner ones but in most examples here there was some loss to this ridging.

Table 79. Saul Platform, Sharpham Park: macrofossil summary table.

	5.09–5.14m OD	5.30–5.35m OD	5.41–5.46m OD
Total macrofossils counted	100	78	2
Estimated total in sample	200	78	2
Total taxa	8	10	2
Total well preserved	47	44	0
Total <25% fragmented	43	15	0
Total 25%–50% fragmented	5	7	1
Total >50% fragmented	5	12	1
Total <25% erosion	23	32	2
Total 25%-50% erosion	19	15	0
Total >50% erosion	1	3	0
Preservation index	**1.33**	**1.74**	**3.5**

Preservation index 1.33. Eight taxa in 100 counted. Analysis recommended

5.30–5.35m OD: Much of this sample float also consisted of soft wood fragments and twigs, although fewer macrofossils were preserved, with 10 taxa out of 78 fruits counted. Alder no longer occurs and sedges and branched bur-reed are most common. Many of the branched bur-reed were complete, although there was some (<25%) erosion of the surface ridging. Similarly over 50% of sedges were entire, with a further 30% <25% fragmented with more than half showing deterioration to surface cell structure, although identification to species should be possible for most nutlets. Preservation index 1.74. Ten taxa in 78 counted. Analysis recommended

5.41–5.46m OD: Preservation in this well-humified woody peat was very poor with only two seeds noted. The single water-crowfoot was >50% fragmented, with the single common chickweed (*Stellaria media*) also fragmented showing some erosion to the warty protruberances which cover the surface of this seed. Preservation index 3.5. Two taxa in two counted. Analysis not recommended.

Recommendations

Macrofossil preservation in the lowest sample in the silty peat at the base of the sequence was good with a preservation index of 1.33, however a scan of the remaining sample added no additional species to the fairly small assemblage of only 8 taxa, so further analysis would need to be based on the processing of larger samples.

Similarly abundance was low in the overlying silty peat, the higher preservation index of 1.74 mostly due to deterioration of sedges and branched bur-reed; larger samples would again permit further analysis. Little recognisable material remained in the well-humified woody peat at the top of the sequence and further analysis is not recommended.

Coleoptera

Harry Kenward

Three samples were assessed from the site (Tables 81 and 82) at 5.41–5.46m OD (upper woody peat), 5.30–5.35m OD and 5.09–5.14m OD (both in a silty peat layer). The upper sample showed great chemical degradation (in

Table 80. Saul Platform, Sharpham Park: properties of 250g unprocessed samples.

	Dry weight	0.25mm	0.5mm	1mm	2mm	4mm	Organic matter %
5.09–5.14m	62.95g	3.9g	6.2g	6.3g	5.8g	9g	49%
5.30–5.35m	80.84g	4.5g	4.1g	3.8g	3.6g	4.8g	26%
5.41–5.46m	93.61g	4.6g	3.9g	4.3g	4.3g		19%

Table 81. Saul Platform, Sharpham Park: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
5.41–5.46	Small flot of herbaceous detritus. Few insects (others probably completely decayed), no good ecological indications.	No further action. P0
5.30–5.35	Small flot, fine plant fibres and abundant insect fragments. Many remains borderline for identification through decay. Appreciable and fairly diverse aquatic component (e.g. several *Ochthebius* and *Limnebius*), remaining taxa mainly able to live in swampland.	Larger sub-sample (3kg) would give good account of local ecology, but narrow ecological range means probably of limited value. P1B
5.09–5.14	Small flot, well decayed herbaceous detritus, seeds, snails, abundant invertebrate fragments. Some aquatics (especially *Octhebius*), but mainly terrestrial or damp ground taxa. Hints of trees (*Scolytus* sp.) and shade (*Drymus brunneus* (Sahlberg)).	Larger sub-sample (3kg) would give good ecological resolution, including clearer evidence of trees. Difficult identifications (result of taxa present and preservational condition). P1A

Table 82. Saul Platform, Sharpham Park: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical Erosion				Fragmentation				Colour change					Other properties
	range		mode	str	range		mode	str	To	range		mode	str	
5.41–5.46	4.0	5.5	4.5	D	3.5	5.5	3.5	W	–	–	–	–	–	some remains probably completely decayed
5.30–5.35	2.5	4.0	3.5	D	2.5	5.0	3.0	W	Pale,	1	3	2	W	
5.09–5.14	2.0	4.0	3.0	W	2.5	4.0	2.5	W	–	–	–	–	–	

the range 4.0–5.5, with a mode of 4.5), and some of the remains were extremely fragmented (F 5.5, 'reduced to fine fragments'). Some remains had almost certainly completely disappeared from this layer. Preservation was a little better in the two lower samples, but some fossils were very degraded. This site seems to have undergone significant post-depositional decay, and this related well to the field description of the deposits as 'well humified'. The upper deposit was a wood peat, however, and may have been inherently rather freely draining, so that decay in antiquity is also possible.

Diatoms

Nigel Cameron

A single sample was assessed from 5.38–5.39m OD. Diatoms were absent from the sample. This may reflect unfavourable conditions for diatom silica preservation such as repeated wetting and drying of sediment or extremes of pH either in the water or in the sediment (Flower 1993; Ryves *et al.* 2001).

Monitoring of burial environment

David Hogan

Site description

Transect: From drain westwards towards the foot of the slope with 2 stations, Station 1 next to excavation and pole, and Station 2 at 10m beyond. A description was made at a further 10m but no station was established (Figure 82).

Land use: Permanent pasture of old parkland with a few small trees.

Station 1 (Table 83). Instrumentation: piezometers at 50cm, 100cm and 150cm depth.

Station 2 (Table 84). Instrumentation: piezometers at 50cm, 100cm and 150cm, and redox probes at 40cm, 70cm and 100cm depth.

A profile was described from auger boring at a further 10m along the transect, but no instrumentation established (Table 85). Concave footslope.

Table 83. Saul Platform, Sharpham Park: Station 1.

Depth (cm)	Description
0–15	Very dark greyish brown (10YR 3/.2) moist silty clay loam with common fine rusty mottles
15–25	Dark grey (10YR 4/1) moist silty clay with many fine mottles of dark reddish brown (5YR 3/4)
25–35	Dark grey (10YR 4/1) clay with many fine and medium mottles of yellowish red (5YR 5/8) and also with patches paler and darker than the matrix
35–60	Yellowish red (5YR 5/6) moist clay with many fine and medium mottles of pinkish grey (7.5YR 6/2) and common fine and medium areas of black material
60–75	Dark grey (10YR 4/1) moist clay with few fine mottles of dark reddish brown (5YR 3/4), and many medium and coarse pockets of black material
75–120	Black (5YR 2/1) hard, slightly moist humified peat (H9)
120–150+	Brown (7.5YR 5/2) amorphous peat (H7), darkens on exposure

Table 84. Saul Platform, Sharpham Park: Station 2.

Depth (cm)	Description
0–10	Very dark greyish brown (10YR 3/2) slightly moist friable silty clay loam
10–25	Very dark greyish brown (10YR 3/2) slightly moist clay with common medium mottles of yellowish red (5YR 4/6). Includes limestone fragment dark reddish brown (5YR 3/4)
25–45	Dark grey (10YR 4/1) slightly moist dense clay with common medium mottles of yellowish red (5YR 5/8), common medium and coarse areas of grey (10YR 5/1) also with black patches
45–70	Brown (7.5YR 5/2) moist clay with common fine faint mottles of yellowish bown (10YR 5/6) and with patches of darker material
70–120	Black (5YR 2/1) moist amorphous peat (H8) with a few twigs and small grass–sedge leaves
120–150	Black (5YR 2/1) hard, slightly moist humified peat (H9)
120–150+	Brown (7.5YR 5/2) amorphous peat (H7), darkens on exposure

Table 85. Saul Platform, Sharpham Park: augered profile at 10m along transect.

Depth (cm)	Description
0–20	Brown to dark brown (7.5YR 4/2) moist silty clay loam
20–35	Brown to dark brown (10YR 4/3) moist silty clay with common medium mottles of reddish yellow (7.5YR 6/6)
35–40	Very dark grey (7.5YR 3/1) moist humose silty clay with common fine mottles of strong brown (7.5YR 5/6)
44–50+	Light grey (10YR 7/2) very stony humose silty clay with many small angular hard stones and areas of black (10YR 2/1)

Results

Figure 93 indicates that the upper parts of the wood remained above the level of the water table throughout the year. From March onwards the water level declined to expose an ever greater proportion of the archaeology to more oxidised conditions, though possibly within the influence of a wetting front. For a brief period in the summer, the water table fell below the level of the base of the remains altogether. A substantial rise in water level was delayed until late autumn (Figure 93), when the remains became saturated by the water table.

At both stations the water table fell briefly in summer to about 100cm below the ground surface (Figures 93 and 95). The balance between oxidised and reduced conditions is demonstrated by the results from measuring redox potential (Figure 94). Probe R40, representing conditions at the top of the remains, moved rapidly from being *slightly* to *moderately reduced* through the spring months, and to becoming *oxidised* from June to October.

Within the depth range of the remains themselves, a similar pattern was apparent, though with lower redox values, giving a change from *moderately* to *highly reduced* in spring to a shorter summer period of *oxidised* conditions. At 100cm depth, where conditions remained more or less permanently waterlogged, redox remained *moderately reduced* throughout the year with only minor fluctuations taking place. Groundwater taken from piezometers beside the structure had a pH of 6.8, while a pH of 7.4 was recorded from water from the ditch on the eastern side of the field.

Conclusions

The upper layers of archaeological material remained above the water table throughout the year, with exposure in the summer months to *oxidised* conditions, and with only *slightly reduced* conditions established during the rest of the year. Conditions suggest continued degradation of organic material is likely to be taking

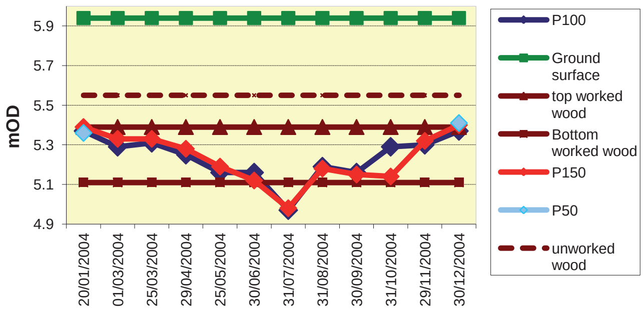


Figure 93. Water table at Station 1.

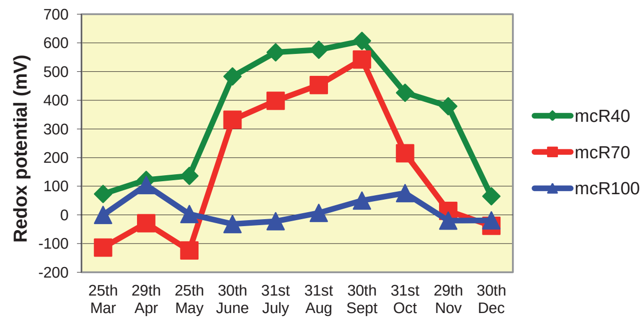


Figure 94. Redox potential at Station 1.

place here. Towards the base of the preserved material, conditions appear to remain waterlogged for most of the year, though a short period of *oxidised* or only *slightly reduced* conditions are likely to occur, probably allowing some degradation to take place, but at a slower rate than in upper layers.

Preservation conclusion

The anthropogenic activity identified in the excavations occurred at a level of fluctuating water levels where the water table dipped just below the wooden remains for several months during the summer. The largely decayed cell structure of the wooden remains means that they are in theory very vulnerable to desiccation and associated shrinkage. A slightly higher summer water table would be required to ensure the site's long term preservation.

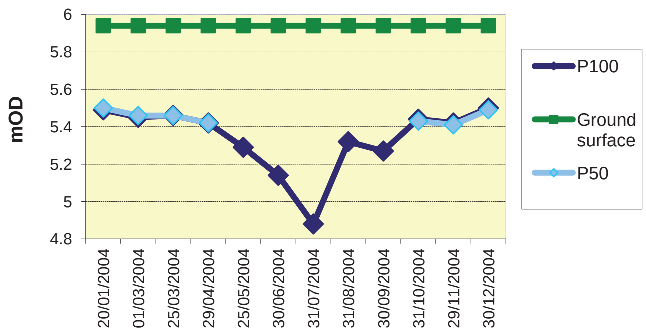


Figure 95. Water table at Station 2.

9. Harding Alignment, Harter's Hill fieldwork

Somerset HER 25637

Previous fieldwork

The site is located in Queen's Sedge Moor, at the base of Harter's Hill near Coxley (ST53354255; Figure 96). The structure is contained within peat deposits that deepen rapidly from the edge of the 'dry' land to reach a depth of 8.5m in the middle of the moor (information from Soil Survey cores taken 1978–9). The known site is contained within one field, which is used for pasture and is bounded on all four sides by water-filled rhynes. An arable field is present on the east side separated from the pasture field by a drove road. Bog oaks have often been encountered in the rhynes during routine ditching work on the north, east and west sides.

The farmer, Mr Harding, discovered the site during harrowing in September 1996. The tops of fourteen oak posts, protruding slightly above ground level, damaged some harrowing machinery. Ten of the posts were extracted (Figure 97 and Figure 99: 1–10) and, as they had cut ends, Mr Harding realised they were not bog oaks and contacted a local museum. The extracted piles were photographed, recorded, and sampled for tree-ring dating by the Somerset County Council Heritage Service. The piles were all oak, left in the round with diameters varying between 160mm and 230mm and surviving lengths from 1.35m to 1.92m. All the piles showed evidence of cracking on the surface resulting from their exposure in the field surface (Figure 98). Clear toolmarks could be seen on the ends where they had been cut to a point. The small width (50mm max.) of the toolmarks and the pronounced concavity of the facets immediately suggested that a bronze axe made them.

A brief surface survey of the field identified another 19 piles that could be felt just below the ground surface. When the positions of these piles were plotted alongside the original timbers a picture emerged of several rows of piles extending out from the dry ground at the edge of the hill into the wetland for a distance of at least 60m (Figure 99).

In 1997 a further four piles had been extracted and left by the field gateway and were in a very poor condition. Their point of origin is uncertain but they

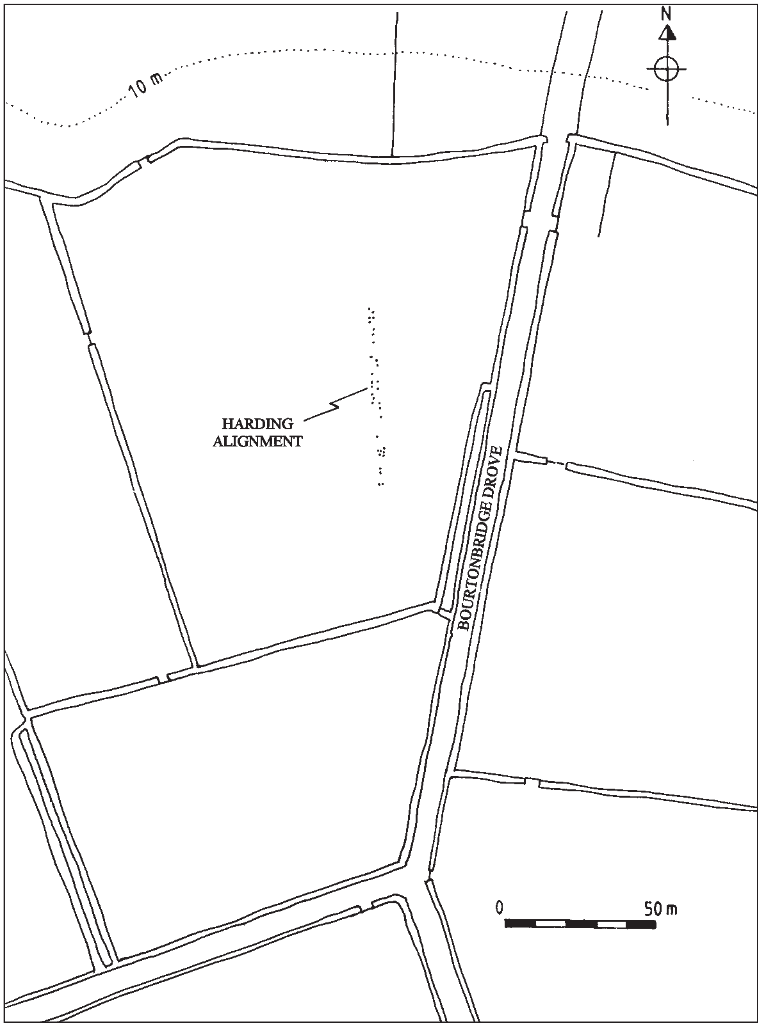


Figure 96. Location map of the Harding Alignment, Harter's Hill.

Figure 97. The site shortly after discovery looking north towards Harter's Hill. Mr and Mrs Harding in foreground.

Figure 98. Some of the original piles shortly after their extraction. Scales 1m and 0.5m. Left: piles 3, 8 and 9. Right: piles 7 and 10.

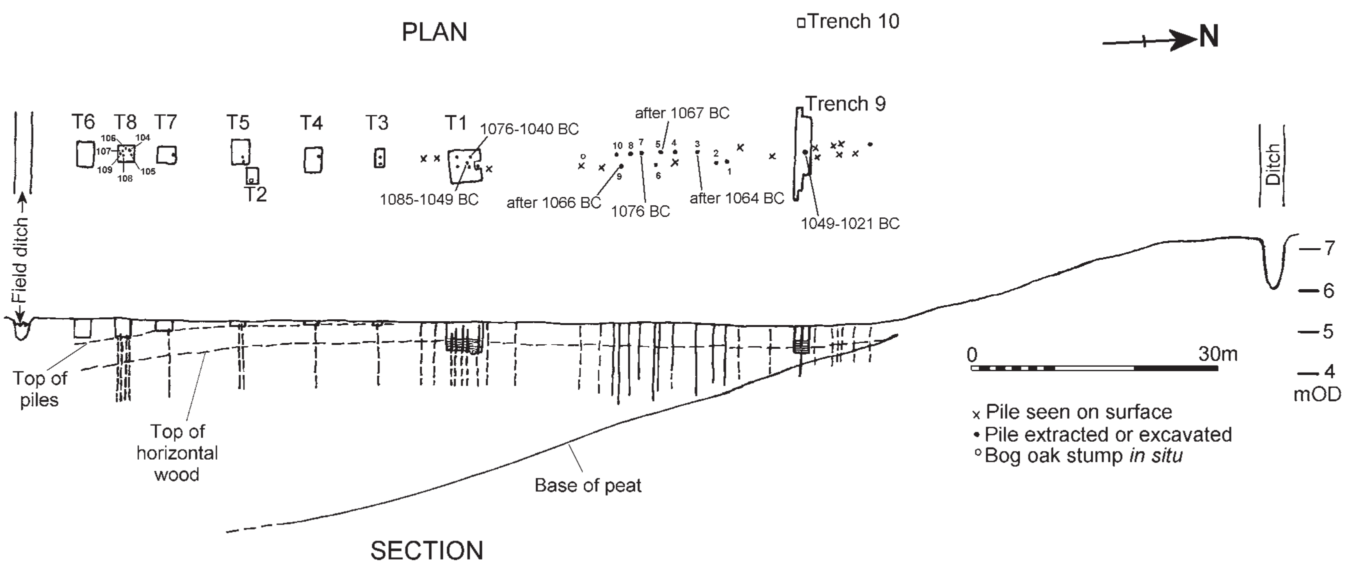


Figure 99. Plan (top) and section (below) of the Harding Alignment.

probably came from the northern end of the alignment where the posts were closest to the surface. SCC Heritage Service undertook evaluation excavations in 1997 and 1998 with funding from English Heritage. The objectives were to establish the extent, character, function, condition and date of the structure. The results have previously only been summarised as a brief note (Brunning 1998) so a fuller report has been included as part of this publication. One main trench (Trench 1) was opened to assess the character and dimensions of the structure and seven other trenches (Trenches 2–8) were excavated to try and determine the southern end of the alignment (Figure 99). These trenches were intended to be as shallow as possible while allowing confirmation of the presence or absence of oak piles. The tree-ring dates, woodworking analysis and species identifications from this fieldwork are presented alongside the MARISP results below. An environmental sample assessed as part of this initial fieldwork was subject to full analysis as part of the MARISP project (see below).

Trench 1

Trench 1 was 4m by 4m in size and was positioned near the northern terminal of the alignment. Six large oak piles were contained within the trench (11–15 and 24). Their lengths and full diameters are not known because they were not extracted. The tops of the piles were between 4.72 and 4.96m OD, just below the ground

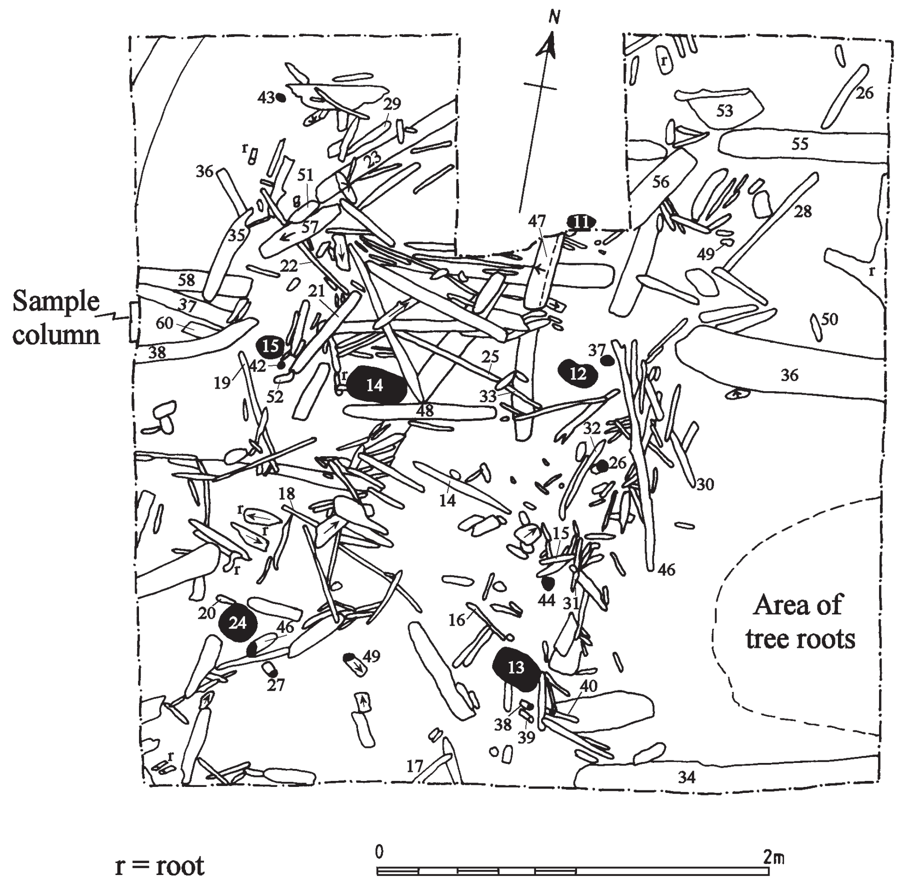


Figure 100. Trench 1 plan, Harding Alignment. Tops of vertical timbers shown in black. 'r' = root.

surface (Figures 100 and 101). At a depth of *c*. 450mm below ground level the top of a large deposit of wood was encountered around the posts. The uppermost levels consisted of a mass of small roundwood, 14mm and 49mm in diameter, and twiggy material broadly orientated along the line of the alignment. Although much of this material was in a poor state of surface preservation cut ends were noted on many of the pieces. Immediately below this roundwood was a further dense concentration of wood orientated in different directions in the horizontal plane. The top of this horizontal material was between 4.53m and 4.42m OD.

The horizontal wood was composed of small cut roundwood and twigs, with numerous woodchips, short plank fragments, offcuts from woodworking, and whole logs. Only a small quantity of this material was lifted to enable a characterisation of the deposit to be made. Twelve hazel, ash, oak and alder stakes (26, 27, 33, 37, 38–45) appeared to be holding the wood in position. All the stakes were roundwood except for a half split oak (41) and a quarter split ash (42). Their diameters varied from 34mm to 59mm, and surviving lengths from 75mm to 270mm. The tops of the stakes varied between 4.54m and 4.70m OD. A large alder tree stump was present in the south-east corner of the trench and alder roots had penetrated through much of the deposit.

All three of the planks (47, 48 and 56) were radially split oak (*Quercus* sp.) with widths of 130mm, 105mm and 140mm, and thicknesses of 71mm, 60mm and 55mm respectively. Only one (48) was uncovered to its complete length of 866mm. The other plank (57) was tangentially split, 490mm long, 105mm wide and 64mm thick. With only two exceptions (22 and 54), all of the 17 woodchips and offcuts lifted proved to be oak. They probably represent waste from the splitting and trimming of planks rather than the pointing of the oak piles. Another piece of woodworking debris was some bucking waste (53) from an oak log that had been shortened to a specific length leaving a 330mm long piece that still retains a fine series of axe marks at both ends, and a jam curve 37.7mm wide which preserves the curvature of the axe blade (Figure 102).

Large alder logs were encountered on the east side

Figure 101. Oak piles and horizontal wood looking north along the alignment. Scales 1m and 0.5m.

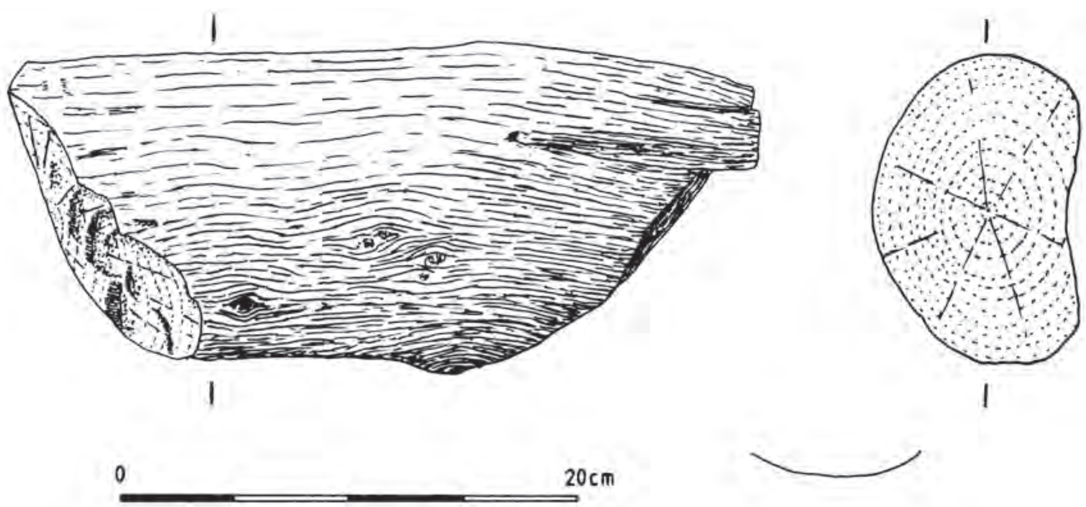


Figure 102. Woodworking debris (53) and jam curve.

(55, 95 and 96) and a cluster of smaller alder and ash logs on the west side at quite a high level. Where excavation was taken lower to permit the removal of an environmental sample column on the west side of the trench, dense concentrations of wood were still encountered including logs (58 and 97) and oak offcuts (60). The top of the lowest element uncovered (log 97) was 540mm below ground level. There may well have been structural elements below this but the excavation could not be carried any further without removing significant quantities of material.

Trenches 2–8

Trench 2 was excavated to a depth of *c*. 0.4m but did not reveal any structural wood. Trenches 3, 4, 5, 7 and 8 all revealed the tops of oak posts proving the continuation of the structure in a roughly straight line. Trench 6 did not reveal any posts probably because

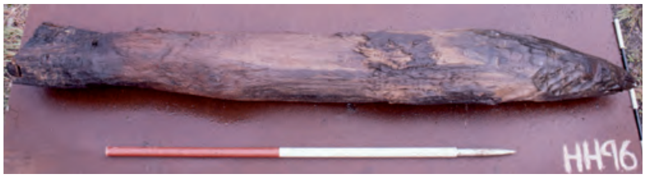


Figure 103. Top of pile branching into two.

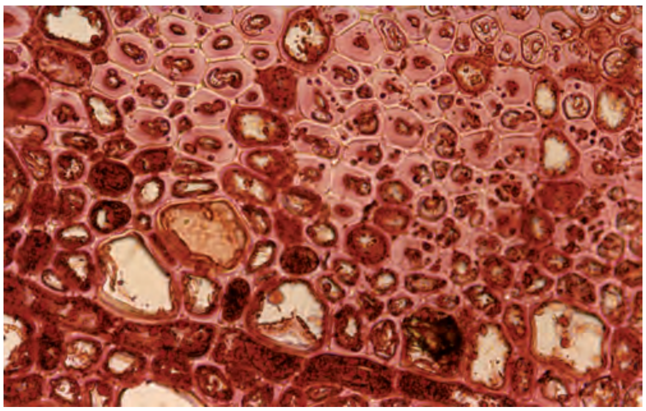


Figure 104. Soft rot in oak pile 15 (40× magnification).

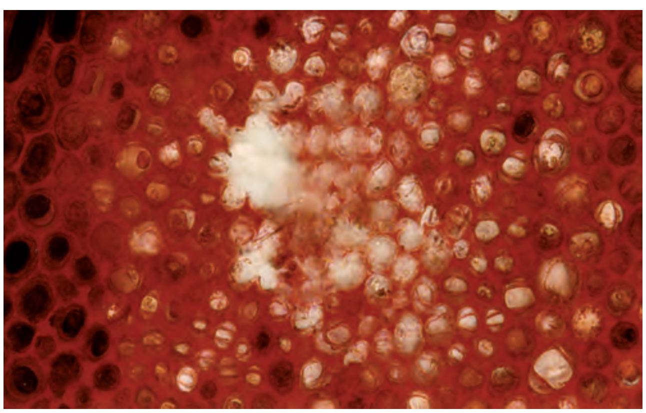


Figure 105. White rot in oak pile 15 (40× magnification).

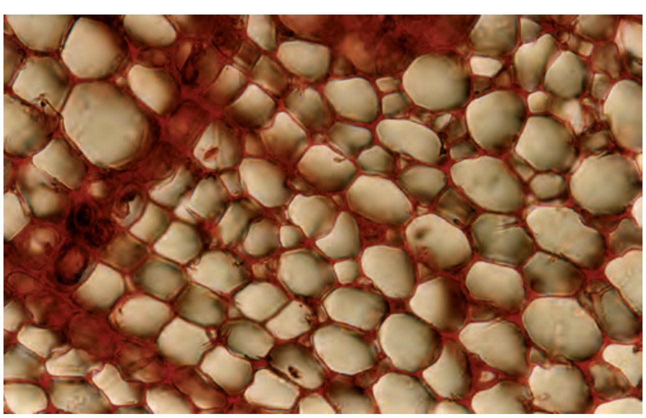


Figure 106. Decay by erosion bacteria in ash log 58 (40× magnification).

the structure was becoming more deeply buried at its southern end. The depth below ground of the tops of the oak posts steadily increased from 30mm in trench 3 to 100mm in trench 4, 130mm in Trench 5, 240mm in Trench 7 and 340–380mm in Trench 8. The ground surface over this distance remained broadly level with minor undulations.

Little detail of the structure was recovered from these trenches as excavation stopped when the tops of the posts were encountered. Trenches 4 and 7 each contained a single post while Trenches 3, 5 and 8 revealed two. It may well be that more posts could exist at a lower depth. The post in Trench 7 and both posts in Trench 5 appeared to be branching into two at the top (Figure 103), as had been noted on several other piles. In Trench 8 four vertical pieces of roundwood may also have formed part of the structure. They were a mixture of alder, hazel, ash and pomaceous fruitwood.

BACPOLES excavation

In 2003 samples from three oak piles from the site were taken for analysis as part of an EU funded BACPOLES project examining the bacterial decay of wooden piles (Klaassen 2005). This resulted in some limited information on the decay of the piles from the site and two of the piles examined also provided tree-ring dates.

Condition of the wooden remains

Visually there was a large distinction between the condition of the upper and lower elements of the structure. The outer surfaces of the vertical piles were heavily decayed over the top *c*. 450mm, and the upper layers of the horizontal structure looked to be in a poor state of preservation. Much of the latter decay may have occurred during the active life of the structure before the wood entered a fully anaerobic environment, as numerous reeds were observed to have grown through some of the larger timbers. Some of this material may have been used and started to decay in other locations before being re-used in the alignment structure. No evidence of any such reuse was noted in the structure however.

White rot was observed on the majority of the piles lifted, usually over the lower portion. Samples of some of the timbers were sent to Professor Thomas Nilsson of the Swedish University of Agricultural Sciences in Uppsala, Sweden. His brief analysis found evidence of decay by soft rot (Figure 104), white rot (Figure 105) and erosion bacteria (Figure 106).

Two oak piles were samples for decay analysis by the BACPOLES project (Figure 107). These showed severe to moderate degradation by bacteria but no presence of active erosion bacteria (Klassen 2005, 83).

Hydrological monitoring

Water level monitoring was carried out on the site from October 1997 for 12 months. This identified a summer draw down of the water table up to 0.7m below the ground surface. This was well below the level of the main horizontal material seen in Trench 1.

MARISP excavation results

A single east–west trench (Trench 9), measuring 6m by 2m, was excavated across the alignment. Extensions were made on the west (2 × 1m) and east (3.25 × 0.5m) to try and find the edge of the worked wood deposit around the pile alignment (Figure 99).

The lowest part of the stratigraphy was a grey-brown clay from 4.08m OD to *c*. 4.17m OD where it gradually changed into a silty peat. The silty peat varied slightly in colour but silt content was present throughout the peaty layers. The top 0.25m below the ground surface, which varied between 4.97m OD and 5.04m OD, was a highly humified, very dry, peat that was almost like dust which readily blew away in a light breeze. A fuller description of the environmental sequences is given in the environmental section below.

The structure consisted of a large pile and smaller stakes surrounded by a mass of horizontal wood. The highest structural element was the top of the oak pile at 5.04m OD, exactly at the ground surface. The top of the horizontal wooden remains around the piles was between 4.63m OD and 4.70m OD. The lowest horizontal material excavated was at *c*. 4.41m OD.

The evidence of the pile alignment consisted of a single large oak roundwood pile (130) 1650mm long and 210mm in diameter (Figure 108). It had been left in the round and still retained 18 rings of sapwood, although no bark was present. At the top end there was considerable decay and the trunk divided into two main branches. The pile was cut to a pencil point over 640mm, a process that left numerous concave axe marks, up to 35mm wide and 38mm long, where the blade had cut into the wood at shallow angles of 1–20° (Figure 109). There was no evidence that the pile had been pushed through the horizontal wood deposit which surrounded it.

There were six smaller stakes (Figures 110 and 111), five of which (125–9) were in the same north–south alignment as the oak pile and one of which (132) was *c*. 0.5m to the east. The stakes were between 230mm and 639mm in length. Four of them were roundwood between 33mm and 44mm in diameter, two of which were alder, one ash and one blackthorn. The other two (128 and 132) were quarter split oak 75–105mm wide and 25–50mm thick. The presence of side branches on two of the roundwood stakes showed that they had been driven in upside down, i.e. opposite to the way

Figure 107. Sampling of a pile for the BACPOLES project. Scale 1m.

Figure 108. Pile 130. Scale 1m.

Figure 109. Tip of pile 130.

Figure 110. Smaller stakes. From left: 132, 129, 128, 127, 126, 125. Scale 50cm.

Figure 111. Piles and small stakes, looking east. Scale 1m.

Figure 112. Middle wood layer in central area, Trench 9, looking south. Scales 1m.

they grew. The blackthorn roundwood was particularly knotty, with six side branches cut off and branching into two at the tip. The tips of the stakes had been cut into a mixture of chisel, wedge and pencil shaped points. The tops of many of the stakes were covered up by accumulations of horizontal wood. This suggests that some, at least, of the horizontal material built up after the stakes were inserted.

Three steeply angled pieces of roundwood, recorded between 0.6m and 1.0m west of the pile, may also have been small stakes, inserted in line with other post rows present outside the trench. Because only the central portion of the trench was excavated to the base of the worked wood it is likely that many other small stakes could have been present elsewhere in the trench.

The horizontal deposit of wood that surrounded the pile extended for over 5.4m eastwards and 5m to the west, although in the latter direction there was a noticeable reduction in the density of the material from 2m west of the pile. The horizontal material consisted of woodchips, offcuts, small planks and cut roundwood along with a very large oak log, possibly a redeposited bog oak. These were only recorded in detail in the central part of the trench as this was the only place where layers of wood were removed to ascertain the depth of the structure and elucidate its character (Figures 112–4).

Nine woodchips were recorded (1, 61, 69, 70, 72, 73, 83, 95 and 99), all radially cut pieces of oak. They varied from 35–103mm in length, 35–62mm in width and 2–16mm in thickness with the vast majority being 2–4mm thick. The 26 recorded offcuts consisted of one quarter split alder fragment, 428mm long by 15mm wide and 15mm thick, an intermediate split fragment of uncertain species and 22 pieces of split oak. Of the latter, 17 were radially split pieces, three intermediate and two tangentially split, the lengths varying from 90mm to over 470mm, widths of 35–132mm and thicknesses of 2–50mm. The oak offcuts were very straight grained and represent the sort of material that could be produced by the radial conversion of large oak trees to produce planks. The woodchips could also have been produced by the finishing of such timbers and had definitely not been produced by cutting points on the oak piles. Four of the offcuts (11, 12, 14 and 77) had evidence of charring on one side.

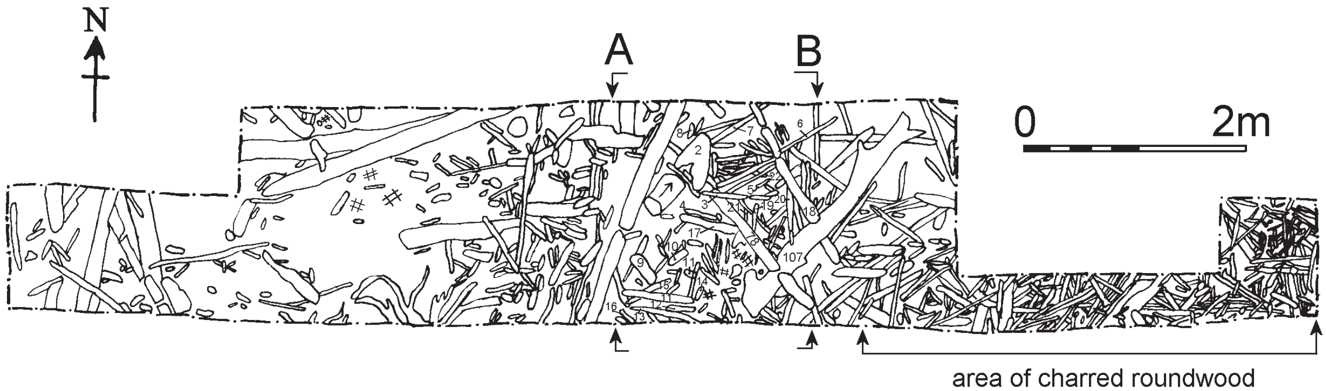


Figure 113. Trench 9, Harding Alignment. Upper levels of wood.

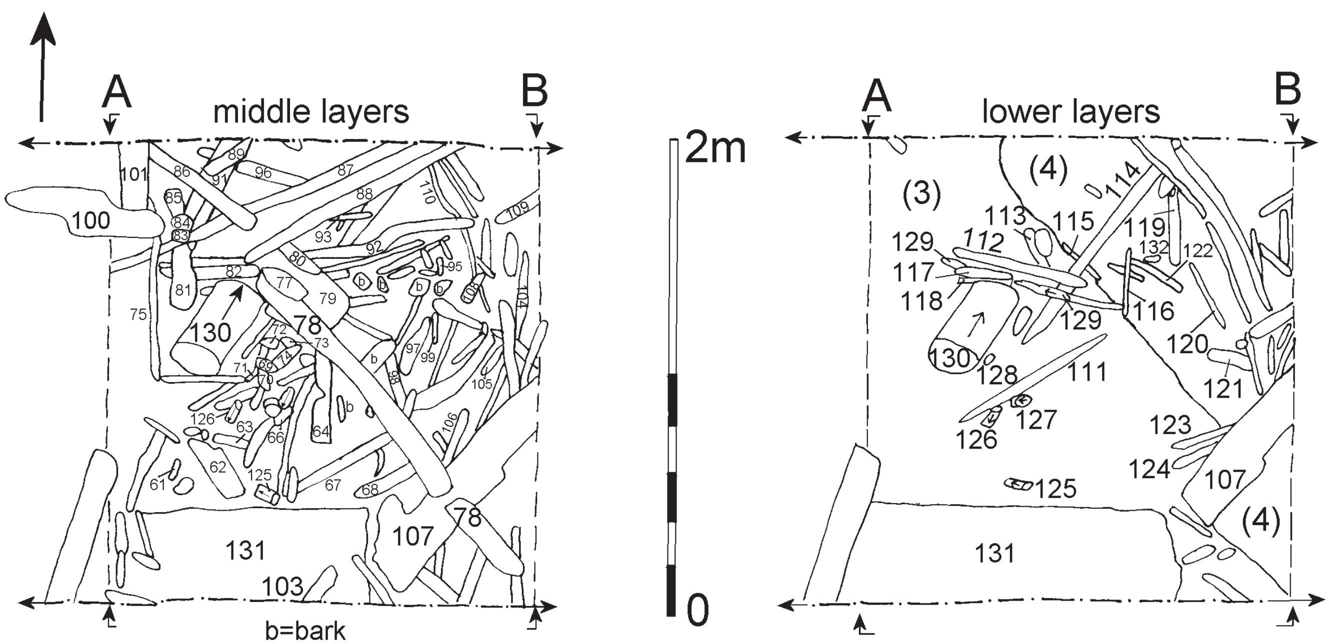


Figure 114. Trench 9 Harding Alignment. Middle and lower wood layers.

Converted pieces consisted of a quarter split oak timber (118) and 13 half spilt roundwood of which five were oak, three ash, two blackthorn, one hazel and two not identified to species. The oak examples varied between 140–700mm, 25–108mm in width and 7–50mm thick. The non-oak was 140–570mm long, 21–50mm wide and 11–29mm thick. One of the split blackthorn pieces (115) was charred on one side.

From the central part of the trench the other recorded wood consisted of 38 pieces of small roundwood, 11 half split roundwood, a quarter split timber and two logs. The largest log (131) was lying east–west amongst the lowest levels of the horizontal wood and only one side and end of it was uncovered. It was over 0.5m long and over 0.4m in diameter. It may represent a reused bog oak but it was not sampled for tree-ring dating as no saw large enough for sampling was available. The other log (107) was also oak, of 2.25m length and 137mm diameter, lying roughly north-east–south-west amongst the upper layers of wood. It had the remains of four side branches removed and had been axed across at one end.

The 38 pieces of roundwood consisted of 12 alder, 5 hazel, 4 ash, 4 alder or hazel, 2 oak, 2 Pomaceous fruitwood, 1 blackthorn, 1 field maple and 6 pieces of uncertain species. The wood from the larger tree species (maple, alder, ash and oak) varied in diameter from 15mm to 300mm, with oak providing the pieces over 120mm. The smaller species had diameters ranging

Figure 115. Trench 9, looking west. Scales 1m.

Figure 116. Charred material at the east end of Trench 9, looking east. Scales 1m and 0.5m.

from 11mm to 44mm. The lengths of the roundwood varied between 0.22m and 2.14mm.

The horizontal worked wood gradually petered out towards the west with no evidence of a distinct boundary (Figure 115). To the east, the worked wood was bounded by a very dense layer of slender roundwood that extended for at least 2.5m. The wood in this deposit varied in diameter from 12mm to 80mm, but out of 36 measured examples only three were over 42mm in diameter (Figure 116). Of the 36 examples studied, 14 had evidence of charring, of which three were slightly charred, two 30–50% charred, three 51–80% charred and six over 80% charred. The boundaries of the charred material to the east, north and south are not known.

Wood species identification

Rowena Gale and Vanessa Straker

The 1997 and 1998 species identifications were undertaken by Vanessa Straker and the 2003 ones by Rowena Gale. The species identification results are shown in Table 86.

Woodworking and woodland management evidence

The oak trees used in the pile alignment had been felled relatively young, probably all being under 110 years of age. The relatively slow annual growth rates suggest that they were derived from dense woodland rather than from hedgerows or wood pasture. This evidence

Table 86. Harter's Hill: wood species composition and form from the 1997–2003 excavations.

Component	Oak	Ash	Alder	Hazel	Field Maple	Blackthorn	Pomoideae	Willow/Poplar	Unidentifiable	Total
Piles	31	–	–	–	–	–	–	–	–	31
Small stakes	5	6	4	5	–	1	1	–	–	22
Logs	2	1	4	–	–	–	–	–	–	7
Horizontal roundwood	7	9	28	12	1	1	2	4	10	74
Offcuts/woodworking waste	32	–	2	–	–	–	–	–	1	35
Plank fragments	4	–	–	–	–	–	–	–	–	4
Half or quarter split	5	3	–	1	–	2	–	–	2	13
Woodchips	15	–	–	–	–	–	–	–	–	15
TOTAL	101	19	38	18	1	4	3	4	13	201

suggests that the timber trees in the local woodland were being carefully managed and were harvested upon reaching maturity.

Numerous side branches were visible on the trunks of the piles and 8 (6, 9, 12, 13, 14, 24, 101 and 130) of the 31 piles were branching into two at their top end. This raises the possibility that the piles were derived from the tops of trees whose lower trunks were used separately, possibly because they were wider and more suitable for splitting into planks. Plank fragments, offcuts and woodchips all show that sizeable planks were being made from oak trunks, mainly by radial splitting with some tangential cleaving. This must have been happening very near the site as the woodchips and other woodworking debris was included in the horizontal material around the piles. A possible splitting wedge of oak heartwood (27b) was also recorded from those layers.

The site produced no evidence for timber production of non-oak species in the form of planks, offcuts or woodchips. Ash and alder were common species in the whole assemblage and one example of field maple was identified, so those three species were present in the local woodland. Their absence in timber form on the site may be because oak was being deliberately managed as the sole timber tree in the local woodland or because only oak was considered a fitting species for use in that role in the alignment. Some of the alder trees growing nearby, presumably fringing the wetlands, were quite sizeable and were used as logs.

The smaller stakes and roundwood in the structure are diverse in species composition, providing a more representative indication of the variety of the local treescape. It is impossible to tell where the species were growing. They could have been present alongside the alder at the edge of the wetland or in the managed oak woodland on the drier ground. Some species such as the blackthorn may have been components of local hedgerows. The charred and semi-charred character of some woodworking debris and much of the small roundwood from the eastern end of Trench 9 suggests that burning of these elements was taking place in the immediate vicinity at the edge of the wetland. This could have been done just to get rid of the smaller debris that was not wanted for the main structure or the lighting of fires in that liminal location could have been part of the ritual activity played out at that end of the alignment.

The toolmarks on the worked timbers displayed facets that were concave in cross section across their width, were up to 50mm wide and 140mm long. On the oak piles they had been produced by axe blows delivered at angles of 2–60°. These characteristics are consistent with the use of late Bronze Age axes of the Ewart Park and Pennard traditions (Brunning 2007, 103).

Dendrochronological dating

Cathy Tyers and Christine Locatelli

A total of 35 samples were submitted for analysis from the Harter's Hill pile alignment. These represented 14 piles, 8 woodchips/offcuts, 7 radially split offcuts, 3 radially split planks, 2 stakes, and 1 half split (Table 87). Six samples were rejected as unsuitable for analysis as they contained too few rings. A further sample was rejected as, although it contained approximately 50 annual growth rings, the outermost rings were badly crushed and hence the rings were severely distorted and the ring boundaries could not be distinguished. The ring sequences of the remaining 28 samples were compared with each other. Twenty-five were found

Table 87. Harter's Hill: details of dendro samples.

Wood no.	Sample description	No. Rings	Sapwood rings	ARW	Cross-section type	Cross-section (mm)	Date of sequence (BC)	Comments
Harter's Hill pile alignment								
1996–2	pile	69	–	1.63	whole	230 × 190	1155–1087	–
1996–3	pile	82	–	1.32	whole	200 × 190	1155–1074	–
1996–5	pile	56	–	2.00	whole	215 × 210	1132–1077	–
1996–7	pile	60	28 ?b	1.40	whole	170 × 160	1135–1076	–
1996–9	pile	72	–	1.88	whole	215 × 200	1147–1076	–
1997–12	pile	63	hs	1.87	whole	180 × 175	–	–
1997–13	pile	62	–	1.50	whole	275 × 185	1166–1105	–
1997–14	pile	73	?hs	1.34	whole	195 × 150	1167–1095	–
1997–15	pile	54	6	1.51	whole	160 × 135	1133–1080	–
1997–32	radially split offcut	47	–	1.55	quartered	75 × 50	1159–1113	–
1997–47	radially split plank	53	–	2.30	quartered	130 × 75	1150–1098	–
1997–48	radially split plank	79	–	1.42	quartered	110 × 65	1187–1109	–
1997–50	radially split offcut	<40	–	–	quartered	55 × 25	–	reject
1997–56	radially split plank	76	–	1.75	plank: radial	140 × 40	1156–1081	–
1997–57	radially split offcut	56	–	1.60	plank: tangential	105 × 45	1166–1111	–
1997–60	radially split offcut	58	–	1.39	plank: radial	80 × 10	1133–1076	–
1997–100	pile	54	–	1.36	whole	140 × 120	1135–1082	–
1997–101	pile	70	–	1.77	whole	200 × 165	1155–1086	–
1997–102	pile	80	–	1.45	whole	185 × 165	1163–1084	–
1997–103	pile	73	–	1.27	whole	150 × 125	1159–1087	–
2003–1	woodchip/offcut	<40	–	–	plank: radial	50 × 0.5	–	rejected
2003–8	woodchip/offcut	56	–	1.00	plank: radial	70 × 20	1143–1088	–
2003–10	woodchip/offcut	49	–	1.57	plank: radial	80 × 10	1131–1083	–
2003–14	woodchip/offcut	<40	–	–	plank: radial	80 × 15	–	rejected
2003–62	woodchip/offcut	<40	–	–	–	–	–	rejected
2003–70	woodchip/offcut	<40	–	–	plank: radial	35 × 0.5	–	rejected
2003–77	radially split offcut	52	–	1.37	plank: radial	75 × 30	1134–1083	–
2003–78	half split	<40	–	–	quartered	50 × 30	–	rejected
2003–79	radially split offcut	98	–	0.98	plank: radial	95 × 15	1167–1070	–
2003–82	woodchip/offcut	66	–	0.83	plank: tangential	60 × 20	1157–1092	–
2003–91	woodchip/offcut	76	–	0.88	plank: tangential	60 × 20	1162–1087	–
2003–102	radially split offcut	*c.* 50	–	–	plank: radial	45 × 20	–	rejected, outer rings crushed
2003–128	stake	71	–	0.59	quartered	80 × 40	–	–
2003–130	pile	101	18	0.97	whole	200 × 160	1149–1049	–
2003–132	stake	56	–	0.84	quartered	50 × 25	–	
Harter's Hill pile bog oaks								
1997–99	?bog oak?	130	–	0.57	quartered	80 × 75	1158–1029	–
2003–131	bog oak	148	–	1.52		230 × 170	–	–

Number of rings: total number of measured rings including both heartwood and sapwood; sapwood rings: number of measured sapwood rings only; hs – indicates presence of heartwood/sapwood transition; ?hs – indicates possible presence of heartwood/sapwood transition; ?b – indicates probable presence of bark edge; ARW: average ring width in millimetres

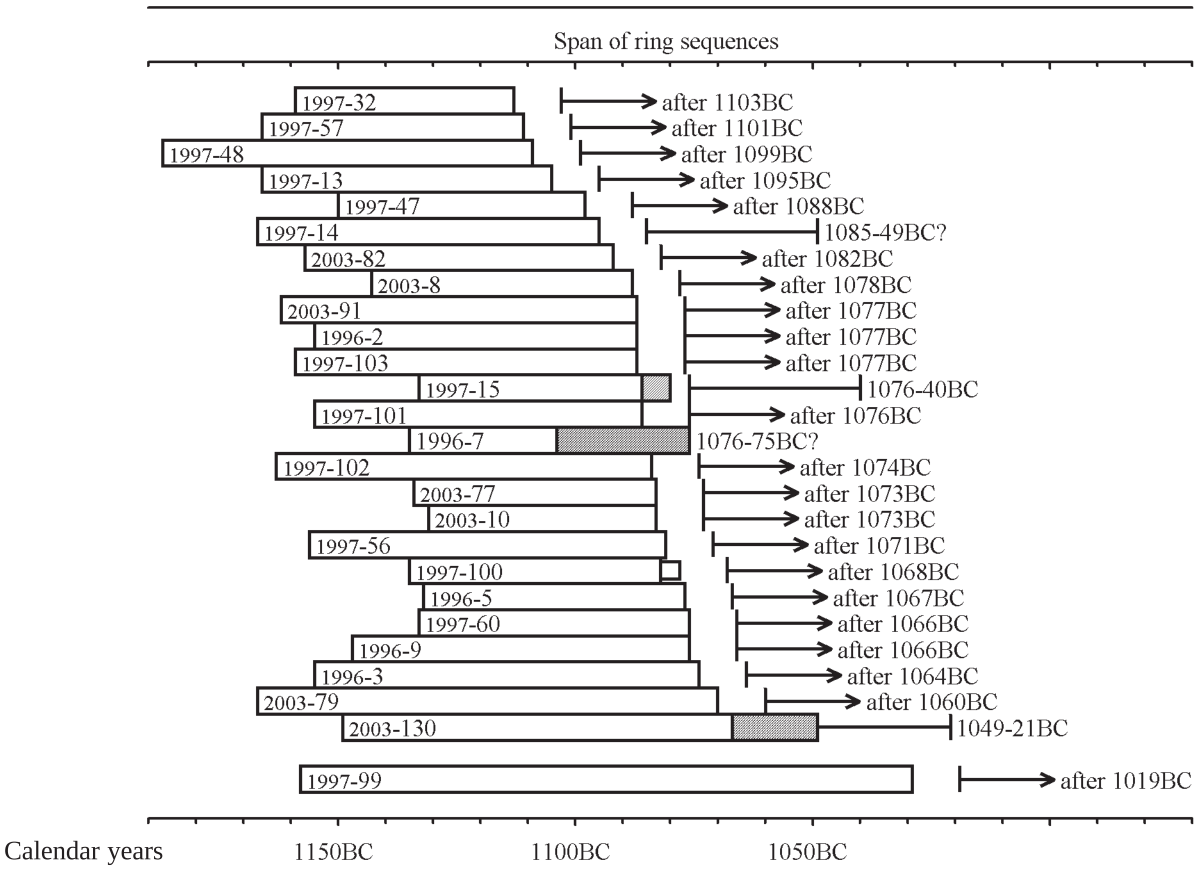


Figure 117. Bar diagram showing the relative positions of the all of the dated sequences from the Harding Alignment, Harter's Hill analyses, including the possible bog oak 1997–99, and their felling dates. White bars heartwood, shaded bars sapwood, narrow bars unmeasured.

to crossmatch, and these were combined to produce a site master sequence, **HH-T25** (Figure 117; Tables 88–9). This site master sequence was compared with a range of dated reference chronologies from Britain and elsewhere in northern Europe and was dated to the period 1187–1049 BC (Table 89).

The three unmatched ring sequences from the pile alignment were compared individually with a range of dated reference chronologies from Britain and elsewhere in northern Europe. No conclusive results were produced, so these samples remain undated.

Both bog oak samples contained sufficient rings for analysis. The ring sequence derived from sample **2003–131**, showed no similarities with the material from the pile alignment, nor could it be conclusively dated when compared individually with a range of dated reference chronologies from Britain and elsewhere in northern Europe. However sample **1997–99** was successfully dated by comparison with the samples from the pile alignment (Figure 117; Tables 89–90).

The analysis has successfully dated 25 samples. This comprises piles, radially split offcuts, radially split planks and woodchip/offcuts all of which are broadly contemporary (Figure 118). In addition two samples from the BACPOLES project were successfully dated. These were piles 133 and 134, the former producing a felling date of spring 1065 and the latter a felling date after 1060–70 BC (Klaassen 2005). The results therefore clearly indicate that the wood deposits surrounding the piles are associated with the construction of the pile alignment.

Only four samples, all from piles, had retained any sapwood. The earliest definite felling activity is represented by pile **1997–7**, the outer surface of which was thought likely to be bark edge and was therefore probably felled in 1076–5 BC. It is however possible that some of the samples without sapwood could have been felled up to approximately 25 years before this. The next definite felling activity is represented by pile **2003–133** which has a felling date of spring 1065 BC. The next felling episode is represented by **2003–130** which has a felling date range of 1049–21 BC. The

Table 88. Harter's Hill: ring width data from the site master chronology HH-T25, dated 1187–1049 BC inclusive.

Date BC	Ring widths (units of 0.01mm)									
1187				217	238	284	292	320	289	199
	122	197	245	231	203	252	214	172	169	173
	119	135	196	224	241	193	239	225	268	154
	234	250	194	185	143	180	226	186	196	112
1150	147	132	195	121	116	123	138	148	148	137
	98	130	104	92	102	152	156	157	176	211
	149	153	140	126	149	99	113	132	179	163
	140	111	111	106	134	133	146	154	145	131
	176	154	125	78	110	167	157	139	162	104
1100	88	135	132	141	141	135	117	131	111	95
	109	103	120	134	151	118	145	143	177	154
	164	141	123	111	141	98	122	98	106	128
	129	95	73	85	80	76	100	74	78	48
	45	66	78	87	105	108	86	69	65	103
1050	86	89								

Table 89. Harter's Hill: dating the site master chronology HH-T25, *1187–1049 BC inclusive. Example t-values with some relevant reference chronologies.*

Area	Reference chronology	Date span BC	*t*-value
England	England 2 (Hillam pers. comm.)	1804–323	4.77
Cambridge	Flag Fen basin (Neve 1999)	1406–937	4.63
Kent	Swalecliffe (Masefield *et al.* 2003)	1432–1085	4.48
Somerset	Skinners Wood (Hillam 1993)	1162–983	5.18
Somerset	Greylake (Howard pers. comm.)	1131–1062	7.96
Ireland	Mid1000 (Brown pers. comm.)	1336–886	3.53
Wales	Caldicot (Hillam 1997)	1169–990	6.30
Wales	Goldcliff boat (Hillam and Groves 2003)	1139–1027	4.72

Table 90. Harter's Hill: ring width data from bog oak, 1997–99, dated 1158–1029 BC inclusive.

Date BC	Ring widths (units of 0.01mm)									
1158			100	61	54	74	68	71	84	88
1150	65	37	81	57	47	81	63	60	52	46
	69	99	86	60	62	83	65	84	81	61
	58	39	51	66	73	40	57	73	74	66
	34	42	63	54	69	52	57	43	40	26
	78	71	57	41	37	64	57	47	40	37
1100	35	51	61	60	56	41	37	37	38	25
	47	59	43	43	56	35	40	46	74	51
	46	42	49	59	40	45	49	58	53	44
	48	45	34	44	56	58	57	67	62	48
	67	50	56	83	54	44	47	43	41	64
1050	70	72	53	65	64	64	61	52	83	62
	48	51	34	61	56	68	62	50	59	50
	72	56								

other pile with sapwood, **1997–15**, has a felling date range of 1076–40 BC. A probable felling date range of 1085–49 BC can also be calculated for pile **1997–14**, the outermost ring of which was thought likely to be the heartwood/sapwood transition. Consequently these two piles could be contemporary with either **1997–7** or **2003–130** or alternatively they could represent additional felling phases. The *terminus post quem* for felling for the remaining samples ranges from after 1103 BC to after 1060 BC.

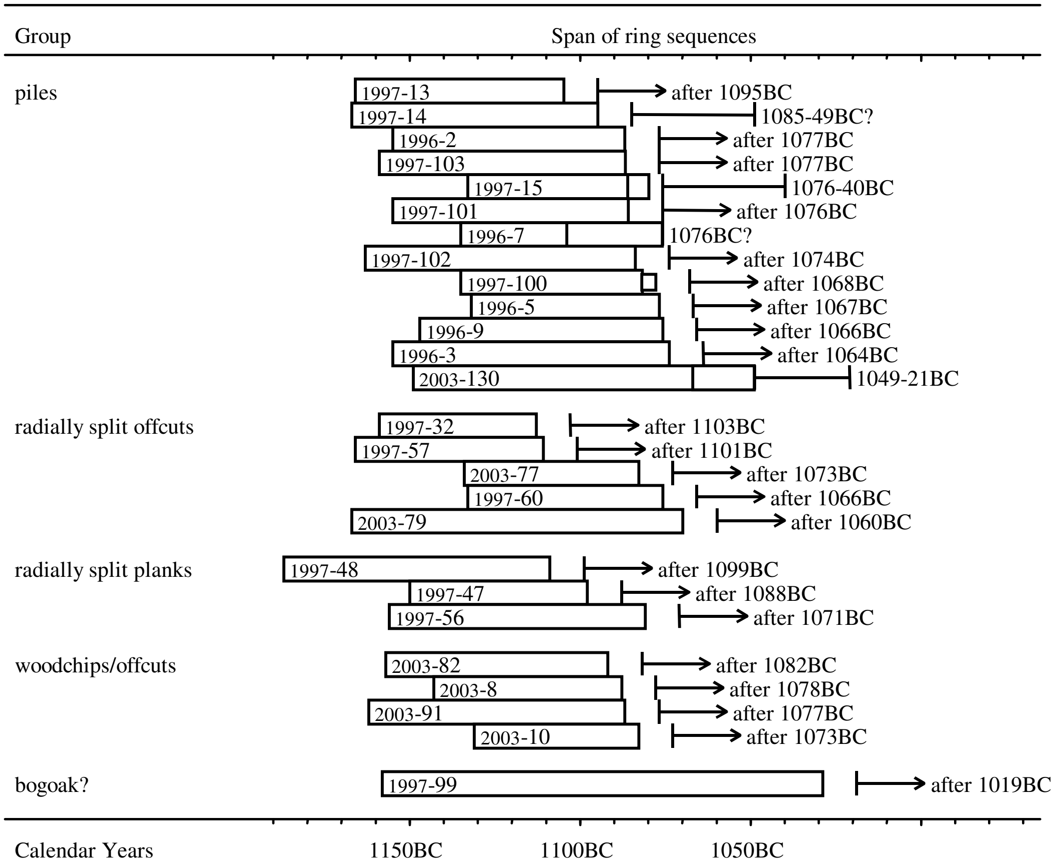


Figure 118. Bar diagram showing the relative positions of the all of the dated sequences from the Harding Alignment, Harter's Hill analyses, including the possible bog oak 1997–99, and their felling dates sorted by element type. White bars heartwood, shaded bars sapwood, narrow bars unmeasured.

The results show that there are at least three different phases of felling during the mid-11th century BC but the general lack of sapwood prevents a more detailed understanding of the phasing. The pile alignment was probably in use for a minimum of approximately 30 years.

The bog oak sample, **1997–99,** was felled after 1019 BC and therefore appears to have died or been felled after the felling activity associated with the pile alignment (Figures 117 and 118). This timber was a radial fragment sticking out from a ditch. It had consequently suffered from severe desiccation and decay, but it showed no evidence of working and was therefore thought potentially to represent a bog oak that may have been disturbed during ditch cleaning. The fact that it is broadly contemporary with the pile alignment is of interest. If it is a bog oak located on the wetland edge then it was clearly growing within close proximity to the pile alignment. Alternatively, if it was a worked timber then it may represent another structure of similar, though slightly later, date to the pile alignment.

Radiocarbon dating

P. D. Marshall, W. D. Hamilton, R. Brunning, G. Cook and C. Bronk Ramsey

Sequence

The sample of waterlogged plant remains (OxA-16024) came from the base of the fibrous peat. The bulk sediment sample from 4.18–4.19m came from the top of a phase of organic silty clay deposition and before the onset of woody peat growth. The two measurements (OxA-16179 and OxA-16247) are statistically consistent (T'=2.6; T' (5%)=3.8; ν=1; Ward and Wilson, 1978) and allow a weighted mean to be calculated (3636±23 BP). SUERC-9825 comprised a collection of waterlogged plant remains from 4.36–4.37m, where the stratigraphic record indicated a possible change in environmental conditions as the clay fraction in the peat increased. The samples from 4.54–5.55m (bulk peat) and 4.55–4.56m (waterlogged plant macrofossils) came from the top of the peat deposition at the site (Table 91). The two measurements on the humic and humin fractions

Table 91. Harter's Hill: radiocarbon results.

Lab. no.	**Sample ID (m)**	**Material**	**δ¹³C (‰)**	**Radiocarbon age (BP)**	**Weighted mean (BP)**	**Calibrated date (95% confidence) BC**
OxA-15984	4.55–4.56	Plant macrofossils; *Carex paniculata* ×7; *Schoeno-plectus lacustris* ×13	–25.7	2859±29		1130–920
SUERC-9826	4.54–4.55	Peat, humic acid	–28.5	2935±35	2968±25 (T′=1.7; T′ (5%)=3.8; ν=1),	1300–1110
SUERC-9836	4.54–4.55	Peat, humin fraction	–28.7	3000±35		
SUERC-9825	4.36–4.37	Plant macrofossils; *Rubus glandulosus* ×2; *Methula aquatica* ×3; *Spar-ganium erectum* ×3; *Alisma plantago-aquatica* ×2; *Alisma sp.* ×2; *Urlica dioica* ×1; *Eleocharus palusris* x6; *Hydrocotyle vulgaris* ×1; *Chenopodium album* ×1	–27.2	3150±35		1500–1320
OxA-16179	4.18–4.19	Peat; humic acid fraction	–27.7	3668±30	3636±23 (T′=2.6; T′ (5%)=3.8; ν=1),	2125–1935
OxA-16247	4.18–4.19	Peat; humin acid fraction	–28.7	3593±35		
OxA-16024	4.08–4.09	Plant macrofossils; *Sparganium erectum* ×5 and *Alnus glutinosa* cones ×4	–26.5	3030±33		1400–1130

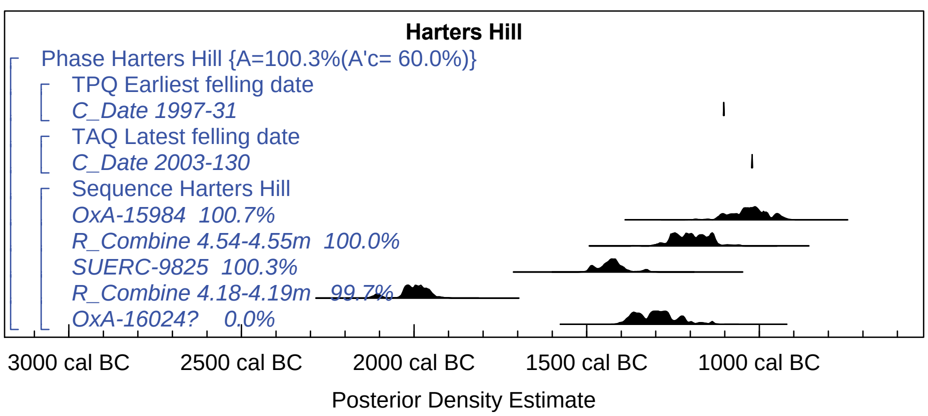


Figure 119. Probability distributions of dates from the Harding Alignment, Harter's Hill. Each distribution represents the relative probability that an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. A question mark (?) indicates that the result has been excluded from the model The large square brackets down the left hand side along with the OxCal keywords define the model exactly.

from 5.54–4.55m (SUERC-9826 and SUERC-9836) are statistically consistent (T′=1.7; T′ (5%)=3.8; ν=1; Ward and Wilson, 1978) and allow a weighted mean to be calculated (2968±25 BP).

Results

The lowest measurement (OxA-16024) is clearly too young for its stratigraphic position and has therefore been excluded from the model shown in Figure 119. The model shows good agreement between the remaining radiocarbon results and their stratigraphic positions ($A_{overall}$=100.3%) and suggests that environmental evidence associated with the pile alignment probably does survive, although not at the 2003 site at the wetland/dryland boundary.

Palaeoenvironmental analysis

Heather Tinsley and Julie Jones

1997 samples

In the base of the 1997 trench, between 4.08m and 4.49m, brown fibrous peat was exposed which became structureless and amorphous towards the surface. Above 4.64m the peat contained some silt

Table 92. Harter's Hill 1997: stratigraphy, sampling locations and calibrated radiocarbon date ranges.

Depth (m aOD)	Stratigraphy	Pollen	Depth/calibrated radiocarbon date range BC
Ground surface at 5.02m OD			
4.64–5.02	Brown disturbed amorphous silty peat with modern roots. Trace of herbaceous plants. Very gradual boundary	4.74–4.75	
4.49–4.64	Brown/black amorphous peat with black streaks with trace of fine herbaceous plants. Occasional modern roots. Very gradual boundary	4.62–4.63 4.55–4.56	4.55–4.56 130–920
4.39–4.49	Dark brown fibrous peat with occasional herbaceous plants. Very gradual boundary	4.44–4.45	
4.08–4.39	Dark brown/black woody peat, with twigs and wood fragments	4.34–4.35 4.22–4.23 4.08–4.09	4.08–4.10 400–1130

Table 93. Harter's Hill 2003: stratigraphy, sampling locations and calibrated radiocarbon date ranges.

Depth (m aOD)	Stratigraphy	Pollen	Macros Beetles Forams	Depth/calibrated radiocarbon date range BC
Ground surface at 5.02m OD				
4.55–4.58	Mid reddish brown largely homogeneous oxidized, very dry, fibrous silty peat with roots which may be modern. Very gradual boundary			
4.37–4.55	Mid brown largely homogeneous very well humified silty peat with traces of herbaceous plants. Some roots may be modern. Possible charcoal flecks Very gradual boundary	4.54–4.55 4.50–4.51 4.46–4.47 4.43–4.44 4.39–4.40	4.44–4.49 macros, beetles	4.54–4.55 1300–1110
4.25–4.37	Dark brown peat with very decomposed wood fragments. Diffuse boundary	4.36–4.37 4.32–4.33 4.27–4.28	4.35–4.40 macros	4.36–4.37 1500–1320
4.17–4.25	Dark grey–brown largely homogeneous very well humified silty peat, with occasional well-rotted wood. Diffuse boundary	4.22–4.23 4.21–4.22 4.18–19 4.17–4.18	4.21–4.26 macros assessed	4.18–4.19 2125–1935
4.08–4.17	Grey-brown clay with woody fragments and organic detritus.		4.16–4.21 macros assessed 4.19 Forams	

and appeared disturbed. Assessment of both pollen and macrofossils was carried out by Vanessa Straker (English Heritage) who concluded that the area immediately around the site (referred to in this report as Harter's Hill 1997) had been initially dominated by alder woodland, which was replaced by herbaceous wetland communities at around the period that the alignment was constructed (V. Straker, pers. comm.). The stratigraphy, along with the sampling scheme used for the full analysis, is shown in Table 92. No macrofossil samples were available for full analysis from this site.

The ground surface at the MARISP site (referred to as Harter's Hill 2003 in this report) was at 5.02m OD. At the base of the trench, below 4.17m OD, grey clay was exposed; its upper surface was weathered to a soil containing humus, plant detritus and silt. This was overlaid by grey-brown silty peat or mud, with occasional well-rotted wood fragments. Above this was a peat with abundant decomposed woody detritus.

Above 4.37m OD the wood fragments became fewer and the peat became significantly siltier. At the top of the section, from 4.55m OD to the ground surface, the peat was very dry and oxidised, with what appeared to be modern roots present throughout. The stratigraphy and sampling scheme for pollen, plant macrofossils, insects and radiocarbon dating is shown in Table 93.

At both Harter's Hill sites the upper peat was dry, oxidised and penetrated by modern roots and therefore could not usefully be sampled. From the radiocarbon dates shown in Table 93 for Harter's Hill 2003, it can be seen that the date range for the top of the sampled section (1300–1110 cal BC at 4.55m OD) is older than the dendrochronological date for the oak pile (1076/5 BC). Thus all the palaeoenvironmental record from Harter's Hill 2003 predates the alignment. At Harter's Hill 1997, the date from the base of the sequence (1400–1130 cal BC at 4.09m OD) overlaps with the date from 4.36–4.37m OD at the 2003 site (1500–1320 cal BC). The date from the top of the sequence (1130–920 cal BC at 4.56m OD) overlaps with the dates from the oak piles, therefore the pollen diagram from the 1997 site spans a period from before the building of the alignment, through to its construction. As the earliest radiocarbon dates are found at the 2003 site, this will be discussed first.

The pollen assemblage zones from Harter's Hill 2003

Heather Tinsley

The pollen diagram for this site is in Figure 120.

HH03 1 (Below 4.25m OD; 77–85cm below the ground surface). Tree pollen forms 89–92% TP, principally *Alnus* (35–43% TP) and *Quercus* (26–34% TP). *Corylus*-type contributes 15–19% and *Ulmus* forms 1–2% TP. *Pinus, Betula, Fraxinus*, *Tilia* and *Acer campestre* are present as occasional grains. Herbaceous pollen consists principally of Cyperaceae (2–7% TP). There are occasional pollen grains of clearance herbs including *Plantago lanceolata and* all samples contain occasional grains of cereal-type pollen. Spores of Pteropsida (undifferentiated), *Pteridium* and Polypodiaceae are present at low frequencies. Unknown and indeterminable grains form 12–15% TP+indeterminables. The majority of *Corylus*-type grains show some biochemical deterioration. Pollen concentrations are consistently high. Microscopic charcoal concentrations are relatively low.

HH03 2 (4.25–4.38m OD; 64–77cm below the ground surface). Overall tree pollen falls slightly to form 79–86% TP in this zone; the fall is most marked in *Quercus* (17–19% TP) and *Corylus*-type (7–12% TP). *Alnus* rises somewhat at the start of the zone to 57% TP before falling gradually to 39% TP by the zone end. *Ulmus, Fraxinus* and *Betula* continue to be represented at very low frequencies. Poaceae form 5–9% TP. Cyperaceae continue unchanged, *Sparganium emersum*-type increases to form 9% TP+aquatics. Pollen of a range of other aquatic plants is present as occasional grains, including *Myriophyllum verticillatum, Lythrum, Lemna,* Potamogetonaceae and *Alisma*. Pollen of herbs associated with clearance is represented at the same levels as HH03 1, as are Pteropsida. Unknown and indeterminate grains form 2–7% TP+indeterminables. Almost all the *Corylus*-type and Poaceae grains show signs of biochemical deterioration. Pollen concentrations remain high. Microscopic charcoal concentrations fall at the start of the zone, then recover slightly.

HH03 3 (4.38–4.56m OD; 47–64cm below the ground surface). Tree pollen falls further at the start of the zone to form 49% TP mid-zone, but recovers to 77% TP by the zone end. *Alnus* mirrors this initial fall and later rise, forming 17–50% TP. *Quercus* forms 9–15% TP and *Corylus*-type falls to 3–8% TP. There is a small increase in pollen of *Salix* to 3% TP mid-zone. *Tilia, Ulmus, Fraxinus* and *Betula* are present at very low frequencies. Poaceae increase at the start of the zone and eventually reach 19% TP. Cyperaceae form 6–13% TP. *Sparganium emersum*-type peaks at 25% TP+aquatics at the start of the zone but later declines. Pollen of a range of other aquatic plants continues to be present as occasional grains. There is a marked increase in the pollen of clearance herbs particularly cereal-type (3–13% TP) and also *Plantago lanceolata* (1–3% TP). Pteropsida (undifferentiated) and other ferns continue to be represented throughout the zone. Unknown and indeterminable grains increase to 7–15% TP+indeterminables. More than 75% of Poaceae grains and the majority of *Corylus*-type show some biochemical deterioration. Pollen concentrations increase further as do microscopic charcoal concentrations, which peak towards the top of the zone.

The plant macrofossils from Harter's Hill 2003

Julie Jones

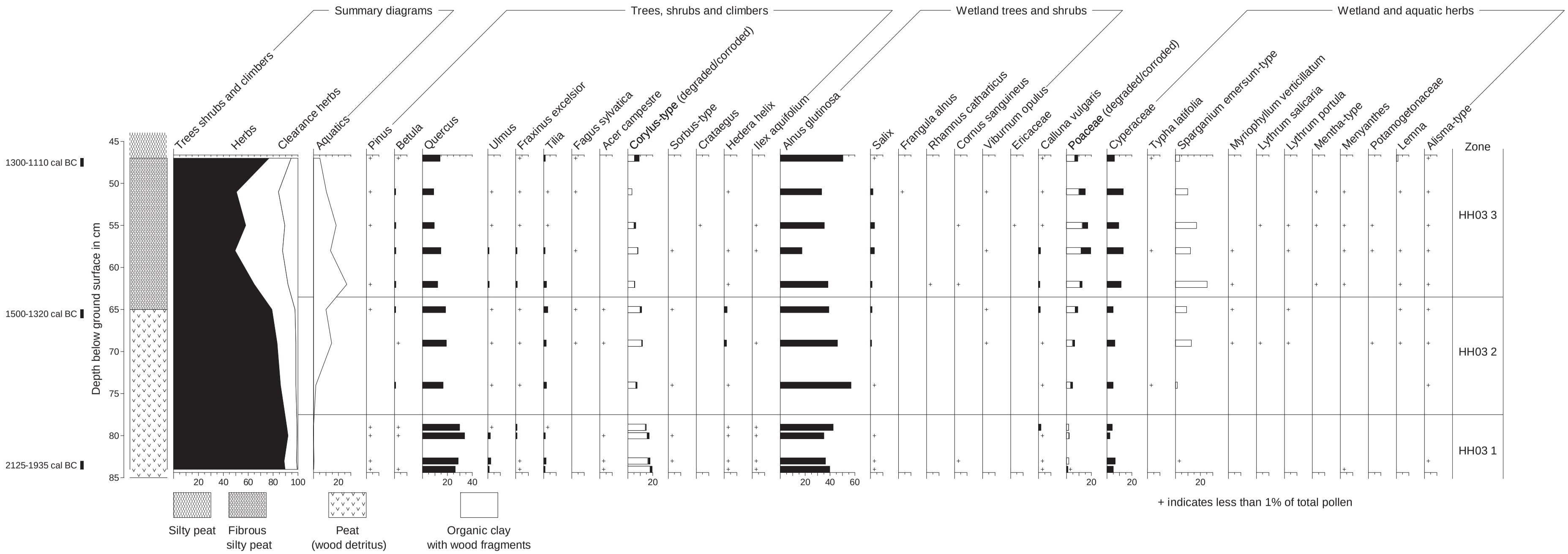
The plant macrofossil results are shown in Table 94.

4.16–4.21m OD: This basal sample from the grey-brown clay was originally assessed (Jones 2005) and was composed primarily of wood fragments with buds, scales and occasional *Corylus* nut fragments, although a few additional macrofossils were recorded. A range of Cyperaceae and *Callitriche* suggested a wetland environment. Some examples of *Rubus* sect *Glandulosus* and *Urtica dioica* may reflect the proximity of the higher, dry ground, although both can occur in damp ground conditions. Preservation was too poor to justify further analysis.

4.21–4.26m OD: Preservation was also poor in the overlying silty peat and the assessment showed a

Harter's Hill 2003

Part 1
Percentages of total pollen minus aquatics



Part 2
Percentages of total pollen minus aquatics

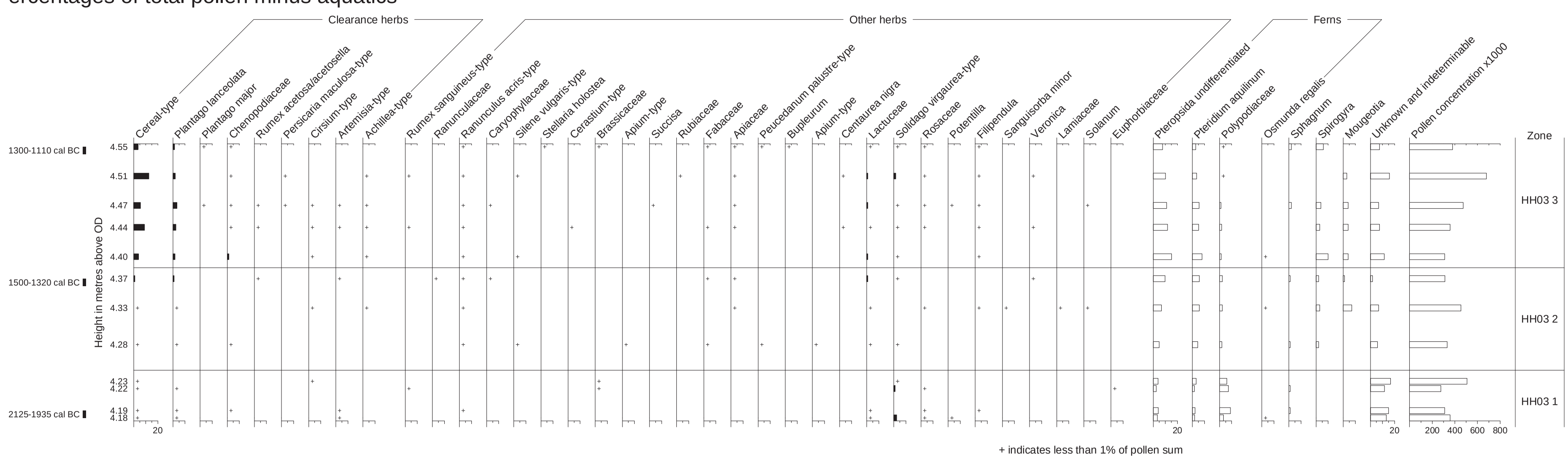


Figure 120. Harding Alignment MARISP pollen diagram.

dominance of the aquatic *Ranunculus* subg. *Batrachium* with a range of Cyperaceae. Other taxa included *Rubus* sect *Glandulosus Urtica dioica* and *Viola odorata*.

4.35–4.40m OD: The peat with wood detritus was dominated by aquatic taxa (83%), consisting largely of *Ranunculus* subg. *Batrachium,*, in addition to *Alisma plantago-aquatica*, *Potamogeton* and occasional *Lemna* and *Chara*, with *Sparganium erectum* fringing the water's edge, with other marsh taxa (13%) including *Lycopus europaeus*, *Mentha aquatica*, *Lythrum salicaria*, *Hydrocotyle vulgaris* and *Juncus*. Evidence for *Alnus* comes from occasional cones. Some drier areas are indicated by *Rubus* sect *Glandulosus* and a range of herbaceous taxa of disturbed ground such as *Atriplex*, *Rumex*, *Chenopodium album* and *Cirsium*/*Carduus*.

4.44–4.49m OD: The assemblage in this silty peat is similar to the underlying woody peat, although there is a decrease in the aquatics (69%) caused principally by fewer water crowfoot and a corresponding increase of marsh taxa (25%), notably *Mentha aquatica* and *Juncus*.

The insect remains from Harter's Hill 2003

Harry Kenward

The statistics for beetles and bugs results are shown in Table 95.

4.44–4.49m OD: The numbers of insects in this sub-sample were rather limited, and identification made difficult, and often impracticable, by a high degree of fragmentation and erosion. Only 30 adult beetles and bugs were identified (29 taxa, only and *Ochthebius* being represented by two individuals). A third of these were aquatics (ten individuals, nine taxa, but also numerous water flea resting eggs and small numbers of some other aquatic invertebrates), and waterside forms were also important (five individuals); the whole assemblage might have lived in or beside water.

The foraminifera from Harter's Hill 2003

Annette Kreiser

A sample of highly organic, silty clay was analysed from 39–40cm depth (4.19m OD). Forams were very sparse in the 125µm fraction and absent in the 63µm fraction. Three foram tests were picked out but identification of these is problematic. Test morphology closely resembles the common brackish species *Ammonia beccarii* but these tests differ from the commonly found tests of *A. beccarii* and its variants in that they are heavily encrusted with calcitic ornament. The test surface also appears heavily pitted which may indicate some dissolution.

In an effort to find further tests, the remaining material from this 39–40cm level (*c.* 30cm^3) was also processed. This yielded a further four tests. One of these closely resembles a 'nominate' *A. beccarii* with only slight pitting and encrustation. The other three tests have the appearance of the three found in the initial analysis. *A. beccarii* is known to exist as several different morphotypes, each thought to be adapted to local environmental conditions (Schnitker 1974). It is possible that the heavy ornamentation seen in these specimens is an example of ecotypic variation, although this feature has not been observed in *A. beccarii* from other estuarine deposits, either from the Severn Estuary, or elsewhere. Despite this, the presence of a 'near-normal' test suggests the most likely identity of these tests is *A. beccarii*. The pitting seen on the tests is more likely to be the result of post-mortem dissolution.

With so few tests and uncertainty over the identity of the foraminifera found, it is difficult to draw any firm conclusions about the palaeoenvironment. Assuming the species is *Ammonia beccarii*, this would indicate a brackish habitat with a wide fluctuation in salinity. The heavily ornamentated tests may well be indicative of a particular environmental condition, but with no knowledge of the distribution of this variant, it is impossible to say what that condition might be.

Environmental interpretation, Harter's Hill 2003 site

Heather Tinsley and Julie Jones

During the field excavations in 2003, clay was observed in the base of the sampling trench; that was interpreted as either a colluvial deposit or *in-situ* weathered Lias which, in this area, dips steeply from the ridge of Harter's Hill south towards the centre of Queen's Sedgemoor (Housley *et al.* 2000). The stratigraphic unit below 4.17m OD described in Table 93 as '*clay with woody fragments and organic detritus*' therefore represents a soil developed in the weathered surface of the Lias or in colluvium overlying it. LPAZ HH03 1 spans the upper part of this soil and the overlying peat up to 4.25m OD; the basal peat is dated to 2125–1935 cal BC at 4.18–4.19m OD. The pollen assemblage is characterised by high frequencies of tree pollen, the very low representation of herbaceous taxa suggesting that woodland with a dense canopy occupied the site. The woodland was dominated by *Alnus* (alder) and *Quercus* (oak) with *Corylus* (hazel) (evidenced by occasional hazelnut fragments in the macrofossil record). The values for *Quercus* pollen (26–34% TP) suggest that *Quercus* was growing in close proximity to the *Alnus* and the site was probably just above the margin of the wetland proper at this stage, with alders and oaks growing intermingled with an understorey of *Rubus* sect *Glandulosus* (brambles) and *Urtica dioica* (common nettle). The damp nature of the substrate is indicated by the presence of Cyperaceae (sedges) in the ground flora, with some areas of open water supporting aquatic

Table 94. Harter's Hill: plant macrofossil remains.

	Height (m aOD)	**4.35–4.40**	**4.44–4.49**	**Habitat**
	Sample size (g)	**930**	**930**	
Characeae				
Chara spp.	Stonewort	3	9	A
Ranunculaceae				
Ranunculus subg. *Batrachium* (DC.) A. Gray	Water Crowfoot	1018	482	APR
Urticaceae				
Urtica dioica L.	Common nettle	1	1	DGHWp
Betulaceae				
Alnus glutinosa (L.) Gaertner (fruit)	Alder		1	RWw
Alnus glutinosa (L.) Gaertner (cone)	Alder	2	1	RWw
Chenopodiaceae				
Atriplex spp.	Orache	1	–	CDn
Chenopodium album L.	Fat-hen	2	–	CD
Chenopodiaceae indet	Goosefoot family	–	2	CD
Caryophyllaceae				
Moehringia trinervia (L.) Clairv	Three-nerved Sandwort	1	–	WH shady
Polygonaceae				
Rumex sp.	Dock	2	–	DG
Violaceae				
Viola spp.	Violet/Pansy	1 + 6f	12 f	HSW
Salicaceae				
Populus sp. (bud scale)	Poplar	1	–	WH
Rosaceae				
Alchemilla spp.	Lady's-mantle	–	1	GW – damp
Filipendula ulmaria (L.) Maxim	Meadowsweet	1	–	w
Potentilla c.f. reptans L.	Creeping Cinquefoil	1	–	DG, o, H
Rubus sect. *Glandulosus* Wimmer and Grab	Bramble	13 + 11f	16 + 13 f	DHSW
Lythraceae				
Lythrum salicaria L.	Purple-loosestrife	36	17	BMF
Apiaceae				
Berula erecta (Hudson) Cov	Lesser Water-parsnip	1	–	MPw
Hydrocotyle vulgaris L.	Marsh Pennywort	4	5	FM
Oenanthe aquatica (L.) Poiret	Fine-leaved Water-Dropwort	8 + 10 f	1	P
Lamiaceae				
Lycopus europaeus L.	Gipsywort	3	–	FRw
Mentha aquatica L.	Water Mint	81	107	MPw
Callitrichaceae				
Callitriche spp.	Water-starwort	1	2	A or on mud
Scrophulariaceae				
Veronica beccabunga L.	Brooklime	1	–	BMPR
Asteraceae				
Cirsium/Carduus sp.	Thistle	–	1	DGMW
Eupatorium cannabinum L.	Hemp-agrimony	–	2 f	w-shade/open
Alismataceae				
Alisma plantago-aquatica L.	Water Plantain	19	4	APR
Alisma sp.	Water Plantain	227	204	
Potamogetonaceae				
Potamogeton sp.	Pondweed	35	100	APR
Lemnaceae				
Lemna sp.	Duckweed	14	10	A
Juncaceae				
Juncus sp.	Rush	35	130	GMRw
Cyperaceae				
Carex spp.	Sedge	2	1	GMPRW
Carex paniculata L.	Greater Tussock-sedge	10	1	BFMw,Ww
Carex pendula Hudson	Pendulous sedge	8 + f	2 + f	Whw
Carex riparia Curtis	Greater Pond-sedge	3		PMN, w
Eleocharis palustris/uniglumis	Spike-rush	16	21	MPw
Schoenoplectus tabernaemontani (C. Gmelin) Palla	Grey Club-rush	3	6	BMPRs
Poaceae				
Glyceria sp.	Sweet-grass	6	4	MPR shallow
Poaceae indet	Grass	2	1	

For habitat codes, see Appendix 1.

Table 94. continued.

	Height (m aOD)	4.35–4.40	4.44–4.49	Habitat
	Sample size (g)	**930**	**930**	
Sparganiaceae				
Sparganium erectum L.	Branched Bur-reed	31	43	MPR
Sparganium sp.	Bur-reed	5	–	
Typhaceae				
Typha sp.	Bulrush		7	PR-reedswamp
	Total:	**1595**	**1180**	
Other Remains				
Caddis fly larvae		20f	4 f	
Charcoal fragments		occ	occ	
Cladoceran ephyppia	Water-flea egg-cases	occ	–	
Leaf abscission pad			6	
Sphagnum leaf	Bog-moss		3 f	
Wood fragments		abund	v. freq	

Table 95. Harters Hill 2003: main statistics for assemblages of adult beetles and bugs (excluding aphids and scale insects).

	4.44–4.49m OD
S	29
N	30
ALPHA	x
SEALPHA	x
SOB	23
PSOB	79
NOB	24
PNOB	80
ALPHAOB	x
SEALPHAOB	x
SW	9
PSW	31
NW	10
PNW	33
SD	5
PSD	17
ND	5
PND	17
SP	6
PSP	21
NP	6
PNP	20
SRT	3
PSRT	10
NRT	3
PNRT	10

For explanation of abbreviations, see Appendix 2

taxa such as *Callitriche* (water-starwort) and *Ranunculus* subg. *Batrachium* (water-crowfoot).

The opening of LPAZ HH03 2 at 4.25m OD is marked by a fall in the frequency of pollen of *Quercus* and *Corylus*-type indicating a decrease in oak and hazel close to the site (though they continued to grow on the higher land). This must have been a consequence of increasing wetness, probably associated with the rise in water table which initiated peat formation. The pollen evidence suggests that the *Alnus* carr remained established on the site, but although there is a concentration of decomposed wood fragments in the peat, alder macrofossils are restricted to several cone fragments. An expansion of pollen of *Sparganium emersum*-type and the presence of fruits of *Sparganium erectum* (branched bur-reed), indicates that open areas dominated by bur-reeds were expanding, colonising mud or shallow areas on the edge of slow moving or still water (Stace 1991) and the entire insect assemblage consists of aquatic taxa and waterside forms.

Occasional pollen grains of *Myriophyllum verticillatum* (whorled water-milfoil) and pollen and macrofossils of *Lemna* (duckweed) and Potamogetonaceae (pondweed) are evidence of the pools of open water which also supported *Ranunculus* subg. *Batrachium* and *Alisma plantago-aquatica* (water plantain). *Ranunculus* subg. *Batrachium* is a floating leaved aquatic, which roots in the mud and usually occurs in relatively shallow water up to 0.5m deep and is mostly confined to still or slow-moving water. Similarly *Alisma plantago-aquatica* prefers shallow water on muddy margins though it may grow amongst other emergent vegetation in marshy areas. The ground flora of this wetland community also included *Lythrum portula* (water-purslane), *Lythrum salicaria* (purple loosestrife), *Mentha aquatica* (water-mint) and *Hydrocotyle vulgaris* (marsh pennywort).

The end of HH03 2 is dated to 1500–1320 cal BC, so by the middle Bronze Age it is clear that this site was becoming increasingly waterlogged. This might have been a result of increased run-off from Harter's Hill, flooding the flat land (see below) or the rising water table may have been associated with more widespread changes in hydrology in the Somerset Levels. Aalbersberg *et al.* (in press) have discussed the possibility of flooding associated with the 'backing up' of river water as the marine transgression, which deposited the Upper Wentlooge alluvium in the Axe valley and in the Brue valley north of Glastonbury Lake Village, advanced. Housley *et al.* (2000) noted that the lower contact of this alluvium does not appear to be synchronous. Haslett *et al.* (1998) reported dates from Nyland Hill in the Axe valley which calibrated to 1860–1520 cal BC and 1720–1320 cal BC (Housley *et al*. 2000). However, at Long Run Farm in the Brue valley (nearer to Harter's Hill) the lower boundary of the Upper Wentlooge clay is dated later, to 1210–900 cal BC (*ibid.*).

In the period of LPAZ HH03 3 (from 1500–1320 cal BC to 1300–1110 cal BC) the flat land at the base of Harter's Hill remained waterlogged. The macrofossils indicate that *Typha* (bulrush) became established. There is a further expansion of *Sparganium emersum*-type pollen and a corresponding increase of *Sparganium erectum* fruits, along with an increase in pollen of Cyperaceae and Poaceae (grasses) suggesting the spread of sedge and bur-reed beds, partly at the expense of the carr woodland. Pollen of *Alnus* declines somewhat in this zone, although again there is no real macrofossil evidence for *Alnus*, but pollen of *Salix* (willow) increases. *Salix* is insect-pollinated and an under producer of pollen compared to *Alnus* and Bunting and Tipping (2004) considered values of 2–3% *Salix* pollen sufficient to indicate its presence in local wetland communities. The expansion of *Salix* in this zone is either a result of a spread of willow in response to the thinning out of the alder trees or it could simply represent an increase in the influx of *Salix* pollen as the carr canopy opened. There is a continued presence of the aquatic herbs found in HH03 2, with the addition of *Menyanthes trifoliata* (bogbean), a native of shallow water and fen communities (Stace 1991). However, there is a sharp decline in the abundance of *Ranunculus* subg. *Batrachium* and an increase in *Potamogeton* suggesting that there were some fluctuations in areas of open pools. At the end of the zone, right at the top of the pollen diagram, at the level dated to 1300–1110 cal BC (4.54–4.55m OD), there is a decline in the pollen of the aquatic herbs and *Alnus* frequencies increase again, suggesting the site may have become drier, but this may simply be a temporary, short-lived fluctuation.

The pollen diagram provides some interesting evidence of possible farming activity on the dry land of Harter's Hill in the period from 1500–1320 cal BC to 1300–1110 cal BC. During LPAZs HH03 1 and HH03 2 the pollen frequencies for the clearance herbs are low, but above 4.37m OD, at the start of HH03 3, there is a marked change and the curve for clearance herbs increases, primarily due to an expansion of cereal-type grains (which eventually form 13% TP towards the end of HH03 3) along with a parallel, but smaller increase in pollen of *Plantago lanceolata* (ribwort plantain). Interpretation of the record for cereal-type pollen in wetland environments is complicated by the inclusion of *Glyceria fluitans* (floating sweet grass) in this taxon (as discussed above) and while *Glyceria caryopses* occur in the macrofossil record they are at very low frequency in association with other wetland taxa. The cereal-type grains in HH03 3 are generally thin, as a result of biochemical deterioration of the exine, and a proportion are crumpled, however some remain well preserved and have the clear features of cereal grains, i.e. a large pore with a raised annulus around it, their size and sculpturing suggests *Hordeum* (barley). The curve for *Plantago lanceolata* closely parallels the cereal-type curve, also peaking in HH03 3, and at the same horizon pollen of *Quercus* and *Corylus*-type falls to lower levels than previously, indicating a further reduction in the adjacent dry land woodland. All these features suggest that the peak in cereal-type pollen was indeed associated with Bronze Age cultivation on Harter's Hill and that the pollen curve, while it may include some *Glyceria,* largely reflects the cultivation of cereals on the drier ground. Pollen from harvested fields may have been washed down onto the wetland in overland flow, triggered by disturbance of the soil associated with cultivation. Incidentally, this increase in run-off could account (at least in part) for the increased wetness at the slope foot in the mid-Bronze Age. The stratigraphic record from Harter's Hill 2003 offers support for the overland flow hypothesis of cereal pollen transport, as there is a significant silt component in the peat apparently derived from colluvium. Transport of cereal grains by overland flow, along with silt, would also help to account for the rather poor preservation state of some grains.

The cereal-type pollen frequencies are surprisingly high. Cereals are self pollinated, and their pollen, if released, does not disperse far (Faegri and Iversen 1989). This would suggest that, if the source of this pollen was the dry land, then the cultivated fields were very close to the site. Vuorela (1973) has shown that increased amounts of cereal pollen may be deposited during the threshing season when pollen is beaten out of the glumes. There was a general increase in arable intensification in the mid–late Bronze Age in southern England and records for *Hordeum vulgare* (naked barley) from archaeological sites in the south west date from this period (Campbell and Straker 2003). A peak in the frequency of microscopic charcoal particles in HH03 3 is further evidence of local occupation at this time. Charcoal dust is carried up into the atmosphere by the heat from fires and then dispersed like pollen (Faegri and Iversen 1989). When particles are found in pollen preparations they either represent a record of firing of vegetation (accidental or spontaneous), or of domestic fires. In the wet environment of the Somerset Levels the latter is most likely.

The pollen assemblage zones at Harter's Hill 1997

The pollen diagrams for these samples are shown in Figure 121.

HH97 1 (Below 4.51m OD; 51–95cm below the ground surface). Tree pollen forms 52–90% TP, principally *Alnus* (26–70% TP), with *Quercus* 7–13% TP and *Corylus*-type 6–9% TP. *Betula, Ulmus, Fraxinus Tilia* and *Salix* are represented by occasional grains. Herbaceous pollen consists mainly of Cyperaceae, which fluctuate from 5–30% TP, with Poaceae forming 2–15%TP. *Sparganium emersum*-type fluctuates from <1%–13%TP+aquatics; there are small peaks in pollen of Lemnaceae and *Typha latifolia* in the later part of the zone. *Plantago lanceolata* forms <1%–3%TP and there are occasional grains of other clearance herbs. Cereal-type pollen occurs at <1% TP. Pteropsida (undifferentiated) contributes 3–28% TP+ferns along with *Pteridum,* which forms 1–11% TP+ferns. Unknown and indeterminate grains make up 1–12% TP+indeterminables. Below 4.23m OD, the majority of *Corylus*-type and Poaceae grains show poor biochemical preservation, but this improves higher up the zone. Pollen concentrations fluctuate widely, increasing mid zone and then falling markedly at the zone end, where pollen is very scarce. Microscopic charcoal concentrations are low.

HH97 2 (4.51–4.75m OD; 27–51cm below the ground surface). Tree pollen falls to 17–36% TP in this zone, with *Quercus* forming 7–12% TP and *Alnus* only 2–9% TP. *Corylus*-type contributes 5–11% TP. *Betula, Ulmus* and *Fraxinus* are represented by occasional grains. The herbaceous pollen is dominated by Cyperaceae which form 44–59% TP with Poaceae 7–14%TP. There are small peaks in other wetland taxa such as *Cladium mariscus, Typha latifolia* and *Sparganium emersum*-type. The frequency of pollen of clearance herbs is largely unchanged from HH97 2. Spores of Pteropsida (undifferentiated) increase markedly at the start of the zone, fall, then rise again, fluctuating between 17 and 67% TP+ferns. Unknown and indeterminable grains form 7–10% TP+indeterminables. The majority of grains of *Corylus*-type and Poaceae exhibit some biochemical deterioration. Pollen concentrations increase at the start of the zone. Microscopic charcoal concentrations reach very high peaks in the upper two samples.

Environmental interpretation, Harter's Hill 1997 site

Heather Tinsley and Julie Jones

The Harter's Hill 1997 site is 50m to the south of the 2003 site, on the line of the Harding alignment and therefore slightly further away from the dry land. The lowest sediment sampled, from 4.09m OD, was a well humified peat with abundant woody detritus, with a date of 1400–1130 cal BC. This date falls within the time period of LPAZ HH03 3 at the 2003 site. Thus the environmental record from the two sites overlaps, however that from the 1997 site extends further, through the upper dated horizon of 1130–920 cal BC, at 4.56m OD. The top of the diagram at 4.76m OD is undated.

In general pollen preservation at the 1997 site is similar to that at the 2003 site, i.e. moderately good. There is no evidence of over-representation of robust pollen taxa. Pollen concentration does fall to extremely low levels at 4.45m OD, towards the end of HH97 1, in the top of the woody peat, and in the assessment stage it was suggested that pollen might have been destroyed at this level in the stratigraphy (V. Straker pers. comm.). However, in the full analysis, the *Corylus*-type and Poaceae grains (though only represented at low frequencies) did not exhibit marked biochemical deterioration at this level, and the numbers of unknown and indeterminable grains were not high. Therefore it appears that the low pollen concentrations must represent a short period of more rapid sediment accumulation, rather than poor preservation.

The values for *Alnus* pollen in LPAZ HH97 1 are similar to those from HH03 3, suggesting that at around 1400–1130 cal BC carr woodland with a relatively open canopy extended out from the 2003 site at the wetland margin at least as far as the 1997 site. The woody detritus in the lower peat, and the presence of *Alnus* macrofossils (V. Straker pers. comm.) support this interpretation. The ground flora was dominated by Cyperaceae, with less *Sparganium* than at the 2003 site. Pools of open water, or channels, were present colonised by *Lemna* and *Nuphar lutea* (yellow water-lily), *Nuphar* generally prefers water between 1 and 5 metres deep (Haslam *et al.* 1975). Towards the end of HH97 1, a small peak in pollen of *Typha latifolia* at 4.45m OD and the presence of *Typha* macrofossils (V. Straker pers. comm.) indicates the spread of bulrushes and just before this, at 4.39m OD, there is a change in sediment type to peat characterised by the detritus of herbaceous plants rather than wood.

At the start of HH97 2, at 4.49m OD, *Alnus* pollen frequencies fall dramatically and macrofossil remains are absent. By 1130–920 cal BC (4.56m OD) it is clear that the local carr woodland had drastically declined. It was replaced by an open fen community dominated by Cyperaceae with *Typha*, *Sparganium* and *Cladium mariscus* (great fen-sedge), which thrives in base-rich conditions where the water table remains between 15cm below the ground surface and 40cm above (Rodwell 1995). In places there were ferns, Pteropsida spores are frequent, but largely undifferentiated. Occasional pollen grains of *Myriophyllum verticillatum*, *Nuphar* and *Lemna* indicate the continuing presence of open water habitats. It was across this open, wet environment that

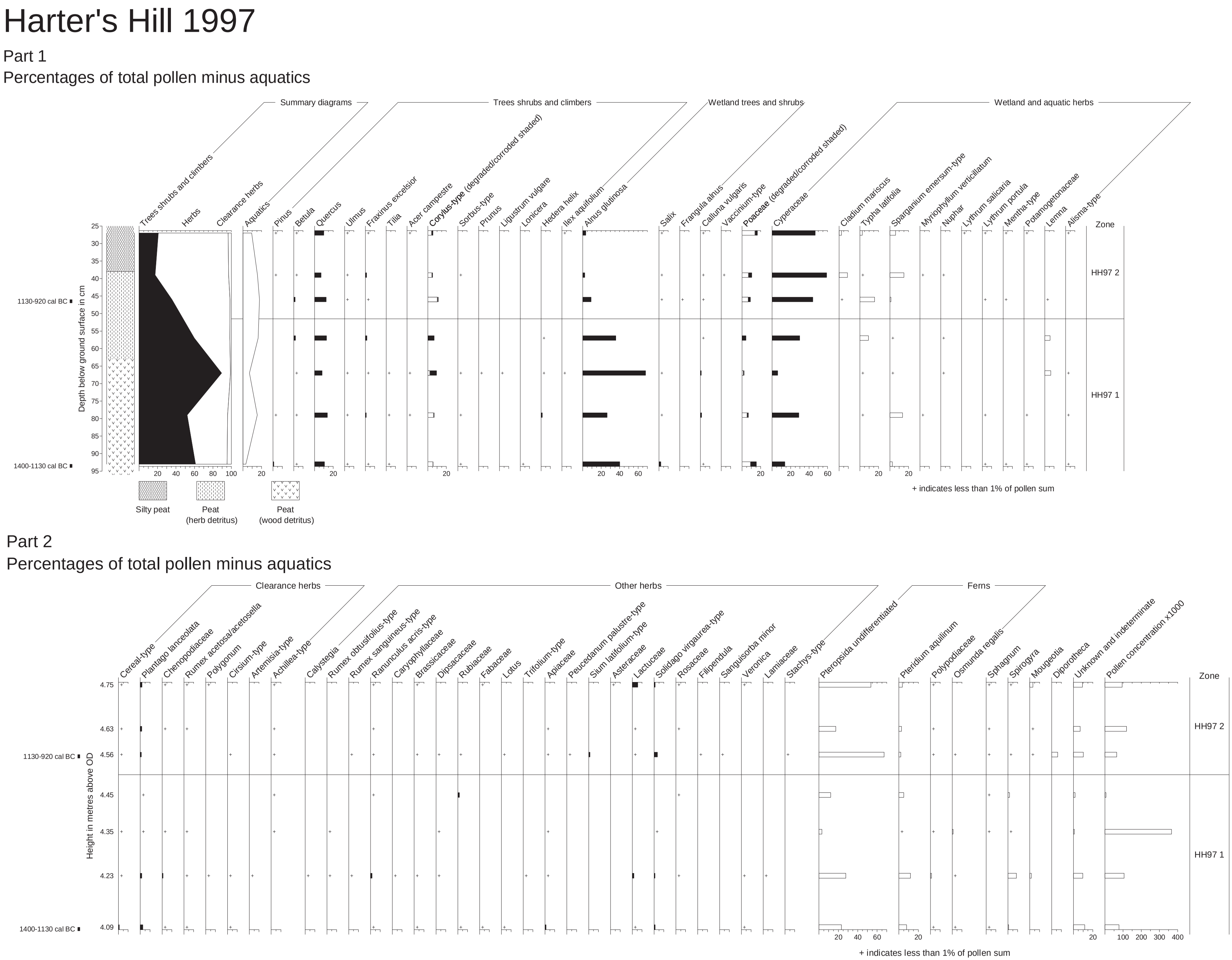


Figure 121. Harding Alignment 1997 pollen diagram.

Figure 122. Reconstruction picture of the Harding Alignment, looking north towards Harter's Hill (Peter Lorimer).

the Harding alignment was built around 1076/5 BC. The evidence from the two Harter's Hill sites, considered together, demonstrates that for around 400 years prior to this the environment on Queen's Sedgemoor had been getting steadily wetter, culminating in the demise of the carr woodlands and their replacement by sedge fen.

The pollen record from the Harter's Hill 1997 site supports the interpretation of the pollen data from the 2003 site in suggesting that oak-hazel woodland was growing on Harter's Hill in the mid–late Bronze Age. *Quercus* and *Corylus*-type are the principal dry land tree taxa in the pollen diagram and, as would be expected, the frequencies are less at the 1997 site than at the wetland margin location. The period of mid Bronze Age agricultural activity, seen in the Harter's Hill 2003 pollen diagram, cannot be identified at the 1997 site. *Plantago lanceolata* and cereal-type pollen occur at low frequencies throughout, with the former increasing slightly towards the end of HH97 2. However, the major peak of pollen of clearance herbs, found in LPAZ HH03 3, is not seen in HH97 1, which represents some of the same time period. This emphasises the very local nature, and probably also the small-scale, of the farming on Harter's Hill. It is significant that the silty, colluvial component found in the peat at the 2003 site is absent at Harter's Hill 1997, below 4.64m OD. It seems that the colluvial activity that brought both silt and cereal-type pollen down from the hill onto the wetland margin did not extend the 50m across to the 1997 site. However, post 1130–920 cal BC, at Harter's Hill 1997, there is evidence of increased human activity in the wider area, as microscopic charcoal frequencies increase markedly.

Fieldwork conclusion

The environmental analysis undertaken on the site has allowed a detailed picture of the wetland and dryland landscape to be developed covering the second to early 1st millennium cal BC. At the beginning of this period oak and hazel woodland dominated the dryland on Harter's Hill and were mixed with alder at the bottom of the slope along the wetland fringe. In the first half of the 2nd millennium cal BC stands of bur-reed and open water pools developed in the woodland at the bottom of the slope and by the middle Bronze Age conditions had become significantly wetter with the alder carr replaced by sedge swamp and shallow open water. It was during this period that clearance activity and cereal cultivation on the nearby dryland expanded significantly, resulting in run off into the wetland. This lasted until at least the end of the Bronze Age.

A brief resurgence of alder carr at the edge of the floodplain occurred around 1300–1100 BC but was soon replaced by sedge swamp and shallow open water. This was the environment in which the pile alignment was created by at least 1076 BC (Figure 122). The monument was added to until at least 1049 BC showing a minimum of 27 years during which piles were added. There were a minimum of three felling episodes for the piles in 1076 BC, 1065 BC and sometime between 1049 and 1021 BC.

The younger felling dates are consistently closer to the dry land with the 1049–1021 BC date being derived from the pile found in the MARISP excavation. This slender evidence might suggest that the alignment developed towards the dry ground possibly in response to the expansion of the shallow water sedge swamp.

The mass of wood around the piles consisted of waste material from working oak planks and lots of small roundwood, seemingly designed to provide a walkway through the sedge swamp. The piles and small stakes would have helped to secure this material but their insertion may also have been part of the rituals undertaken at the site. These may have involved metalwork deposition, as a bronze sword was discovered at the southern edge of the field in the early 20th century (donated to Wells Museum but now lost). The extensive deposit of semi-charred roundwood beside the dryland end of the alignment could represent the destruction of material derived from scrub clearance or may be the remains of fires lit at the end of the monument to perform some role during the ritual activity undertaken at the monument. There is no evidence that the piles supported a superstructure. Their morphology, alignment and sequential insertion, all suggest that they could not have performed such a role. Their periodic insertion into the alignment was probably one of the most visual and long lasting acts of the activity on the site. They would have been the only component of the structure that stood proud of the water surface, so to the eye they were the site.

Comparative sites

In England and Wales 16 other pile alignments have been dated to the late Bronze Age, between 1200 and 800 BC. Eight of these have been the subject of extensive excavations. The most thoroughly investigated is undoubtedly the pile alignment known from the Power Station and Flag Fen sites in Cambridgeshire although after 25 years of study '*our knowledge of Flag Fen is still partial*' (Pryor 2001, 432).

The Power Station site is in effect one end of the Flag Fen post alignment that extends for *c.* 1km across the Flag Fen basin effectively cutting off the end of the embayment to the west. The basin had experienced increased groundwater table rise by the late Bronze Age forming sedge fen conditions with shallow water and some reedswamp and alder/willow carr fringing the wetland edges (Scaife 2001, 373–81).

The pile structure was formed of five rows of piles with mass of surrounding horizontal timber (Pryor 2001, 93–6, fig. 8.50). Row 3 was the densest with no significant gaps along its length while row 4 converges with row 3 in some places. The gaps between rows varied from almost nothing up to 3m. Each row had a different species make up. Row 1 was all alder with the exception of one willow, row 2 was almost all oak, row 3 was mainly oak with some alder and a few ash, willow, poplar and field maple, row 4 was mainly oak with some ash and alder and row 5 was all oak. Many uprights were radially split and a smaller number tangentially split, from trees aged from less than 20 years to over 200. A phased development of the rows has been proposed (*ibid.*, 421–36) but this is clearly at odds with the tree-ring dating evidence that shows that piles were added to all the rows intermittently with no evidence of large scale building phases.

The horizontal material was excavated in six arbitrary layers revealing a mixture of split oak planks, woodchips, timber offcuts and roundwood, mainly of 5–60mm diameter with some larger logs of up to 260mm diameter. Some sand and gravel was incorporated into the upper layers, especially between rows 2 and 3 where it has been proposed that a walkway existed.

An extensive wooden platform has been proposed towards one end of the alignment although the published plans suggest intermittent spreads of material and it is admitted that there were '*areas of open water within the platform*' (Pryor 2001, 426). The possibility of a platform forming a dry surface is also contradicted by the environmental evidence, especially the coleopteran analysis which '*gave no indication that the platform was a timber structure*' (Scaife 2001, 389) and suggested that the 'platform' timbers became rapidly waterlogged in stagnant pools of water that were periodically flooded (*ibid.*).

A huge quantity of objects were deposited within and beside the pile alignment. A total of 276 items of metalwork were recovered, including swords, spearheads, pins, brooches, knives, parts of shields and an axe of later Bronze Age to Iron Age date. Of these only nine were from the main Flag Fen site, the remainder all derived from the Power Station site (Pryor 2001, tab. 10.1). Other artefacts included pottery, a shale bracelet, quernstones and animal bone, the latter including some part skeletons of horse and cow at Flag Fen and large hunting dogs at both sites. Most of the deposition occurred at the Power Station site with the metalwork generally to the south and the animal bones to the north. At the main Flag Fen site the ritual deposition of quernstones and dog skeletons was also on the south side of the alignment.

There are two human bones from the Flag Fen site, a mandible and a tibia from an adult and an infant. The Power Station produced bones from a minimum of seven individuals but these may represent the remains of disturbed earlier burials (Halstead *et al.* 2001).

The Power Station end of the alignment appears to have been built first, possibly as late as 1254 BC and piles were added there until at least 924 BC. The main Flag Fen area could begin as late as 1094 BC and piles were added until at least 955 BC (Neve and Groves 2001). This suggests that the structure was extended further out into the sedge fen over a period of perhaps 150 years. As most deposition of artefacts occurred at the Power Station end of the alignment it is possible that the character of use also changed during that time with a move away from the deposition of metalwork. The alternative explanations are that a subtle difference in the local environment, or the proximity to dryland prompted the differential spatial deposition or that more objects are present at the Power Station end because it was in use for a longer period.

The hypothesis of changing deposition and linear expansion of the site over time is supported by the pottery evidence from the site. Although the metalwork from the Power Station end of the alignment suggests deposition from the middle Bronze Age, pottery of that period is almost completely lacking. Instead the Power Station assemblage is dominated by Iron Age pottery, possibly associated with the nearby Cat's Water settlement. Later Bronze Age pottery did exist on the site but mainly only further out along the alignment at the main Flag Fen site (Barrett 2001). The metalwork also shows chronological variation with the earlier Pennard material concentrated at the Power Station and deposition at the main Flag Fen site peaking in the late Wilburton/early Ewart Park phases (Rohl and Northover 2001).

A site with many structural similarities to Flag Fen was discovered in 1932 crossing *c*. 800m of wetland between Fordy and Little Thetford in Cambridgeshire. Arable farming had caused peat shrinkage that caused the tops of oak piles to catch in the farmer's tractor so he:

> set to work to remove the offending objects, and as a result of the effort he uprooted a veritable forest of great stakes which were embedded within the clay. These he replaced temporarily in their respective holes, bottom upwards and projecting considerably above the ground, to show the course of the causeway, and had them photographed (Lethbridge 1935, 86).

That photograph shows 3–4 irregularly spaced lines of at least 33 piles stretching off into the distance (*ibid.*, pl. I). Subsequent excavation revealed that the piles were all oak roundwood, often of 200mm diameter or more, forming up to five rows between 3.3m and 9m wide. Between the posts was a mass of decayed brushwood '*kept in place by occasional beams and stakes*' (*ibid.*, 87). Bronze Age pottery was found within the structure and a bronze ring to one side and early Iron Age pottery was noted in a layer of sand that overlay the structure but was separated from it by a layer of peat (*ibid.*, 87–8). Continued peat shrinkage caused more piles to be removed in 1936 and at that time further investigations revealed that the brushwood was full of bones of red deer and ox (Lethbridge and O' Reilly 1936, 161).

At Greylake, on Kings Sedgemoor in Somerset, excavations revealed an irregular non-linear pattern of split oak piles associated with some horizontal oak planks and isolated cut roundwood (Brunning 1998). Piles were inserted at the site from 963 BC until at least 952 BC and around the piles were the remains of disarticulated human remains (a clavicle, a humerus and some ribs) sheep jaw bones, broken pottery, white quartz pebbles and a bronze socketed axe that appeared to have been deliberately crushed. Deposition occurred over an area of at least 10 × 5m in shallow, slow moving freshwater fen (Dinnin 1999). The owner of the field reported that her father had found a human skull from the ditch on the south side but did not know what had happened to it (Mrs Roberts pers. comm.).

The Shinewater Park 'trackway' near Eastbourne in East Sussex also dates to this period with multiple radiocarbon dates showing activity in the 9th and 10th centuries cal BC (BM-3042, 2730±45, 990–810 cal BC; BM-3043, 2600±45BP, 850–750 or 690–540 cal BC; BM-3044, 2690±40BP, 920–800 cal BC; BM-3056, 2680±45BP, 920–790 cal BC). The site was built from dryland to a 'platform' over a distance of *c*. 250m through a fen environment with slow flowing or standing water up to 1m depth and with probable seasonal fluctuation shortly before a marine transgression began (Greatorex 1995; 1998). It consisted of an alignment of oak piles, 70–210mm in diameter, forming three rows each *c*. 1.5–2.2m apart giving a total width of 5.5m. The piles appeared to be in groups of three, spaced *c*. 2.8–5.2m apart and a mass of horizontal wood surrounded the piles, including layers of oak, alder and willow/poplar brushwood that sometimes supported large horizontal timbers, up to 3.7m long, set either transversely or longitudinally on top of the structure. Occasional roundwood stakes helped to hold it together and in two instances small piles were driven through holes in upper transverse timbers. The upper levels were augmented by some sand patches and charcoal and singed timbers showed that there was some *in situ* burning in places.

The date of the Shinewater site coincides with the later phase at Flag Fen when little metalwork was deposited. The only metalwork from the pile alignment was a copper alloy knife, a copper blade tip and an iron fragment. Other artefacts associated with the structure included a shale bracelet fragment, 44 pieces of flint, three flint clasts and three pebbles and 230 sherds of Late Bronze Age pottery and a significant quantity of animal bone (Greatorex 1995; 1998).

The 'platform' covered an area of at least 50m by 30m at the end of the alignment and was formed of numerous oak roundwood piles, 100–200mm in diameter, surrounded by horizontal oak and hazel roundwood of 50–70mm and 7–20mm diameters respectively together with isolated planks (Greatorex 1995). In one area four hearths were recorded associated with 'floor layers' although there was no evidence of the walls of a building. Associated artefacts included 4 amber beads, some worked antler, 5 bronze axes, a bronze bracelet and sickle, lead pendants, 559 animal bones of 16 species, pottery, fire cracked flint and two groups of human skull fragments, a femur and a burnt clavicle. The remains of a 10–12 year old child were also recovered from the spoil (Greatorex 1995).

Two other sites similar to the Harding Alignment were originally interpreted as pile dwellings when first excavated in the later 19th centuries. The site of West Furze near Ulrome in Holderness was excavated by Thomas Boynton between 1880 and 1883 and has been reinterpreted by many others since then (Smith 1911; Evans 1885; Varley 1968; Van de Noort and Ellis 1995, 323–34; Coles 2006, 119–20). Smith recorded the site as having two platforms or layers, both associated with 'piles'. His description of the upper and lower piles is significant:

> At the beginning of the excavation a number of piles were dug out of the bottom of the drain … and it was noticed that they had been sharpened in a very primitive fashion. The lower end had been trimmed rather than pointed, and evidently with a stone adze, as the concave cuts were comparatively short. In fact the stone tool seems to have been used as a wedge as well as an adze, and it is possible that the extremity of the pile was first reduced by burning. The upper piles on the contrary, had been sharply pointed with a metal axe used vertically in the right hand, and from the associated relics it is practically certain that the metal was bronze. In some instances the sharp points had been driven into the top of the older piles which had decayed (Smith 1911, 600).

The description of the sharpening of the lower piles is consistent with beaver felling and Boynton recorded that many of the timbers had been gnawed by beavers and the animal bones from the site included several beaver bones (Coles 2006, 119–20). As the site occupies the narrowest point of the mere complex between Skipsea and Lissett it would be a natural location for a beaver dam and it may be that a human structure was built on top of an earlier beaver one. The lower levels can therefore probably be discounted as entirely natural and it seems that this is exactly what Boynton did as his description of the site in the *Yorkshire Post* of 26 July 1883 only describes a single complex structure rather than Smith's multiple levels:

> the builders placed first brushwood, and then, at a later date, tree-trunks, which crossed each other horizontally, and for the most part without any definite arrangement. They were fastened in position by pointed piles, and the interstices were filled in with broken wood and twigs to the depth of a foot [*c.* 0.3m] or more until a level surface was obtained, and the whole was then strewn with sand. On this solid surface there was placed an additional thickness of about 18in. [*c.* 0.46m] of broken twigs and bark, and on this foundation, which probably reached a little above the water level, were erected the dwellings of the builders (quoted in Smith 1911, 598)

The evidence of dwellings consisted of numerous piles but these were not arranged in a pattern consistent with a building. Smith recorded that:

> here and there in the upper structure stood upright piles or stakes, principally of oak, and 3 or 4 in. [76–102mm] in diameter, which had been driven in between the tree-trunks to fix and hold them together (Smith 1911, 596).

Smith's published plan of the site shows an alignment of multiple piles on the south-east edge of the excavation and his description of these is informative:

> One side of the platform, furnished with extra piling, appears to have reached the land at either end, thus connecting it with both shores of the narrow waters. The strengthening of this side consisted of sharpened upright piles in two rows 5ft. [1.52m] apart; … The excavation made for a distance of 12–15 yd. [10.9–13.7m] along this side brought to light flints and other stones, some pottery and human skulls (Smith 1911, 598).

This pile alignment and associated horizontal material has many similarities to the other structures described in this section and one of the few stratified finds was a late Bronze Age spearhead (*ibid.*, 602–3 and fig. 9) which place it in an approximately similar time period. A large assemblage of wild and domestic animal bone was also recovered from the site but there are no firm details of where exactly in the structure they came from Smith (1911, 103). A short distance away (20yd/18.3m) from the structure Boynton excavated a pit that had in its fill some flints and a complete pot containing a human skull and the bones of one hand (*ibid.*, 604).

The site of Round Hill was discovered on the Skipsea Drain midway between West Furze and Skipsea in Holderness and was excavated by Boynton in 1885. The only published description of this excavation is by Smith (1911), who seems to have had some difficulty understanding what the wooden remains on the site represented.

In a trench on the north side of the site six substantial piles were drawn on the only published section of the site, contained within a freshwater marl deposit that was labelled '*with piles, stakes and brushwood intermingled*' (Smith 1911, fig. 11, 605). Part of a human skull was recovered from a depth just below the top of the piles suggesting that it may represent contemporary deposition and a jet armlet at a slightly higher level.

Charred wood and flints may also have been derived from the top of the structure along with pottery fragments of possible Bronze Age date but the text does not make this clear (*ibid.,* 606). Another human skull, displaying axe cuts, was found in a ditch at the site in 1969 (correspondence from Mr Watson of Ulrome Grange in Humber HER 3764).

The late Bronze Age (100–900 BC) linear wooden structure at Lingley Fen, Haslingfield in Cambridgeshire, had very limited recording during its destruction by gravel extraction (Pullinger *et al.* 1982). Two small areas were excavated but the rest of the archaeological information was derived from observation of draglines. In area B brushwood was recorded supporting 2m long oak planks with 'notches' in the ends into which stakes were driven (*ibid.*). The uprights were mainly radial and tangentially split oak timbers. Area A contained lines of ash posts with brushwood and timber packed between them. The artefacts associated with the structure comprised animal and human bones, including many skulls.

Structure 1208 from Goldcliff in Gwent only shares some of the characteristics of the previous structures. It consists of 12 alder, willow, birch, ash, field maple, hawthorn and willow/poplar posts in two rough lines covering an area of 10 × 5m although one end is likely to have been lost to coastal erosion (Bell *et al.* 2000, 64–8). They were erected in an area of raised bog around 920–510 cal BC (SWAN-102, 2600±70 BP). Only 1.5m away were some human cranium fragments that have a possibly contemporaneous date of 830–550 cal BC (OxA-7659, 2580±35 BP) and earlier nearby deposition of a defleshed and broken human cranium is dated to 1450–1260 cal BC (OxA-7744, 3095±40 BP).

Eight other similar pile alignments dated to the later Bronze Age have been discovered but the existing information about them is limited either by the lack of detailed excavation or because they are recent discoveries that are not yet published. The latter applies to a structure from the Eton Rowing Lake excavations at Boveney in Buckinghamshire. It consisted of three large posts at the edge of a sand island and lines of smaller stakes on the island itself. Two complete late Bronze Age/early Iron Age pots were recovered from the base of the large posts and human remains and animal skulls of the same date from around the smaller stakes (Allen 2002).

In 1936 there is a brief mention of a causeway *c.* 1600m long connecting the islands of Ely and Stuntney in Cambridgeshire '*now almost completely destroyed*' that was '*of a similar character*' to the Fordy–Little Thetford structure (Lethbridge and O'Reilly 1936, 162). There appears to have been no other record of this structure but the Stuntney hoard of 83 bronze objects (72 socketed axes, 5 palstaves, 3 spearheads, a gouge, a rapier and a knife) in an alder tub was a found '*within a few feet*' of it (Clark and Godwin 1940, 52). A '*cluster of bronzes at either end of the Stuntney causeway*' was also mentioned and the context of the structure and the hoard was described as a reed and sedge peat (*ibid*., 59 and 71).

Another site associated with the discovery of bronze hoards is Fiskerton 2 in the Witham Valley in Lincolnshire where Naomi Field saw two parallel lines of posts in a field '*some years ago*' (Field and Parker Pearson 2003, 159). Several finds of Bronze Age metalwork had been discovered close by including two hoards of late Bronze Age socketed axes (*ibid*., 159). Another instance of the discovery of metalwork and piles is from Barnes in London where a palstave with an ash haft was found in a '*pile dwelling in river*' (Needham *et al.* 1997).

The Trent valley has produced several instances of the discovery of Bronze Age metalwork, human remains and occasional oak piles over 20km of river between Attenborough, Clifton, Colwick and Holme Pierrepoint. Over this area 67 items of high status metalwork have been discovered, mainly through gravel extraction (Davis 2003). The most detailed account of these discoveries is from the site at Clifton where gravel extraction in 1938 uncovered a 'large number of oak stakes driven into the bed of the river ... set about a yard apart' (Phillips 1941, 133). From the same place 2 bronze spearheads, a beehive quern, a stone crucible and 6 human skulls were recovered while other middle or late Bronze Age metalwork found nearby included 8 spearheads, 2 rapiers, a dagger, 2 swords and 2 knives. Elsewhere along the Trent military metalwork predominates as at Holme Pierrepoint where oak piles and two swords and one socketed axe were discovered in dredging (*ibid.*).

At Sutton Common in Yorkshire the early excavations revealed a series of posts and postholes 'not in strict alignment' joining the two Iron Age enclosures over *c*. 70m including the crossing of a palaeochannel (Whiting 1938). The posts were oak roundwood, up to *c*. 130mm diameter, and the alignment was traced under the Iron Age rampart suggesting that an earlier, possible Bronze Age, date is probable. Part of a human skull and a sheep shin bone were found in association with the structure (Whiting 1938).

Human bone associated with late Bronze Age pottery and an oak post has been recorded at the site of Chapeltump 2, on the Gwent foreshore (Whittle 1989, 211; Bell *et al.* 2000, 300). The bone is the left femur of an adult male dated to 1520–1130 cal BC (CAR-956, 3080±70 BP) and the post to 1220–830 cal BC (CAR-961, 2830±70 BP) suggesting that they may be contemporary, at a time when raised bog was giving way to a marine transgression.

The final site is from Northney on Hayling Island in Hampshire where an alignment of oak roundwood piles, *c*. 320mm diameter, was recorded associated with an area of wattlework (Williams and Soffe 1987; Allen and Gardiner 2000, 212). These have been dated to 1320–820 cal BC (*ibid*.).

The evidence from Harter's Hill and these other 16 sites suggests that it may be possible to identify a new type of monument associated with ritual deposition in wetland contexts. The key characteristics of the monument can be summarised as follows:

1. The presence of oak piles forming lines.
2. A body of horizontal worked wood around the piles (e.g. cut roundwood, logs, split planks).
3. Local environment of shallow freshwater, typically sedge fen with at least one end of the pile alignment connected to the contemporary dryland.
4. Date of construction between 1250 and 850 BC.
5. Presence of smaller roundwood stakes among the horizontal material.
6. Evidence of ritual deposition of martial metalwork, pottery, animal or human bone or a combination of all four.

The Harding Alignment appears to represent a ritual monument that was of a type commonly created across the lowland wetlands of late Bronze Age England and Wales. The creation of these monuments and the deposition associated with them represent a focus of freshwater wetlands in comtemporary religious activity.

Harding Alignment assessment and monitoring

Assessment of preservation

Visual assessment of wood

The upper part of oak pile 130, excavated in 2003, had obviously suffered significant decay but the surface condition of the majority of the horizontal wood was fair and there was little sign of shrinkage or cracking. The toolmarks at the ends of the cut stakes and the large pile were in a very good visual condition. The survival of 18 rings of sapwood on the pile was also very significant as oak sapwood is often one of the first elements to decay. The absence of sapwood on the woodchips and offcuts may be because it was not present on these elements or because it decayed before those pieces were deposited in the wetland.

It is very difficult to be certain about when the observed decay happened. The top of the oak pile must have protruded above the late Bronze Age water level and must have begun to decay at that time. The upper levels of the horizontal wood may also have been occasionally seasonally exposed to the air at that time and would only have required a very short period of exposure for significant decay to have occurred.

Detailed examination of wood structure

Mark Jones

The state of degradation, taken from an average of three samples is shown in Table 96. The condition of the timber samples excavated from this site range from medium degrades to heavily degraded. There are also some variations in the degree of degradation between the different wood species. All ash samples have moisture content values above 683% and range up to 977%. Alder samples had the lowest recorded values listed in Table 97 (329 and 332%). The Pomoideae sample had a moisture content of 825%.

Table 97 lists the original and present density values for each timber sample. Density values of the samples provided range from 0.25 to 0.09. There are also variations in the degree of degradation between wood species. Ash samples were once again found to have the lowest recorded density values (0.09) of the different wood species found at the Harter's Hill site. With most of the ash samples examined, a pin could be pushed through the timber without any difficulty. Alder samples at this site, had the highest density values (0.25). All samples have lost original cell wall material.

Examination of wood samples under the SEM give similar results for alder, ash, and oak. Figure 123 shows the decayed region of ancient alder. The secondary wall layer is still present in most cells. However, this layer has undergone extensive deterioration by microbial decay. Chemical analysis (Figure 125) confirms this picture of decay. FT-IR of alder sample 126 shows a loss of hemicellulose and a reduction in the crystallinity and content of cellulose. The middle lamella, which is rich in lignin, is once again well preserved.

SEM and FT-IR analysis of ancient ash (Figures 124 and 126) indicate structural and chemical changes to the secondary wall layers. This layer has been attacked by bacteria and has lost its entire hemicellulose component. Another notable feature is the reduction in cellulose content.

Figure 128 shows the extent of deterioration to oak sample 130. The pattern of attack is microbial and the porous nature of the secondary wall (S_2) indicates decay by erosion bacteria. FT-IR of this wood (Figure 127) shows major losses of hemicellulose and a reduction in cellulose content. Lignin component of the cell walls remains unaffected. The integrity of this wood cellular structure is being maintained by the compound middle lamella. If samples from this site were allowed to dry without consolidation, the cellular system would irreversibly collapse.

Table 96. Harter's Hill: moisture content values and state of degradation.

Timber no.	% Moisture content	Timber condition
23	329	Medium degraded
60	825	Heavily degraded
86	683	Heavily degraded
126	332	Medium degraded
127	977	Heavily degraded
129	955	Heavily degraded
130	712	Heavily degraded

Table 97. Harter's Hill: wood species, % moisture content (MC) and density values.

Timber no.	Wood species	% MC	Original density	Present density
23	Alder	329	0.48	0.25
60	Pomoideae	825		0.11
86	Ash	683	0.67	0.13
126	Alder	332	0.48	0.25
127	Ash	977	0.67	0.09
129	Alder	955	0.67	0.09
130	Oak	712	0.67	0.12

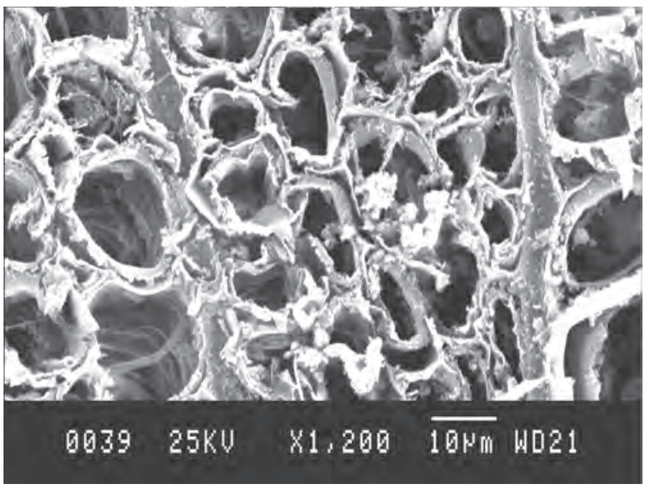


Figure 123. SEM of ancient alder (126). Transverse section showing medium degraded condition.

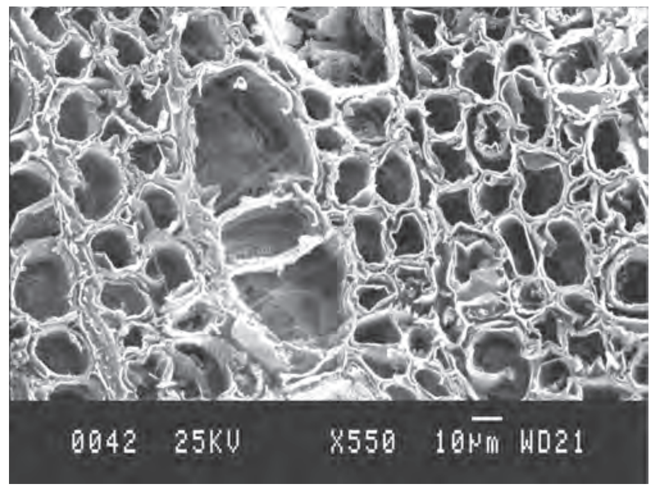


Figure 124. SEM of ancient ash (86). Cells are heavily degraded.

Pollen evidence

Heather Tinsley

Four samples were assessed from the MARISP excavation. The stratigraphy has been described earlier in the palaeoenvironmental report.

Pollen preservation

At 4.18–4.19m OD, in the basal organic clay, pollen preservation was rather poor, only 4% of grains were well preserved. There were 24 indeterminable grains, the majority of these were amorphous, but seven showed very extensive corrosion and six were mechanically damaged. 61% of all grains identified were poorly preserved (Table 98), due largely to extensive degradation, which affected the dominant taxa of *Quercus, Alnus* and *Corylus*-type. Quite a high proportion of *Corylus*-type grains also showed marked corrosion. Partial degradation also affected the principal tree pollen taxa and all but one of the Cyperaceae grains. Quite a substantial number of grains (28%) showed some mechanical damage, though in most cases this was not extensive. The biochemical preservation index was 2.01 and the mechanical preservation index was 0.68. There were only a few fern spores present, and these were largely well-preserved.

In the lower part of the peat bed, at 4.21–4.22m OD, pollen preservation slightly better, though still not good. 11% of grains were well-preserved, with 14 indeterminate grains, the majority of which were amorphous. 35% of all grains identified were poorly preserved and, as with the lower sample, this was largely due to extensive degradation. There was also extensive corrosion on some *Alnus* grains in particular. A significant number of both *Alnus* and *Corylus*-type grains were partially corroded and partial degradation was also widespread in these taxa, and in *Quercus*. There was less evidence of mechanical damage to grains in this sample, only 12% showed crumpling or breakage. The biochemical preservation index was 1.52 and the mechanical preservation index was 0.48. Again, only a limited number of ferns was recorded,

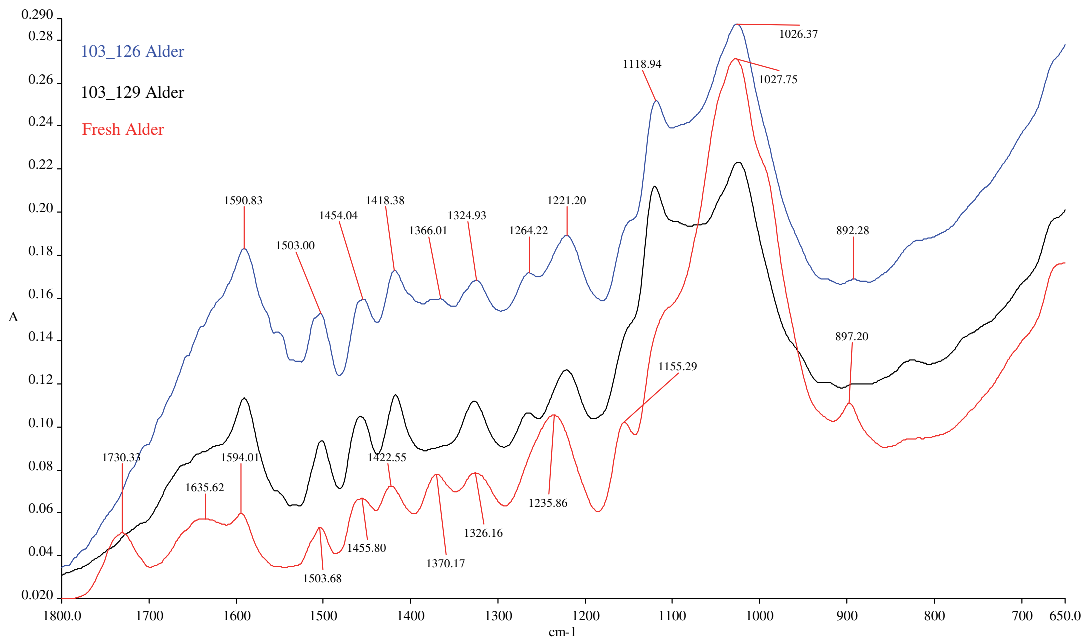


Figure 125. FT-IR spectra of Harter's Hill timber 126 (alder), 129 (alder) and modern alder.

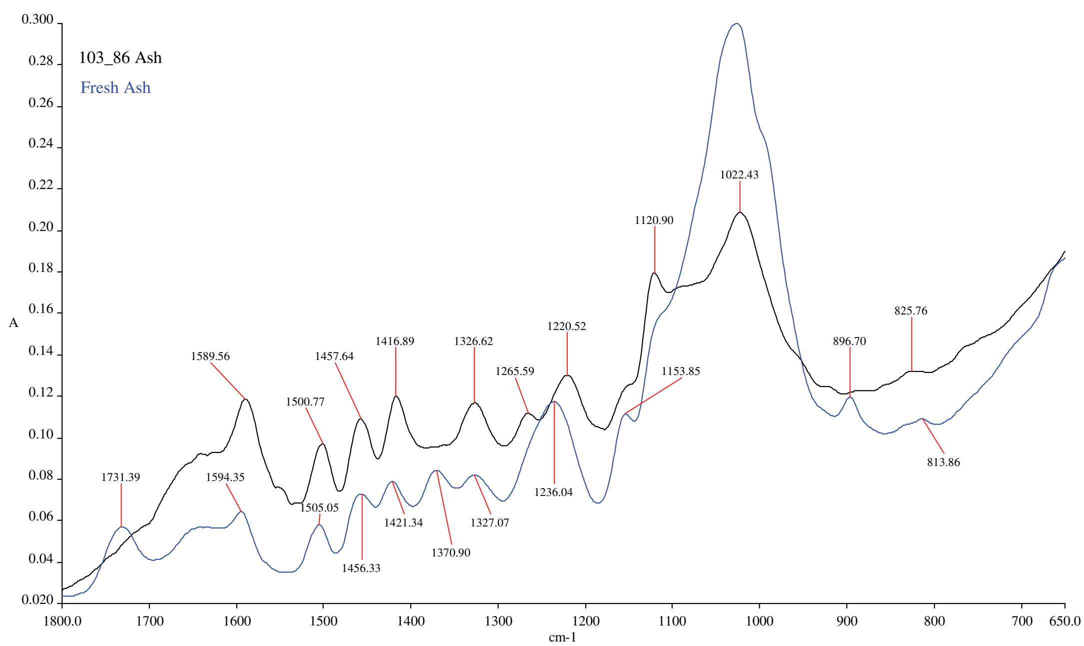


Figure 126. FT-IR of Harter's Hill timber 86 (ash) and modern ash.

mainly Polypodiaceae and the majority of these showed some etching.

Pollen preservation was further improved at 4.37–4.38m OD where 31% of grains were well preserved and only one indeterminable grain was recorded. 15% of grains identified showed poor preservation, and both corrosion and degradation deterioration types were represented, though degradation was more common. Partial degradation affected 34% of all grains, and 10% showed some mechanical damage. The biochemical preservation index was 0.92 and the mechanical preservation index was 0.24. The majority of fern spores were in a good state of preservation.

In the upper most sample, at 4.46–4.47m OD preservation had deteriorated somewhat, only 21% of all grains were well preserved with 6 indeterminable

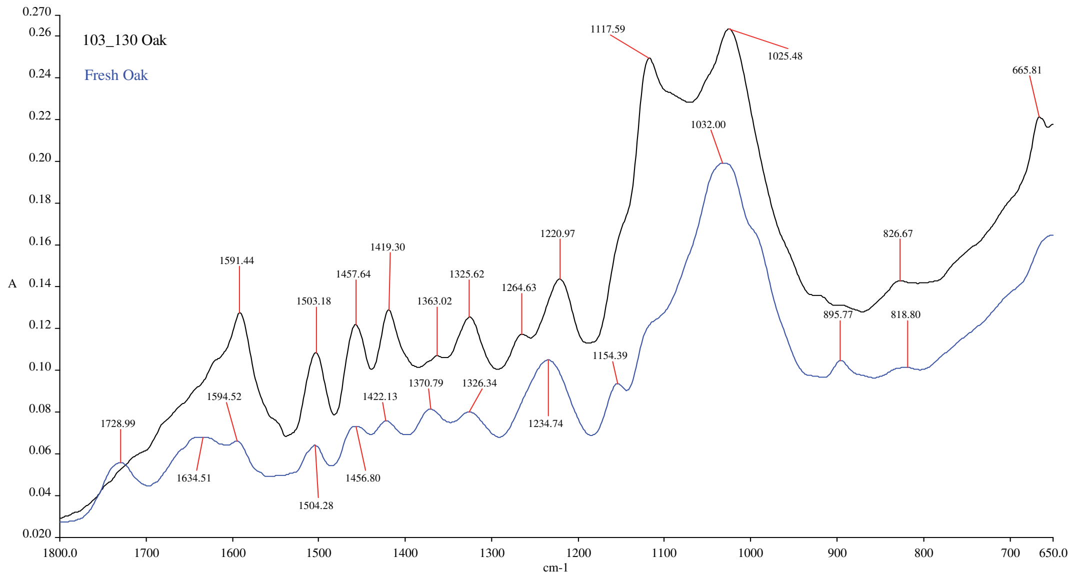


Figure 127. FT-IR spectra of ancient oak (130) – Harter's Hill.

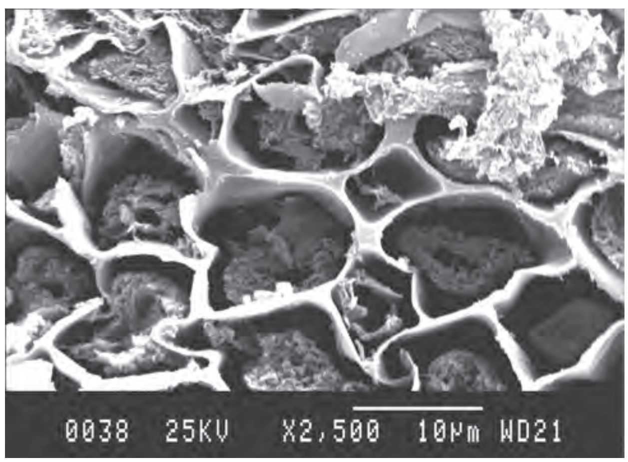


Figure 128. SEM of ancient oak (130). Cells heavily degraded with a porous looking secondary wall layer.

Table 98. Harter's Hill: pollen preservation.

	4.18–19m OD	**4.21–22m OD**	**4.37–38m OD**	**4.46–47m OD**
Total identified pollen grains	100	100	100	100
Pollen concentration	278,220	231,850	309,100	695,550
Number of pollen taxa	11	11	18	16
Total indeterminable grains	24	14	1	6
Total identified extensively corroded grains (a)	14	11	4	4
Total identified extensively degraded grains (b)	41	21	8	23
Total identified extensively crumpled grains (c)	5		2	1
Total identified extensively broken grains (d)	1	3	1	1
Total identified grains with poor preservation (a+b+c+d)	61	35	15	29
Total well-preserved grains	4	11	31	21
Total grains of resistant taxa	1	1	4	4
Total ferns	7	17	25	19
Biochemical preservation index	2.01	1.52	0.92	1.11
Mechanical preservation index	0.68	0.48	0.24	0.24

Table 99. Harter's Hill: stratigraphy.

Stratigraphy	Plant macrofossil/ beetle samples
4.57–4.58m OD Brown, oxidized, very dry, rooty peat.	
4.34–4.57m OD Dark brown peaty clay, very well humified. Some wood fragments. Some modern roots. The clay is possibly a result of slope wash from higher ground.	4.44–4.49m 4.35–4.40m
4.21–4.34m OD Well–humified dark brown peat. Abundant macrofossil remains of wood. Occasional modern roots. Gradual merging boundary	4.21–4.26m
4.08–4.21m OD Organic silty clay	4.16–4.21m

grains, largely due to fragmentation. 29% of identified grains were poorly preserved, the majority being extensively degraded Once again partial degradation was widespread and affected 31% of all grains. 12% of grains showed some mechanical damage, largely breakage. The biochemical preservation index was 1.11 and the mechanical preservation index was 0.24. The limited numbers of fern spores were mainly well preserved.

Overall, pollen preservation at Harter's Hill ranged from poor to moderately good. The samples came from peat that appeared waterlogged, but degradation was quite marked at all levels suggesting biochemical oxidation. The sediments at the base of the sequence, and in the well-humified dark brown peat, contained a very significant inorganic component, mainly clay, but with some silt. The origin of this could be colluvial, as the land rises immediately to the north of the sampling site. Hill wash may have included pollen that was already significantly decayed, along with eroded topsoil. Transport of pollen grains by water could also account for the relatively high levels of mechanical damage to grains, seen particularly in the basal sample. The slight deterioration in preservation in the uppermost sample at 4.46–4.47m OD compared with the sample beneath may be the result of drying out at the site and lowering of the water table, certainly the peat immediately above this was very highly oxidised.

Full analysis could not be recommended from 4.18–4.19m OD, the basal organic silt at this site, on account of the very high number of identified grains with poor preservation and also the relatively high numbers of indeterminable grains (19% of TP + indeterminables). It is very likely that less robust taxa will have been differentially lost from this assemblage. Full analysis would probably be justified for the sample from 4.21–4.22m OD, and would certainly be worthwhile in the upper part of the peat band from 4.37–4.38m OD and 4.46–4.47m OD.

Plant macrofossils

Julie Jones

Three samples were taken from the peat and one from the lower organic silty clay at the base of the trench. The stratigraphy and preservation assessment results are shown in Tables 99–102.

Preservation

4.16–4.21m OD: The bulk of the sample float comprised wood fragments, with buds, scales and occasional hazel (*Corylus avellana*) nut fragments. Only six taxa out of 100 macrofossils were recorded, a further scan of the float estimating *c.* 200 individuals occur in the whole sample, although no further taxa were recorded. The sample is dominated by water-starwort, with small (1 × 0.6mm) crescent-shaped fruits, which can be winged or not depending on species. Over 60% of the fruits were entire with the hairs along the margin clearly visible, a further 27% having lost these, were recorded as <25% fragmented. There were also varying degrees of erosion to the fine cell structure on the dorsal face.

Bramble seeds appear to be very resistant to decay, the surface cell structure rarely altering although fragmentation does occur, of four counted here, 3 were >50% fragmented. Fragmentation of the flat circular fruits of buttercup (*Ranunculus acris/repens/bulbosus*) also commonly occurs (four out of 12 >50% fragmented, although seven complete examples). The surface of the fruits shows a reticulate pattern, the epidermal cells forming pits with clear margins and there are varying degrees of erosion of these cells (Figure 17: Appendix 4).

Preservation index 2.36. Six taxa in 100 counted. Analysis would be possible

4.21 4.26m OD: The bulk of this sample was also wood fragments although preservation was poorer with only eight taxa in 41 macrofossils counted. They were predominantly water-crowfoot, the bulk of which

Table 100. Harter's Hill: Plant macrofossil preservation.

Organic silty clay at base of trench								
		Fragmentation				**Erosion**		
4.16–4.21m OD (37–42cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alnus glutinosa	1	0	1	0	0	1	0	0
Callitriche spp.	51	31	14	5	1	24	15	0
Carex spp.	31	7	1	5	18	10	14	1
Ranunculus acris/repens/bulbosus	12	7	0	1	4	5	3	4
Rubus sect. *Glandulosus*	4	0	1	0	3	0	0	0
Urtica dioica	1	1	0	0	0	0	0	0
Other macrofossils: abundant wood fragments, occasional bud scales, *Corylus avellana* nut fragments, and. caddis fly larvae								
Well humified dark brown peat								
		Fragmentation				**Erosion**		
4.21–4.26m OD (32–37cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Carex paniculata	1	1	0	0	0	1	0	0
Carex spp.	11	2	0	0	9	3	6	0
Moehringia trinervia	1	1	0	0	0	0	0	0
Ranunculus subg. *Batrachium*	18	3	1	10	4	15	0	0
Rubus sect. *Glandulosus*	2	1	0	0	1	0	0	0
Urtica dioica	1	1	0	0	0	1	0	0
Viola odorata	1	1	0	0	0	0	0	0
Viola c.f. *odorata*	5	0	1	0	4	0	0	0
Viola sp.	1	0	0	0	1	0	0	0
Other macrofossils: abundant wood fragments, occasional buds/scales, and caddis fly larvae								
Upper brown peaty clay								
		Fragmentation				**Erosion**		
4.35–4.40m OD (18–23cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alisma spp.	5	0	0	0	5	5	0	0
Apiaceae indet	1	0	0	0	1	0	1	0
Callitriche sp.	1	1	0	0	0	0	0	0
Carex spp.	3	1	0	1	1	1	1	0
Chara sp.	1	1	0	0	0	0	0	0
Eleocharis palustris/uniglumis	1	1	0	0	0	0	0	0
Juncus spp.	20	7	11	1	1	7	10	0
Lycopus europaeus	1	0	0	0	1	0	0	0
Lythrum salicaria	1	1	0	0	0	1	0	0
Mentha spp.	2	1	1	0	0	1	0	0
Oenanthe spp.	2	0	0	1	1	0	2	0
Poaceae indet	1	1	0	0	0	0	0	0
Potamogeton sp.	1	0	0	1	0	1	0	0
Ranunculus acris/repens/bulbosus	1	1	0	0	0	0	1	0
Ranunculus subg. *Batrachium*	33	8	2	13	10	2	1	0
4.44–4.49m OD (9–14cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Rubus sect. *Glandulosus*	5	4	1	0	0	0	0	0
Sparganium erectum	18	7	0	0	11	8	3	1
Viola c.f. *odorata*	3	0	0	1	2	2	0	0
Alisma spp.	10	0	1	0	9	0	4	3
Carex spp.	3	3	0	0	0	0	0	0
Chara sp.	1	1	0	0	0	0	0	0
Cirsium/Carduus spp.	1	0	1	0	0	1	0	0
Eleocharis palustris/uniglumis	2	2	0	0	0	0	0	0
Hydrocotyle vulgaris	2	2	0	0	0	2	0	0
Hypericum sp.	1	1	0	0	0	0	0	0
Juncus spp.	25	7	10	8	0	10	14	0
Mentha spp.	2	1	1	0	0	0	0	0
Potamogeton sp.	2	2	0	0	0	0	0	0
Ranunculus subg. *Batrachium*	35	6	2	14	13	0	0	0
Rubus sect. *Glandulosus*	4	4	0	0	0	0	0	0
Sparganium erectum	12	7	2	0	3	3	4	2
Other macrofossils: abundant wood fragments, occasional caddis fly larvae								

Table 101. Harter's hill: macrofossil summary table.

	4.16–4.21m OD	4.21–4.26m OD	4.35–4.40m OD	4.44–4.49m OD
Total macrofossils counted	100	41	100	100
Estimated total in sample	200	41	500	200
Total taxa	6	8	18	13
Total well preserved	46	10	34	36
Total <25% fragmented	17	2	15	17
Total 25%–50% fragmented	11	10	18	22
Total >50% fragmented	26	19	31	25
Total <25% erosion	40	20	28	16
Total 25%–50% erosion	32	6	19	22
Total >50% erosion	5	0	1	5
Preservation index	**2.36**	**2.73**	**2.17**	**2.11**

Table 102. Harter's Hill: properties of 250g unprocessed samples.

	Dry weight	0.25mm	0.5mm	1mm	2mm	4mm	Organic matter %
4.16–4.21m OD	82.93g	3.6g	3.8g	3.2g	4g	13.8g	35%
4.21–4.26m OD	83.67g	3.7g	3.9g	4.9g	7.1g		23%
4.35–4.40m OD	78.3g	3.7g	4g	3.6g	5.1g		21%
4.44–4.49m OD	95.75g	3.2g	3.3g	3.2g	3.3g		12%

were >25% fragmented. In over 80% of the achenes the transverse ridges were less clearly visible suggesting some surface erosion of the seed. Many of the sedge nutlets were also >50% fragmented and the few possible sweet violet seeds also >50% fragmented. The pointed ovoid seeds of violet species appear to easily split lengthwise although sweet violet is separable by its larger size (*c*. 2.5 × 1.8mm). There seems to be little deterioration of the glossy surface cell structure in any of the fragments recorded

Preservation index 2.73. 8 taxa in 41 counted. Analysis would be possible

4.35–4.40m OD: There was a more extensive assemblage in this sample, which continues to be dominated by wood fragments with *c*. 500 macrofossils estimated to occur in the whole sample. The most commonly occurring taxa are water-crowfoot, with nearly 70% >25 fragmented, branched bur-reed (*Sparganium erectum*) and rush (*Juncus*).

The funnel-shaped fruits of branched bur-reed (Figures 18 and 19: Appendix 4) were either entire or >50% fragmented. They have 6–10 pronounced longitudinal ribs, which distinguish this from other *Sparganium* species and in over 60% of fruits recorded there had been varying degrees of erosion of this spongy exocarp. *Juncus* seeds are difficult to identify to species, although the tiny, often pale yellow seeds, between 0.3 and 0.9mm in size are easily recognisable as a genus. They are flimsy seeds that have a tendency to collapse on drying; only seven out of 20 in this sample were entire, with more than half showing <25% fragmentation. The clarity of the surface patterning, usually of regular quadrate to hexagonal cells varied, with most examples showing degradation.

Preservation index 2.17. 18 taxa in 100 counted. Analysis recommended, despite fragmentary nature of many seeds/fruits

4.44–4.49m OD: The range of taxa (13 in the 100 macrofossils counted) and overall abundance in this uppermost sample was less than in the underlying peat. Wood fragments continue to dominate, although there is no indication of woody taxa from the macrofossils identified. Water-crowfoot, again with many examples of half fruits, rush and branched bur-reed most commonly occurs. Other marsh vegetation are well-preserved, examples of marsh pennywort, water-mint and sedge show little deterioration. Water-plantain (*Alisma*), typical of shallow muddy margins, which grows with other emergent marshy vegetation, appears to be more fragmentary. The flat wedge-shaped fruits are obovate in outline and contain a flimsy darker brown U-shaped embryo still identifiable to *Alisma* sp. (Figure 1: Appendix 4). The majority of the examples found here are just the embryos, the outer fruit casing lost, so they have been determined as >50% fragmented. There is also a variation in the clarity of the cell pattern of these embryos.

Preservation index 2.11. 13 taxa in 100 counted. Analysis recommended.

Table 103. Harter's Hill: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
4.44–4.49	A small flot, mainly plant fibres, seeds and some ?rhizome fragments. Modest numbers of cladoceran ephippia (resting eggs of water fleas). Most of the beetles aquatics, the few non-aquatics being able to live in swamps.	Limited potential: a very large sub-sample (5kg or more) would give useful numbers of remains but many would be very time-consuming to identify. P2
4.35–4.40	Small flot, seeds, yellowish plant detritus, invertebrate fragments. Numerous water fleas (Cladocera), aquatic beetles (*Ochthebius* the most abundant). *Trechus ?micros* (Herbst) perhaps post-depositional invader. Remaining taxa able to live in swampland.	Limited potential: very large sub-sample (5kg or more) would give useful numbers of remains. Many would be very time-consuming to identify. P2
4.21–4.26	Small flot, mostly fragments of immature insects, but some seeds. Aquatic and swamp taxa.	Limited potential: very large sub-sample (5kg or more) would give useful numbers of remains. Time-consuming to identify. P2
4.16–4.21	Small flot, fine plant and invertebrate debris. Restricted beetle and bug fauna: aquatics (*Ochthebius* the most abundant) and swamp taxa. Indications of trees or shrubs (*Rhynchaenus*)	Difficult to work on but larger (3–5kg) sub-sample would probably give useful group. P1B

Table 104. Harter's Hill: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical Erosion				Fragmentation				Colour change				
	range		mode	str	range		mode	str	To	range		mode	str
4.44–4.49	2.0	4.5	2.5 4.0	W W	2.5	5.0	3.5	W	Orange	0	1	1	W
4.35–4.40	2.5	4.5	3.5	W	2.0	3.5	2.5	W	Yellowish	0	3	2	W
4.21–4.26	3.0	4.0	3.5	W	2.5	5.0	3.5	W	Pale via brownish	1	3	2	W
4.16–4.21	2.5	5.0	3.5	W	2.5	5.0	3.0	W	Pale via yellowish brown	2	3	3	W

Recommendations

Preservation was variable in the four samples from Harter's Hill. A small assemblage was recorded from the lowest sample in the organic silty clay at the base of the trench. The high scores that resulted in a preservation index of 2.36 were mostly due to the relatively high degree of both fragmentation and erosion to both the sedges and water-starwort which are likely to make species identification difficult. Fewer macrofossils were present in the overlying well-humified peat and the highest preservation index (2.73) was obtained from this sample. There was fragmentation to both water crowfoot and sweet violet, with deterioration to the transverse ridging of water crowfoot achenes, although this has not affected identification.

In the upper two samples preservation is much better, macrofossil abundance increases and there is greater species diversity. Deterioration appears to be restricted to a few species, again fragmentation of water-crowfoot, with both fragmentation and erosion to water plantain, branched bur-reed and rush. Further analysis would be possible with processing of larger samples, particularly in the two lower samples to increase species diversity.

Coleoptera

Harry Kenward

Four samples were assessed (Tables 103–4). The two highest were from the peaty clay at 4.44–4.49m OD and 4.35–4.40m OD. One sample was taken from the peat (4.21–4.26m OD) and one from the underlying organic silty clay (4.16–4.21m OD). All the deposits contained a proportion of well decayed fossils (worst decay at E 4.0–5.0), with at least some, and sometimes substantial, colour change. Three layers included

Table 105. Harter's Hill: Station 1.

Depth (cm)	Description
0–25	Dark reddish brown (5YR 2/2) moist crumbly loamy peat
25–35	As above but firm and massive
35–45	Black (5YR 2/1) wet amorphous peat (H9)
45–110	Dark reddish brown (5YR 3/2) humose silty clay loam with woody material and some flattened leaves, also some hard rounded woody remains (piles?) at 78–83cm
110–138	Black (5YR 2/1) waterlogged amorphous peat (H9) with woody material.
138–150	Bluish grey (5B 6/1) soft wet clay with occasional woody fragments

Table 106. Harter's Hill: Station 2.

Depth (cm)	Description
0–25	Dark reddish brown (5YR 2/2) moist crumbly loamy peat
25–35	Black (10YR 2/1) very moist amorphous peat (H9)
35–88	Very dark grey (5YR 3/1) very moist humose silty clay loam and woody fragments (paler and darker matrix colours are also evident) with occasional mottles of yellowish red (5YR 4/6) in root channels
88–120	Reddish grey (5YR 5/2) very moist soft silty clay loam
120–150	Bluish grey (5B 6/1) soft wet clay (as above)

Table 107. Harter's Hill: Station 3.

Depth (cm)	Description
0–15	Very dark grey (5YR 3/1) moist crumbly loamy peat
15–30	As above but firm and massive
30–40	Black (5YR 2/1) waterlogged amorphous peat (H9) with small woody fragments.
40–90	Dark reddish brown (5YR 3/2) wet humose silty clay loam with occasional small woody fragments. Horizon has local variations in colour, density and moisture
90–128	Reddish brown (5YR 4/3) silty clay loam with occasional leaves
128+	Bluish grey (5B 6/1) soft wet clay (as above)

some very fragmented remains (worst fossils at F 5.0). The lower three sampled deposits showed modes for erosion at 3.5, moderately good preservation. The upper deposit contained an insect assemblage with bimodal values for erosion (E 2.5 and 4.0). This was a very well humified peaty clay with some modern roots, and it seems possible that the more decayed fossils were located within the sphere of influence (dehydration, microfloral activity) of the roots.

Monitoring of burial environment

David Hogan

Site description

Transect: From 5m north of ditch bifurcation, westwards across the field towards a gate on the opposite side of the field with Stations 1–3 at 5m, 20m and 40m.

Land-use: Recently ploughed and reseeded pasture with patches of rush. Site recently flooded. Molehills were observed within about 5m of the field boundary.

Station 1 (Table 105): Instrumentation: piezometers at 50cm, 100cm and 150cm depth. Water table standing at 35cm depth in auger hole.

Station 2 (Table 106): Instrumentation: piezometers at 50cm, 100cm and 150cm depth. Water table standing at 26cm depth in auger hole.

Station 3 (Table 107): Instrumentation: piezometers at 50cm, 100cm and 150cm, and redox probes at 40cm, 65cm and 90cm depth. Water table standing at 25cm depth in auger hole.

Results

Archaeological remains occur at about 40–60cm depth below the ground surface. The water table records from the three monitoring stations (Figures 129, 131 and 132) indicate a seasonal pattern of fluctuation between about 50cm and 80cm depth. At Station 3 (Figure 129) close to the excavation, the water table lay at about the top of the remains in early spring and returned to closer to the surface the following winter. During spring the level fell lower than the base of the timbers and remained just below them during the summer and autumn. Redox potential (Figure 130) indicates *oxidised* conditions above the level of the remains (40cm) with *slightly reduced* conditions maintained in the zone of the base (65cm). *Highly reduced* values were confined to permanently waterlogged material (90cm) unaffected by seasonal draw-down of the water table. Groundwater taken from piezometers beside the structure had a pH of 6.5, while a pH of 6.6 was recorded from water from the ditch on the eastern side of the field.

Conclusions

Under present environmental conditions it appears likely that continued degradation of the archaeology is likely to take place. Waterlogging of the remains was confined to the winter period and the water table fell rapidly in the spring to expose the remains during

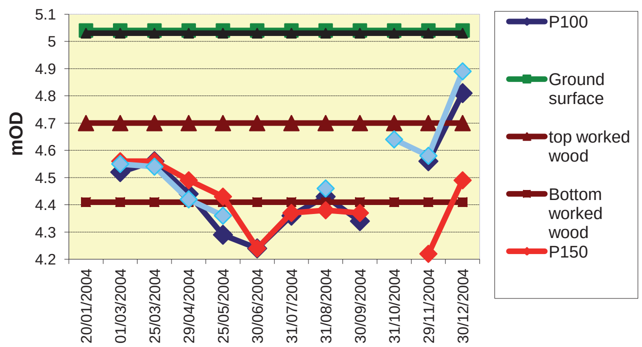


Figure 129. Water table at Station 3.

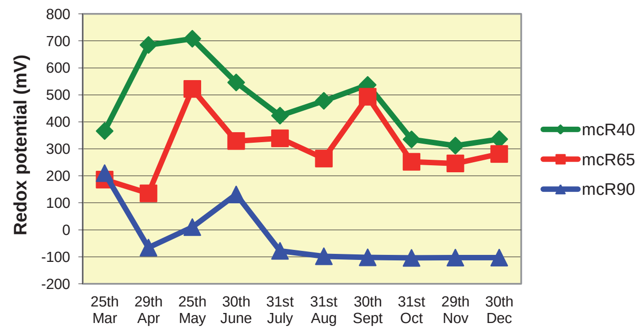


Figure 130. Redox potential at Station 3.

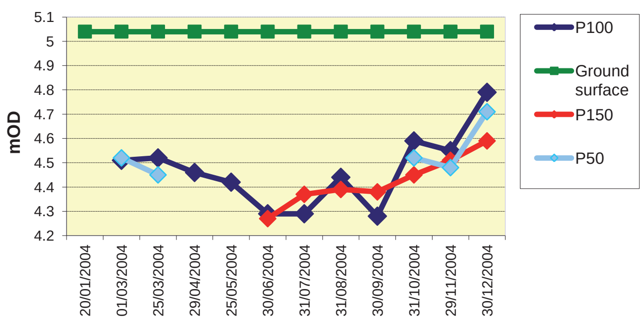


Figure 131. Water table at Station 1.

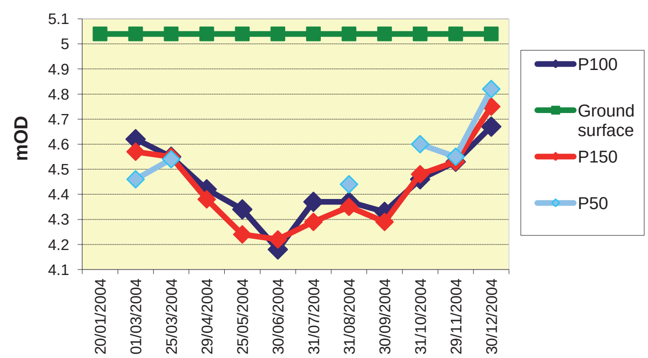


Figure 132. Water table at Station 2.

the summer and autumn. Redox potential indicated only *slightly reduced* conditions around the timbers for most of the year with possible brief episodes of oxidation. *Highly reduced* conditions were confined to greater depth.

Preservation conclusion

The preservation assessment and hydrological monitoring has shown that the archaeological remains are in a very vulnerable condition and are suffering from seasonal drawdown of the local water table every summer. The threat is greatest to the alignment as it approaches its northern boundary with the dryland because the wooden remains are increasingly close to the surface and above the summer water table. As the remains increase significantly in their depth below ground at the southern edge of the field it is likely that any southern continuation would be in better preservation conditions.

5. Lake Villages

Richard Brunning

10. Meare Lake Villages fieldwork

Somerset HER 24277 and 23784: SM349

Previous fieldwork

The Meare Lake Villages were discovered in 1895 when a farmer, Mr Laver, found some pottery, a spindle whorl and a whetstone while digging post holes for a haystack. These were sent to Arthur Bulleid, then excavating Glastonbury Lake Village, and he visited the site and discovered two groups of mounds just to the north of Meare island, extending for about 450m with a 60m gap in between them.

Bulleid undertook a trial excavation in 1908 and from 1909–1914 and 1919–1932 Bulleid and Harold St George Gray excavated about 70% of the western site (Figure 133). From 1932 to 1938 they also excavated part of the eastern site, with Gray directing alone between 1945 and 1956. Roughly 40% of the eastern site was excavated over these periods. The results of the excavations at Meare West were published in three volumes (Bulleid and Gray 1948; Gray and Bulleid 1953; Gray 1966). Both Gray and Bulleid died before the Meare East excavations could be written up and they were only published in one monograph in 1987 (Coles 1987).

In 1966–68 Michael Avery excavated three mounds in Meare East but only an interim account has ever been published (Avery 1968). Avery also excavated numerous long trenches across Meare West in 1968–9 encountering woodwork previously exposed by Bulleid and Gray during their excavations and also exploring previously unexcavated areas. No publication has ever been produced of this work although Professor Avery is apparently still in the process of writing up.

In 1978 the Somerset Levels Project excavated four small evaluation trenches at the eastern end of Meare West, exposing floors and hearths and dumps of wood in a wetter area (Orme *et al.* 1979). In 1979 the Somerset Levels Project carried out a contour survey of the western end of the settlement site and a small excavation (Figure 134) was carried out on one mound (Orme *et al.* 1981).

The Somerset Levels Project excavated part of the Meare East settlement in 1982, covering most of one mound (Orme *et al.* 1983). In 1984 the final SLP excavation at Meare consisted of a small block at the eastern end of Meare West and a trench extending from there across to the western end of Meare East (Coles *et al.* 1986).

A ground-penetrating radar survey by the Centre for Wetland Archaeology at the University of Hull in June 1998 identified earthworks thought to be habitation mounds beyond the eastern edge of the settlement. Coring undertaken by Exeter University in October 1998 suggested that these, in fact, were caused by ditch clearance and the presence of a bank of medieval or later date (details in Somerset HER file 24277).

The settlements at Meare were located on the drying mounds of a raised bog, roughly 100m north of Meare Island. The two settlements are about 70m apart but no causeway or trackway appears to cross the reedswamp that separated them (Coles *et al.* 1986). To the north of the settlements existed a diverse marsh with reeds and patches of open water (Godwin 1941; Coles 1987).

The character of the occupation was slightly different at the two sites. At Meare West extensive spreads of timber, hurdles and brushwood, with occasional square structures formed of oak planks, were placed directly upon the bog surface. These were superimposed by circular and oval clay spreads, 10–13m across, that sometimes had central hearths. Meare East generally lacked the lower wooden deposits, with the clay placed directly upon the bog surface or on a ‘black earth’ occupation deposit. On both sites there were short lines

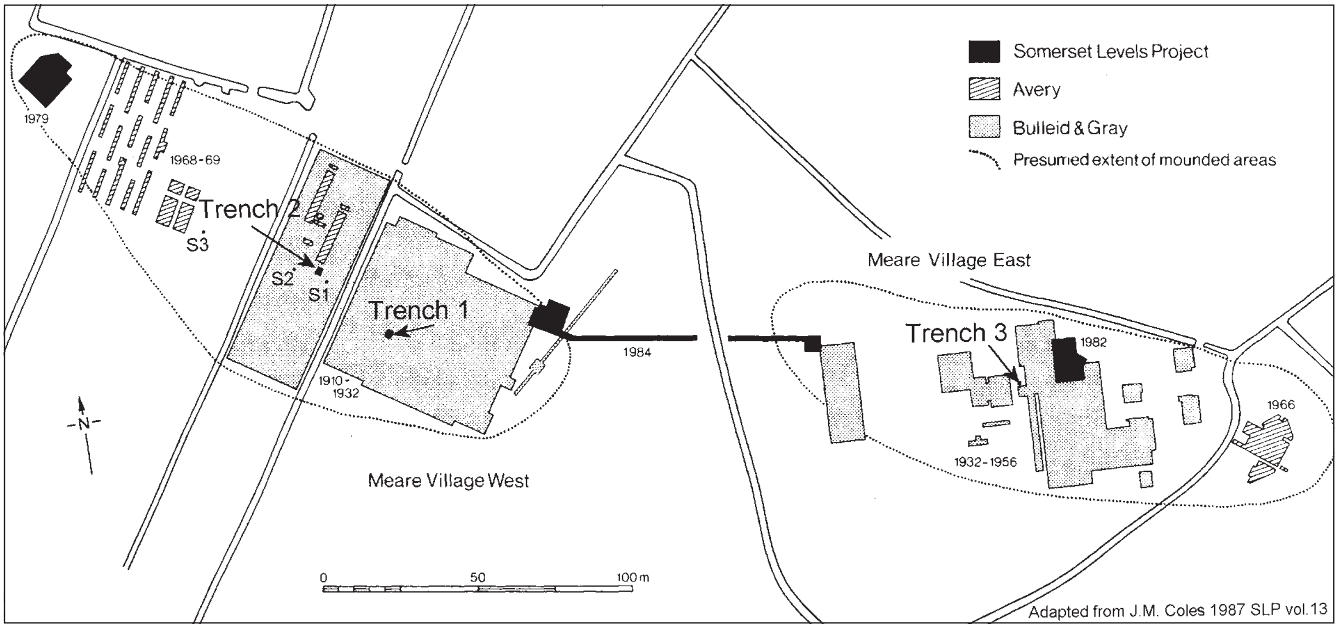


Figure 133. Location plan of Meare Lake Village excavations (after Coles 1987).

Figure 134. Excavations at Meare West by the Somerset Levels Project in 1979.

of stakes that may have formed wind breaks, animal pens or fences. Despite the presence of numerous hearths (at least 150 at Meare East), the remains of possible roundhouses were only located on five mounds at Meare West and one at Meare East.

The scarcity of houses and the evidence for seasonal flooding of the site during its occupation suggest that neither site was a location of permanent settlement. In addition to a large quantity of pottery the Meare occupation areas yielded evidence of spinning and weaving, manufacture of bone, antler and shale artefacts, bronze- and iron-working and the specialised

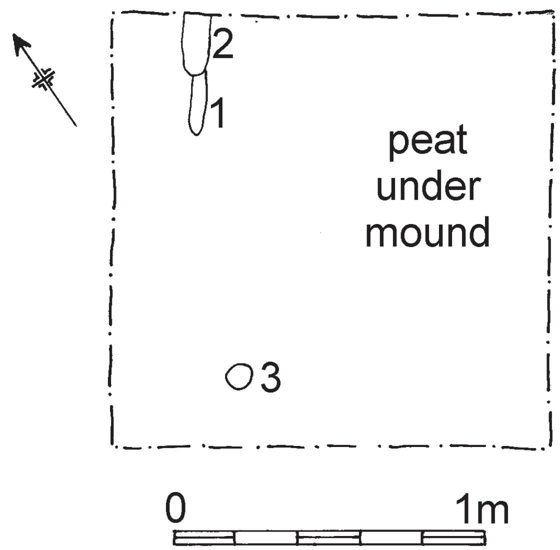


Figure 135. Trench 1 plan, Meare Lake Village West.

production of glass beads that have been found as far away as Cornwall and Scotland. This wealth of production evidence has been used to suggest that the sites operated as seasonal market places, possibly located in neutral territory between the Durotriges and Dobunni tribes (e.g. Coles and Minnitt 1996).

The date of the occupation at the Meare sites has been estimated at 300 BC to 50 BC on the basis of artefact typologies. However, a concentration of 11 coins, possibly from a purse, was probably lost between AD 360 and 380.

A little over half of Meare East remains unexcavated and roughly 27% of Meare West. The extent of the cultural material outside of the mounded area is uncertain. Although the small SLP trench connecting the two sites did not encounter a large amount of cultural material it is probable that midden deposits may exist outside the mounded area, possibly in specific locations around the perimeter.

Photographic evidence from Bulleid and Gray's excavations shows wooden remains in the foundations of the mounds that display obvious signs of desiccation. As only small areas were exposed at any one time it seems likely that this degradation of the organic material had occurred before the excavations, presumably because the deposits had been above the local water table during the summer months for many years. This is supported by the following description of the wall posts from mound 24 at Meare West:

> Many of the alder posts were so much decayed at the upper part that only a round hole remained in the hard peat of the foundation … Sometimes on removing the soft earth filling from the upper part of the hole the pointed end of the post was discovered. Sometimes the hole was lined with the bark that surrounded the wall post (Gray and Bulleid 1953, 156).

Bulleid and Gray noted that in general the condition of the wood was poor (Coles 1987, 237) and the Somerset Levels excavations showed that the condition of the wooden remains was worst on the eastern site (*ibid.*, 238). The 1982 excavations at Meare East found vertical oak stakes in fair condition but the horizontal wood 'too degraded to comment on either structure or function' (Orme *et al.* 1983, 70). At the western end of Meare West the wood in the floor was 'in a poor state of preservation' and a deep pool or gully provided 'the only area on site with even moderately well-preserved wood' (Orme *et al.* 1981, 22 and 19).

MARISP excavation results

Three evaluation trenches were opened, two in Meare West and one in Meare East (Figure 133). Trenches 1 and 2 were located towards the eastern end of Meare West (ST444422), in areas that had been excavated by Bulleid and Gray and had produced significant amounts of wooden remains that may have been left *in situ.*

Trench 1 was 0.7m by 0.7m in size. A pale brown clay with red mottling and patches of grey clay (context 1), represented the backfill from the previous excavations. This extended for up to 1.05m below the ground surface and had a sharp contact with the irregular surface of a black very well humified peat (context 2). On the top of the peat were two pieces of alder roundwood (1 and 2), 75mm long and 40mm in diameter, both of which were in an extremely poor state of preservation (Figure 135). A small stake (3) penetrated the peat to a depth of 420mm and was 56mm wide and 40mm thick (Figure 136). It was entirely oak heartwood (c. 18 rings) that was an intermediate split from a larger timber. The top 29mm of the stake was in a very poor state of preservation, showing obvious signs of desiccation and associated shrinkage. The cut end had severely buckled in antiquity, suggesting that it had been driven in while still green.

Trench 2 was 1.8m square. A pale brown clay (context 3), 0.83m deep, represented Bulleid and Gray's excavation backfill. This contained orange mottles, patches of grey clay and occasional angular stones. Some small fragments of charcoal, pottery, bone and flint were present in the backfill.

An excavation trench (cut 6) opened by Avery (Figures 137 and 138), just clipped the edge of the trench on the western side. Its fill was very similar to Bulleid and Gray's backfill and was only clearly identified in the section and where it cut the underlying peat. It differed slightly from the earlier backfill only in the

Figure 136. Wooden stake (3) showing buckled tip.

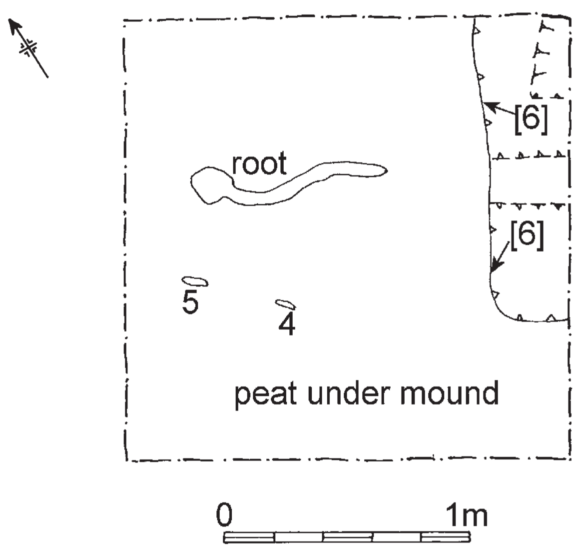


Figure 137. Trench 2 plan, Meare Lake Village West.

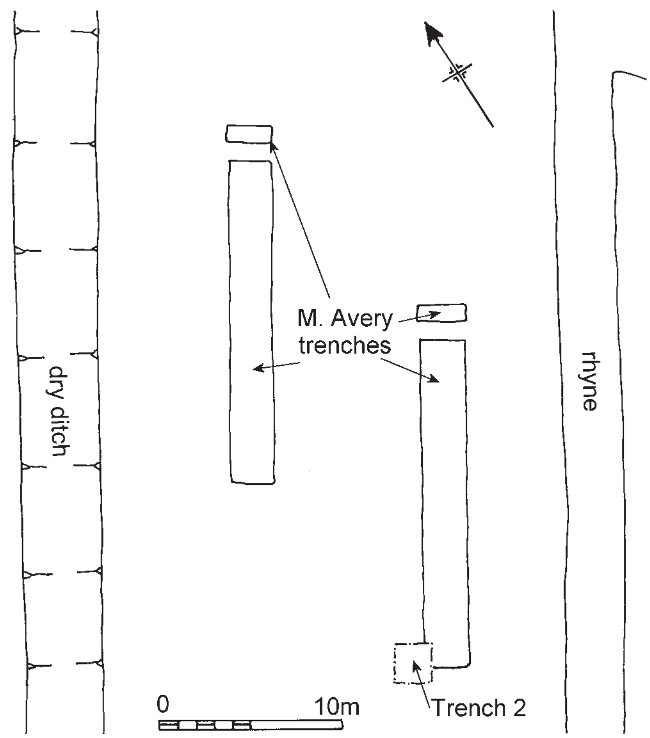


Figure 138. Plan of trench 2 and Avery trenches.

greater proportion of grey clay patches and charcoal fragments. Avery's backfill contained pottery fragments and a stone rotary quern fragment in its backfill (context 5). These artefacts may have been left behind because they were unstratified finds derived from Bulleid and Gray's earlier backfill. Even if the rotary quern fragment was not from a secure context it seems strange that such a significant object was not retained. A more likely explanation may be that it was overlooked as an oddly shaped piece of stone. A rapid surface survey allowed four of Avery's trenches to located from surface depressions (Figure 138). These positions varied slightly from his published accounts (Avery 1968). The base of both backfills was a sharp boundary with a highly humified black peat (context 4). Avery's trench cut into the peat to a depth of between 0.05m to 0.20m. Two woodchips were present on the top of the peat in addition to a small stump and associated root. One woodchip (4) was a radial alder fragment, 66mm long, 28mm wide and 13mm thick and the other (5) was a similar alder fragment, 80mm by 35mm by 16mm in size. Both were extremely compressed and in a poor state of preservation.

Trench 3 was on Meare East (ST446421) at the edge of a previously unexcavated area and was 1.2m square with a 1m by 0.5m extension on its east side (Figure 139). The basal deposit was a black well humified peat (17) that became increasing wet and poorly humified with depth. The top of the peat undulated slightly but was generally at 3.18–3.20m OD (Figure 140). Desiccation

Figure 139. Trench 3 Meare Lake Village East, looking south. Scales 1m.

cracks in the peat were noted extending as low as 1.45m below the ground surface and the remains of numerous mole burrows were present. The top of the peat varied between 0.9m and 1.1m below the ground surface. On the top of the peat were three highly decayed fragments of wood (nos 6–8) that may once have been woodchips (Figure 141). The largest (no. 7) was 125mm by 24mm by 12mm and the smallest (no. 8) 45mm by 20mm by 4mm. Neither of these could be identified to species because they were so decayed but the other fragment (no. 6) was a piece of hazel or alder 46mm long by 20mm wide by 15mm thick.

On top of the peat were numerous superimposed layers of clay that generally dipped towards the north. The lowest (15) was a light grey clay that tapered from a depth of 0.2m to nothing on its northern side, where it was bordered by a line of vertically set lias stones. The stones appear to have been laid first, as some sat directly upon the peat under the clay (15). The base of this clay was very mottled with black patches, probably representing a slight mixing of the peat and clay when this initial layer was being created. Above this was another light grey clay (14) of similar depth, which contained angular lias stones, comprising *c.* 70% of the context. This only existed in the southern half of the trench, tapering out to the north. Above this was an orange grey clay (13) tapering to the north from a depth of *c.* 0.3m to nothing. These stone and clay deposits probably represent the creation and enhancement of an artificial mound on the bog surface in this part of the site.

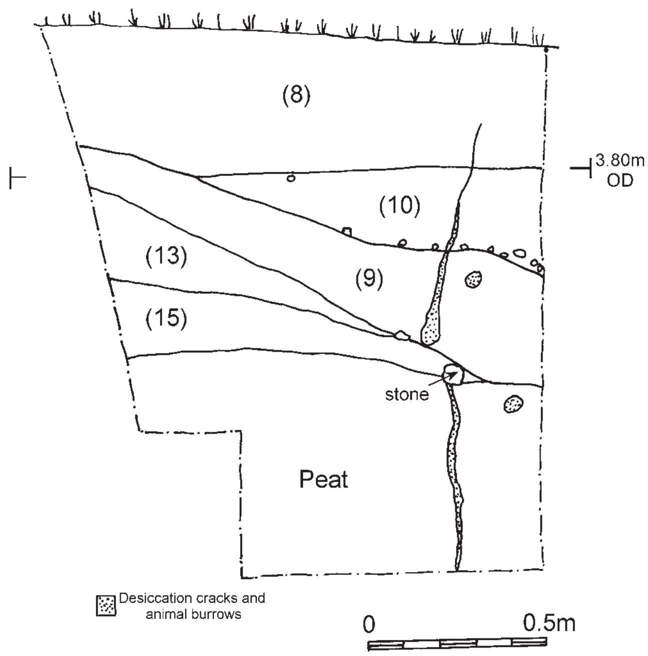


Figure 140. Trench 3 section, north face of trench. Meare Lake Village East.

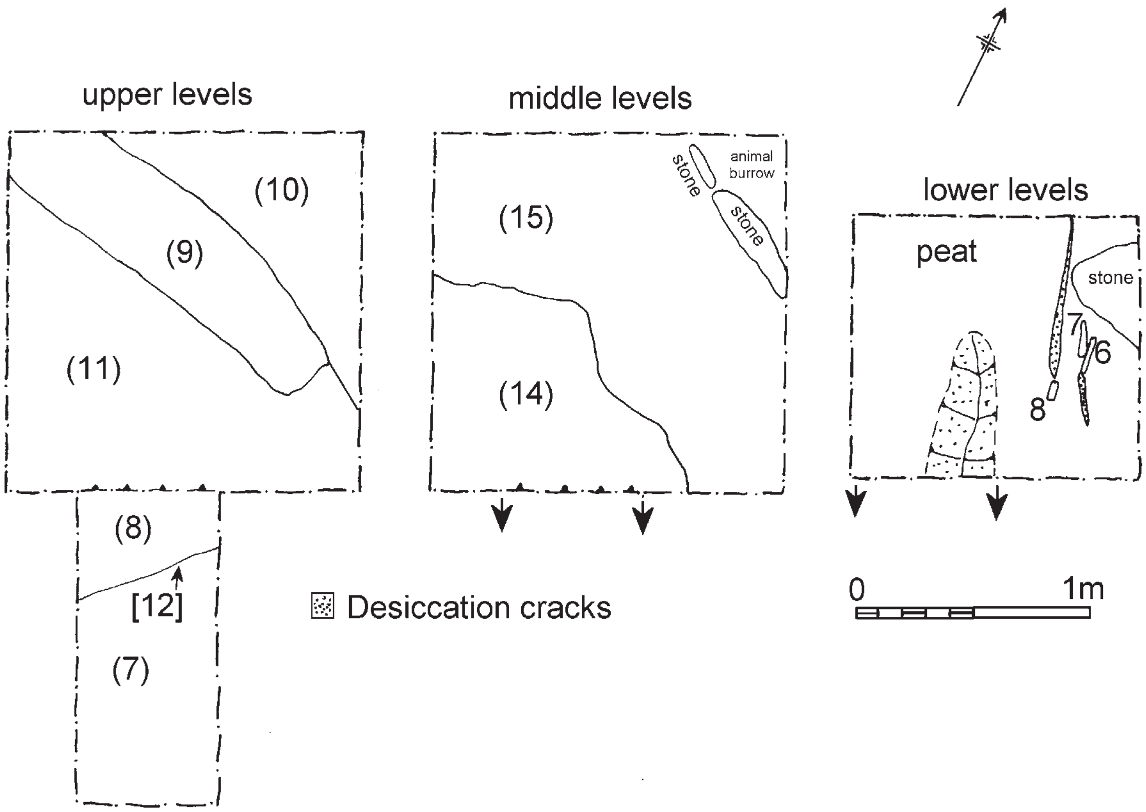


Figure 141. Trench 3 plans, Meare Lake Village East.

Across the northern half of the trench was a dark grey clay (9) with occasional charcoal flecks and pieces of redeposited peat, between 0.1m and 0.4m thick. A single very desiccated woodchip was present towards the top of this deposit. This layer appears to have provided a more level surface across the northern part of the trench and may represent an extension of the mound surface to the north. Numerous small stones were present at the top of the layer, possibly representing an attempt to create a less slippery mound surface.

A deposit of light grey clay (10 and 11) covered most of layer 9 and the previous layer (13) to a depth of up to *c.* 0.2m, creating a fairly level surface across the trench at *c.* 3.77–3.82m OD. No charcoal flecks or stones were present in this deposit and it is possible that it represents naturally deposited material rather than another anthropogenic levelling up episode on the mound. An orange brown clay up to 0.4m thick covered all the previous layers, with a thin topsoil layer at the top. The ground surface was at *c.* 4.26m OD by the south-west corner of the trench but dipped slightly to the north, mirroring the slope of the underlying mound.

An area previously excavated by Bulleid and Gray was contained in the southern extension, consisting of backfill layers of clay and medium to large stones (7) to a depth of 1.23m. The edge of their excavation (cut 12) ran diagonally across the trench east to west. The backfilled trench was left largely unexcavated.

Wood species identification

Rowena Gale

Six samples were examined for species identification. Wood number 2 from Trench 1 was identified as alder (*Alnus glutinosa*). Trench 2 produced two samples, one of which (5) was alder and the other (4) either alder or hazel (*Corylus avellana*). Trench 3 produced three samples of which two (7 and 8) were too degraded to identify. The other sample (6) was either alder or hazel.

Other finds

Keith Faxon

The only significant artefact recovered from any of the trenches was a fragment of rotary quern from Trench 2 (Figure 142). This was derived from the backfill of one of Michael Avery's excavations. The finds are summarised in Table 108.

Figure 142. quern fragment, broken across the exit gulley (left). To one side of that a 1cm wide notch on the side of the quern may have been used to help stabilise it.

Fieldwork conclusion

The limited nature of the excavations at Meare means that little has been added to our already extensive knowledge of the site. The position of the Avery trenches in Meare West has been clarified and the excavation of a very small part of one of his backfilled trenches suggests that some artefactual material was left on site, including some significant artefacts such as the rotary quern fragment. Perhaps that artefact was never examined closely and was just thought to be a stone. The trench through an area of Bulleid and Grays backfill suggested that they had a more rigorous approach to the collection of finds.

Although the surviving wood was in an extremely poor state of decay it is possible that vertical oak timbers might be better preserved. Such timbers are known to exist in various parts of the site. If they are still extant they could potentially help to resolve the dating for the site by dendrochronological analysis.

Meare Lake Villages assessment and monitoring

Assessment of preservation

Visual assessment of wood

The small fragments of wood and the single small stake (3) were all very badly preserved and showed

Table 108. Finds from Meare Lake Village.

Trench	Context	Ceramics	Lithics	Animal bone	Iron object	Other
1	1	2 Iron Age sherds	1 small pebble, possible sling stone?	5 bones and teeth		
	2	1 Iron Age sherd				
2	3	14 Iron Age sherds, 3 rims and 1 base	1 Sandstone rubber/polisher? fragment	72 bones and teeth		
			Fragment of a flint core?			
	5	2 Iron Age sherds	Inferior oolite Rotary Quern fragment			
3	7		2 lias frags.	3 bone	Knife blade fragment with bronze mount and rivet	1 modern glass
	8	6 Iron Age sherds, 1 rim	1 small Lias lump	19 bone		3 charcoal lumps
						1 oyster shell fragment
	9	4 Iron Age Sherds	1 Lias fragment	7 bones and teeth, 1 burnt bone		1 slag? lump
	11	1 Iron Age sherd		5 bone, 1 burnt bone		1 oyster shell fragment
	16					2 slag/natural? lumps

Table 109. Meare Lake Village West: moisture content values and state of degradation

Timber no.	% Moisture content	Timber condition
2	485	Heavily degraded
3	452	Heavily degraded

Table 110. Meare Lake Village West: wood species, % moisture content (MC) and density values

Timber no.	Wood species	% MC	Original density	Present Density
2	Alder	485	0.48	0.18
3	Oak	452	0.67	0.18

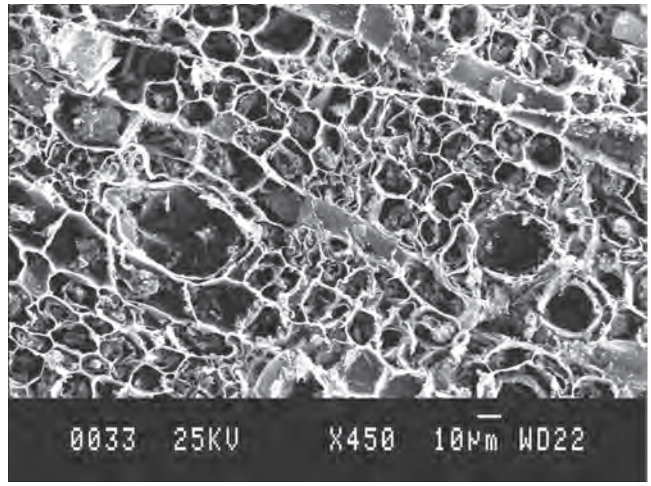


Figure 143. SEM of ancient oak sample 3, from trench 1.

extreme signs of desiccation in the form of shrinkage and cracking. Surface condition was very poor and only slightly better at the bottom end of the stake. As the wooden remains were all recovered from areas that had previously been excavated by Bulleid and Gray it is uncertain how far their poor condition may be ascribed to exposure and desiccation during those excavations.

Detailed examination of wood structure

Mark Jones

The moisture content determined for timbers 2 and 3 are listed in Tables 109 and 110. These values are averages of three samples from each timber sample. Both timbers are classified as highly degraded.

Table 110 lists the original and present density values for each sample examined. Both alder (2) and oak (3) samples have recorded density values, which are less than the original. This indicates a substantial loss of original cell wall material. The oak sample is slightly more degraded than the alder sample (based on the difference between original and present density values).

The cellular organisation of both alder and oak samples when examined by scanning electron microscopy were highly deteriorated. Throughout the timber samples, the greater part of the cell wall material (especially the S_2 layer) was degraded. Examination at high magnification of sample 3 (Figure 143) does suggest ancient attack by erosion bacteria. Similar patterns of attack were observed for sample 2 (ancient alder). A characteristic feature of this form of attack is the non-homogenous distribution of decay. Highly degraded wood cells are found amongst medium degrade ones. Although fungal hyphae were present their degradation effects were not apparent. Figure 143 is a transverse section of ancient oak (sample 3) and although highly degraded, the anatomical features are still very evident (ring porous, fibres, rays and vessels identifiable). On closer examination, the fibres have lost most of their secondary wall layer. The middle lamella is not degraded and in some fibre cells the S_3 is still present.

Chemical changes that follow attack by wood degrading bacteria indicate that the carbohydrates (hemicellulose and cellulose) are degraded preferentially and this degradation results in the accumulation of lignin.

FT-IR spectra (Figures 144 and 145) confirm bacterial attack is restricted to both hemicellulose and cellulose. The lignin peaks are still prominent in both ancient alder and oak. The peak at 1730 cm^{-1} has been lost, suggesting loss of hemicellulose content. Other changes include the decreased absorptions at 897 and 1370 cm^{-1}. These are taken as indicators of decreases in cellulose crystallinity and content. The condition of the wood at Meare Lake Village suggests that irreversible collapse would occur upon drying.

Pollen evidence

Heather Tinsley

The three samples examined extended over some 0.4m of peat, sealed under the grey clay mound, which formed the settlement site of the lake village. The excavation trench revealed a layer of alluvium over the mound, reaching up to the ground surface. The lowest peat sample examined, from 2.86–2.87m OD came from wet, moderately humified peat containing *Phragmites* remains. The upper 2 samples, from 3.01–3.02m OD and 3.17–3.18m OD, came from very well humified peat, which was cracked and desiccated to 3.03m OD (0.18m below the clay).

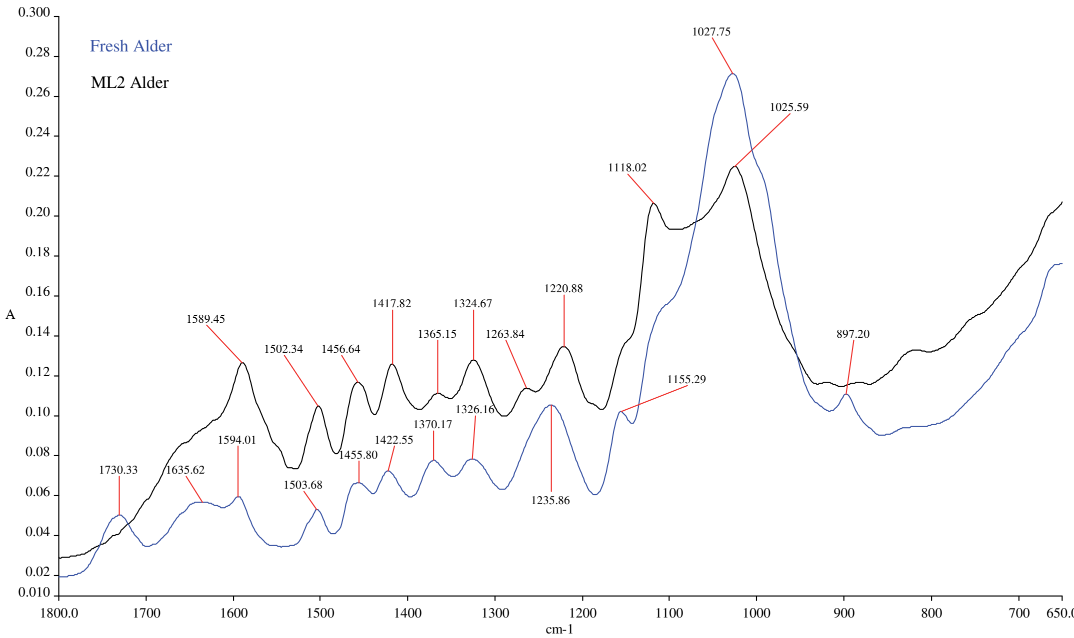


Figure 144. FT-IR spectra of Meare Lake Village West timber sample 2 (alder) and modern alder.

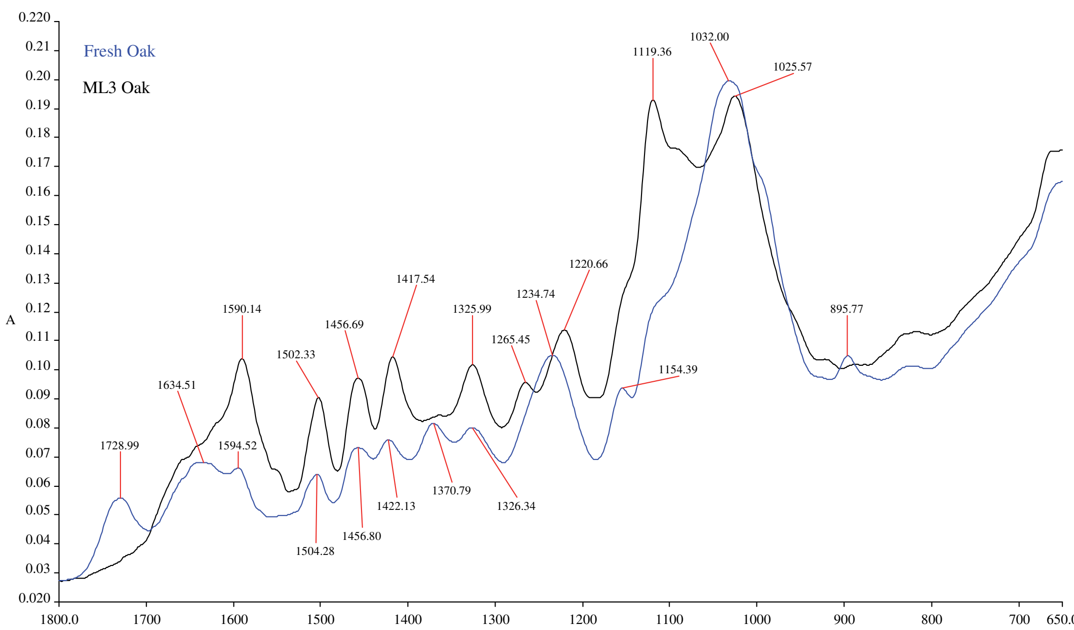


Figure 145. FT-IR spectra of Meare Lake Village West timber sample 3 (oak) and modern oak.

Palaeoenvironmental assessment

2.86–2.87m OD. Tree pollen: 35% TP, principally *Quercus*, *Corylus*-type, and *Alnus* with three grains of *Fraxinus*. Herbaceous pollen 65% TP, almost entirely Poaceae with single grains of *Typha latifolia* and Chenopodiaceae (goosefoot family).

3.01–3.02m OD. Tree pollen: 44% TP, 25% TP *Corylus*-type, with a few grains each of *Quercus, Ulmus, Alnus*, and *Betula* and single grains of *Fraxinus* and *Hedera*. Herbaceous pollen: 56%, dominated by *Sparganium emersum*-type, Poaceae, and *Calluna vulgaris*, with 2 grains of *Vaccinium*-type and single grains of the aquatics

Typha latifolia and *Myriophyllum verticillatum*. Single grains of the herbs *Plantago lanceolata*, Chenopodiaceae and Apiaceae (carrot family). 76 fern spores (largely undifferentiated) and 2 spores of S*phagnum.*

3.17–3.18m OD. Tree pollen: 35%, dominated by *Corylus*-type (22%TP) with a few grains of *Quercus, Betula* and *Alnus* and a single *Fraxinus*. Herbaceous pollen: 65% TP, Poaceae 24%TP, *Calluna vulgaris* 26% TP, with a few grains of Cyperaceae. Occasional grains of taxa associated with human activity, e.g. Brassicaceae (cabbage family), Lactuceae, *Solidago virgaurea*-type and a single grain of Cereal-type pollen. 6 undifferentiated fern spores.

At 2.86m OD the vegetation at this site appears to have been dominated by grasses, and the stratigraphic evidence suggests reed swamp. There was some mixed deciduous woodland in the wider area, on drier ground. By the time the peat at 3.01m OD was forming, the nature of the swamp appears to have changed with increasing bur-reeds or lesser bulrush. The presence of heather pollen and occasional bog moss spores suggests raised bog communities in the vicinity and pollen of ribwort plantain and goosefoot family may be associated with anthropogenic activity in the area. The site appears to have become drier prior to the establishment of the settlement; heather dominated raised bog communities expanded and anthropogenic influence on the surrounding vegetation intensified. Frequent microscopic charcoal particles are evidence of burning in the area, either from domestic fires or from vegetation management. This overall pattern of environmental change is in agreement with the sequence described by Caseldine (1986), which is based on full pollen analysis at a number of locations around the Meare villages.

Pollen preservation

At 2.86–2.87m OD 85% of grains were well preserved. There was only one indeterminable grain, and this was a fragment. 1% of identified grains were poorly preserved (one extensively degraded Chenopodiaceae). Two *Alnus* grains showed some corrosion, and one showed some thinning of the exine. Six Poaceae grains showed some exine thinning. The biochemical preservation index was 0.14 and the mechanical preservation index was 0.08, the lowest found in any of the MARISP samples, indicating extremely good preservation (Table 111).

At 3.01–3.02m OD preservation was significantly poorer, though still good. 50% of grains were well preserved and four indeterminable grains were noted. In all, 14% of identified grains were poorly preserved, 4% showed extensive corrosion and 10% showed extensive degradation, sometimes in combination with corrosion or crumpling. Partial degradation was frequent, particularly in *Sparganium emersum*-type (the dominant herbaceous taxon), with over half the grains recorded showing some thinning of the exine. The biochemical preservation deterioration index was 0.62 and the mechanical preservation index was 0.27. 25% of the undifferentiated fern spores showed etching of the surface.

In the uppermost sample pollen preservation had deteriorated further, only 30% of grains were well preserved. Seven, largely fragmented, indeterminable grains were noted. 30% of identified grains were poorly preserved, 15% were extensively corroded, 11% were extensively degraded and 4% were extensively broken. Corrosion was particularly frequent in *Corylus*-type; the other main taxa, Poaceae and *Calluna,* exhibited a range of deterioration types often in combination. The biochemical preservation index was 1.01 and the mechanical preservation index was 0.48. Only six fern spores were recorded, but all of these exhibited etched surfaces.

The pattern of pollen deterioration in these three samples from Meare Village East is in accordance with the observed desiccation of the peat immediately beneath the clay mound of the settlement site. It seems likely that drying out of the peat surface had occurred prior to its burial by clay, associated with the spread of heather dominated communities. This would have allowed the extension of settlement onto a site where previously the water table had been high (the presence of pollen of whorled water-milfoil at 3.01–3.02m OD indicates pools of water in the vicinity). It is possible that the desiccation cracks, which were observed in the upper peat, had allowed some pollen from the surface to be transported to lower levels, for example the anomalous, poorly preserved Chenopodiaceae at 2.86–2.87m OD. The high levels of corrosion, particularly of *Corylus*-type grains, observed in the uppermost sample (3.17–3.18m OD) suggest active fungal or bacterial activity, which would have been inhibited if the water table had remained high.

All three samples from Meare Village East have potential for full pollen analysis. Despite the observed deterioration of pollen in the uppermost sample, this has not yet proceeded to the stage where the integrity of the results is likely to be compromised. There is no evidence of the differential accumulation of resistant types and numbers of indeterminate grains are low. It is possible that the deposition of clay and later burial by the overlying alluvium retarded the processes of pollen deterioration, which probably began prior to the settlement period.

Plant macrofossils

Julie Jones

Three samples were taken from the base of the mound into the raised bog and from the underlying reed peat (Table 112).

Table 111. Meare Village East: pollen preservation.

	2.86–2.87m OD	3.01–3.02m OD	3.17–3.18m OD
Total identified pollen grains	100	100	100
Pollen concentration	2,782,200	1,319,100	231,900
Number of pollen taxa	7	17	16
Total indeterminable grains	1	4	7
Total identified extensively corroded grains (a)	0	4	15
Total identified extensively degraded grains (b)	1	10	11
Total identified extensively crumpled grains (c)	0	0	0
Total identified extensively broken grains (d)	0	0	4
Total identified grains with poor preservation (a+b+c+d)	1	14	30
Total well-preserved grains	85	50	30
Total grains of resistant taxa	1	1	4
Total ferns	0	76	6
Biochemical preservation index	0.14	0.62	1.01
Mechanical preservation index	0.08	0.27	0.48

Table 112. Meare Lake Village: stratigraphy and samples.

Stratigraphy	Plant macrofossil/ beetle samples
3.21–3.26m OD Grey clay (base of mound)	
2.96–3.21m OD Very well humified peat with wood remains (surface of raised bog on which mound was built). Desiccated wood at 3.08–3.13m OD.	3.15–3.20m
Evidence of desiccation cracks with clay washed in to 3.03m OD. Some fine white modern rootlets	2.99–3.04m
2.42–2.96m OD Moderately humified reed peat, becoming increasingly wet with depth	2.84–2.89m

Palaeoenvironment

The peat at the base of the trench is dominated by stem and root fragments of common reed (*Phragmites communis*), with occasional bulrush suggesting a reed swamp environment. Sedges are also particularly abundant, although only greater tussock-sedge was identified to species, with other marsh taxa including ragged robin (*Lychnis-flos-cuculi*) and marsh pennywort. Preservation was poorer in the drier upper peat although evidence of *Sphagnum*, other moss, heather and cotton-grass suggest a raised bog environment (Tables 113–5).

Preservation

2.84–2.89m OD: Sedges dominate the lowest sample from the reed peat with only six other taxa recorded and make up 79 out of the 100 fruits counted. These are both biconvex and trigonous, whole or only slightly fragmented individuals and are likely to represent only a few species, but at this stage have not been identified further. An example of one species, with an elliptic outline to the achene, shows varying degrees of preservation (Figure 8: Appendix 4). The fruits of greater tussock-sedge, *c.* 1.7 × 1.0mm are irregularly lozenge-shaped in outline with a flat to slightly concave ventral side and rather roof-shaped dorsal side, the generally complete examples here only showing slight deterioration of the surface cell patterning.

Although there is some fragmentation to the small (*c.* 1 × 0.7mm) kidney-shaped seeds of ragged robin they appear to be fairly resistant to decay and the concentric rows of pointed papillae which make them distinctive show no signs of deterioration in the few examples found here.

Preservation index 1.76. eight taxa in 100 counted. Analysis would be possible.

2.99–3.04m OD: Approximately 50% of the sample float comprised unbroken down sediment with occasional small woody and stem fragments and abundant

Table 113. Meare Lake Village: plant macrofossil preservation.

Reed peat								
		Fragmentation				Erosion		
2.84–2.89m OD (37–42cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula sp. (seed)	1	0	1	0	0	0	0	0
Carex paniculata	26	22	4	0	0	9	4	2
Carex spp.	53	22	25	3	3	15	15	15
Hydrocotyle vulgaris	2	2	0	0	0	0	1	1
Lychnis flos–cuculi	5	3	1	1	0	0	0	0
Poaceae indet	7	5	2	0	0	1	1	0
Rubus sect Glandulosus	1	1	0	0	0	0	0	0
Typha spp.	5	4	1	0	0	1	0	0
Other macrofosssils: abundant *Phragmites communis* stem fragments/culm nodes, and *Sphagnum* leaves, occasional wood and charcoal								
Raised bog peat								
		Fragmentation				Erosion		
2.99–3.04m OD (22–27cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula sp. (seed)	6	0	6	0	0	1	0	0
Calluna vulgaris (flower)	1	0	1	0	0	0	0	0
Cladium mariscus	40	10	18	3	9	17	8	15
Hydrocotyle vulgaris	19	13	3	1	2	7	0	4
Typha spp.	1	0	1	0	0	0	0	0
Other macrofosssils: occassional wood and *Sphagnum* capsule lids, abundant *Sphagnum* leaves								
Raised bog peat								
		Fragmentation				Erosion		
3.15–3.20m OD (5.5–10.5cm)	**Total counted**	**whole**	**<25%**	**25–50%**	**>50%**	**<25%**	**25–50%**	**>50%**
Calluna vulgaris (seed)	100	39	39	11	11	20	31	20
Other macrofosssils: occasional wood/twigs ? *Calluna* and *Eriophorum* spindles, abundant moss leaves								

Table 114. Meare Lake Village: macrofossil summary table.

	2.84–2.89m OD	**2.99–3.04m OD**	**3.15–3.20m OD**
Total macrofossils counted	100	67	100
Estimated total in sample	300	67	200
Total taxa	8	5	1
Total well preserved	59	23	39
Total <25% fragmented	34	29	39
Total 25%–50% fragmented	4	4	11
Total >50% fragmented	3	11	11
Total <25% erosion	26	25	20
Total 25%–50% erosion	21	9	31
Total >50% erosion	18	19	20
Preservation index	**1.76**	**2.53**	**2.36**

Sphagnum leaf and capsule lids preserved. The range of taxa was more limited than in the reed peat with only five taxa recorded out of 67 seeds/fruits.

Great fen-sedge (*Cladium mariscus*), occurs most frequently. Its fruits are elliptic to ovate in outline with a truncate base with thick lustrous coriaceous (leathery) walls which enclose the nut. This is very distinctive; an urn-like nut with three grooves and three projecting flanges (Figure 10: Appendix 4). Many of the examples from this level preserved entire well preserved fruits (recorded as whole) or entire urn-shaped nuts (recorded as <25% fragmented), some of which had suffered some erosion of the porous woody nut wall.

Few of the semi-circular fruits of marsh pennywort (*Hydrocotyle vulgaris*) show signs of fragmentation although in over 50% of examples, the slender ribs on

Table 115. Meare Lake Village: properties of 250g unprocessed samples.

	Dry weight	0.25mm	0.5mm	1mm	2mm	4mm	Organic matter %
2.84–2.89m	54.2g	6.7g	6.1g	5.3g	3.9g	6.3g	52%
2.99–3.04m	55.6g	4.5g	5.5g	5.9g	3.4g		35%
3.15–3.20m	73.5g	8.6g	6.4g	8.6g	5.7g		41%

Table 116. Meare Lake Village: assessment of insect and other invertebrate remains

m OD	Description of flot and its fauna	Interpretative potential and priority
3.15–3.20	Flot quite large, plant fibres, fragments of stem. Useful numbers of insects, with some aquatics but mostly suggesting damp acid terrain with *Calluna* (e.g. several *Micrelus ericae* (Gyllenhal)); some pools to support modest numbers of aquatics (e.g. *Ochthebius*). Numerous mites	Larger sub-sample (?3kg) would give useful group, allowing clear reconstruction of vegetation. P1B
2.99–3.04	Very large flot, mostly plant detritus. Very restricted fauna but clearly from swamp. Probably different conditions from above and below	Large sub-sample (3–5kg) would give small but useful group. Difficult identifi-cations. P1B
2.84–2.89	Flot of modest size, mainly plant fibres. Restricted but characteristic fauna, with planthoppers (Cicadellidae, Delphacidae) prominent. Suggesting damp acid terrain, with local pools, and vegetation including *Calluna* and probably grasses or rushes. No dung beetles. Numerous mites	Large sub-sample (at least 3kg) would give useful group but difficult identifi-cations (e.g. of the bugs). P1B

each side of the fruit are less clear, suggesting some surface abrasion has occurred (Figure 11: Appendix 4).

Preservation index 2.53. Five taxa in 67 counted. Analysis would be possible, larger sample may add more taxa.

3.15–3.20m OD: As in the underlying sample, approximately 50% of the float is unbroken down sediment with small woody fragments, some thought to be *Calluna*, with cotton-grass spindles, moss (not *Sphagnum*) branches without leaves as well as individual leaves. All 100 seeds counted were heather and no other taxa were recorded in a scan of the whole sample. 39% were whole, with a further 39% <25% fragmented. 71% of seeds showed some deterioration to the epidermal cells, the elongate cells being indistinct in about half (>25% eroded).

Preservation index 2.36. One taxa in 100 counted. Analysis not recommended.

Recommendations

The best preservation from Meare occurred in the reed peat at the base of the trench, which was dominated by a community of sedges. Although some fragmentation and erosion had occurred it would be possible to identify most of these to species. There is therefore good potential for full analysis.

The overlying raised bog peat was less productive with a higher preservation index than the reed peat. This is accounted for primarily by the deterioration of the great fen-sedge in the lower sample and both fragmentation and erosion of the delicate heather seeds, which were the only taxa recovered from the uppermost sample. Examination of larger samples may increase the number of taxa from the sample at 2.99–3.04m OD, but this is thought to be unlikely from the upper raised bog peat, the low species diversity is merely a characteristic of this type of environment. Further analysis of this sample is therefore not recommended.

Coleoptera

Harry Kenward

Three samples were assessed from the site (Tables 116–7). The highest (3.15–3.20m OD) was taken from just above the wooden remains and the other two samples at increasing depths below (2.99–3.04m OD and 2.84–2.89m OD). While some to many of the fossils in these deposits were in good condition, others were very decayed, all three assemblages including fossils at erosion level 4.0 or 4.5 ('much degradation'). There was some severe fragmentation in the uppermost sampled layer (3.15–3.20m OD), with many remains meeting the criterion 'typically unidentifiable within reasonable time-scale' (E 5.0). This layer also showed significant colour change, probably an indicator of substantial chemical modification to the insect cuticle.

Table 117. Meare Lake Village: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical Erosion				Fragmentation				Colour change				
	range		**mode**	**str**	**range**		**mode**	**str**	**To**	**range**		**mode**	**str**
3.15–3.20	3.0	4.0	4.0	W	2.5	5.0	2.5	W	Pale, hint brown	1	2	2	W
2.99–3.04	2.0	4.5	3.0	W	2.0	3.5	2.5	W	Pale	0	3	–	–
2.84–2.89	2.5	4.0	3.0	W	2.5	4.0	3	W	Pale	1	3	2	D

Table 118. Meare Lake Village: Station 1.

Horizon depth (cm)	Description
0–15	Very dark greyish brown (10YR 3/.2) moist silty clay loam with common fine rusty mottles
15–25	Dark grey (10YR 4/1) moist silty clay with many fine mottles of dark reddish brown (5YR 3/4)
25–35	Dark grey (10YR 4/1) clay with many fine and medium mottles of yellowish red (5YR 5/8) and also with patches paler and darker than the matrix
35–60	Yellowish red (5YR 5/6) moist clay with many fine and medium mottles of pinkish grey (7.5YR 6/2) and common fine and medium areas of black material
60–75	Dark grey (10YR 4/1) moist clay with few fine mottles of dark reddish brown (5YR 3/4), and many medium and coarse pockets of black material
75–120	Black (5YR 2/1) hard, slightly moist humified peat (H9)
120–150+	Brown (7.5YR 5/2) amorphous peat (H7), darkens on exposure

Table 119. Meare Lake Village: Station 2.

Horizon depth (cm)	Description
0–10	Very dark greyish brown (10YR 3/2) slightly moist friable silty clay loam
10–25	Very dark greyish brown (10YR 3/2) slightly moist clay with common medium mottles of yellowish red (5YR 4/6). Includes limestone fragment dark reddish brown (5YR 3/4)
25–45	Dark grey (10YR 4/1) slightly moist dense clay with common medium mottles of yellowish red (5YR 5/8), common medium and coarse areas of grey (10YR 5/1) also with black patches
45–70	Brown (7.5YR 5/2) moist clay with common fine faint mottles of yellowish brown (10YR 5/6) and with patches of darker material
70–120	Black (5YR 2/1) moist amorphous peat (H8) with a few twigs and small grass-sedge leaves
120–150	Black (5YR 2/1) hard, slightly moist humified peat (H9)
120–150+	Brown (7.5YR 5/2) amorphous peat (H7), darkens on exposure

Table 120. Meare Lake Village. Station 3.

Horizon depth (cm)	Description
0–15	Brown to dark brown (7.5YR 4/2) silty clay loam; slightly moist; moderate fine blocky structure
15–40	Brown (7.5YR 5/2) slightly moist clay with common fine mottles of strong brown (7.5YR 5/6)
40–75	Grey (10YR 5/1) moist clay with many medium mottles of yellowish red (5YR 4/8) and common fine strong brown (7.5YR 5/8); lower boundary merges over 70–80cm depth
75–100	Very dark greyish brown (10YR 3/2) moist loamy peat with common fine mottles of yellowish red (5YR 4/8)
100–120	Brown (7.5YR 5/4) very moist semi-fibrous peat with grass-sedge and *Typha* remains
120–150	Dark reddish brown (5YR 3/2) amorphous peat (H7) with remains of grass leaves, birch? twigs and bark

Monitoring of burial environment

David Hogan

Site description

Transect: From ditch east of excavation westwards towards large tree on opposite side of field, with three stations at 5m, 15m (next to excavation) and (beyond old ditch) 50m.

Land use: Permanent pasture of mesotrophic grassland.

Station 1 (Table 118): Instrumentation: piezometers at 50cm, 100cm, and 150cm depth.

Station 2 (Table 119): Instrumentation: piezometers and redox probes at 50cm, 100cm, and 150cm depth.

Station 3 (Table 120): Instrumentation: piezometers at 50cm, 100cm, and 150cm depth.

Results

The water table generally remained between 1m and 1.5m depth (Figure 146 and 148), exposing the remains (found or expected to occur within the upper 1m depth) to dry conditions throughout the year (Figure 146). Levels remained closer to the surface, within the 50–100cm depth range at Station 3. Here a complete water level log for the year indicates only a limited seasonal fluctuation, suggesting the likely impact of artificial drainage in moderating any variations. The soil water regime is confirmed by the redox potentials, which remained almost entirely *oxidised* at 50cm and 100cm depth (Figure 147). *Moderately or highly reduced* conditions were recorded only at 150cm depth, though even here, *oxidised* conditions became established in the autumn months (when the water table fell below the base of the 150cm piezometer, and no data were recorded (Figure 146)). Groundwater taken from piezometers beside the structure had a pH of 6.4, while a pH of 7.0 was recorded from water from the surrounding ditch system.

Conclusions

The water table remained too low for anoxic conditions to be established within the depth range of the archaeological material. Oxidised conditions preclude any potential for preservation of the remains under present environmental conditions.

Preservation conclusion

The excavations showed that small pieces of wood are still present at both Meare East and West in undisturbed areas (Trench 3) and in previously excavated areas (Trench 1). However, the material is in an extremely poor state of preservation and has probably been slowly drying out since before Bulleid and Gray's initial excavations. The present farmer says that the water levels in the surrounding ditches have dropped much lower over the last 15 years because the supply of mains water to the fields meant that water was no longer drawn from the Brue into the field rhynes to provide drinking water for stock. This probably accelerated the decay of organic remains on the site.

The present hydrological regime is undoubtedly causing ongoing desiccation of the site and the raised bog peat in the occupation area. The well preserved

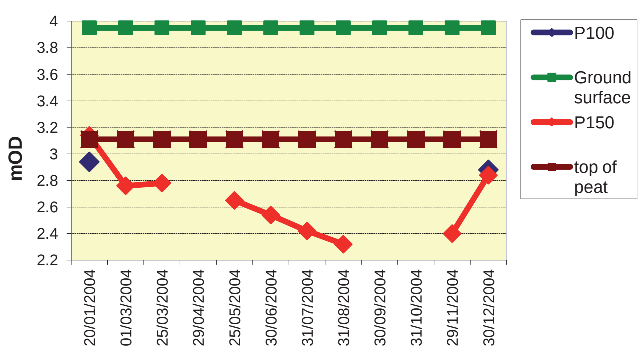


Figure 146. Water table at Station 2.

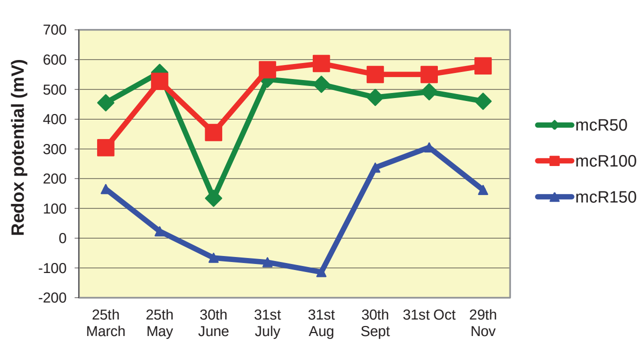


Figure 147. Redox potential at Station 2.

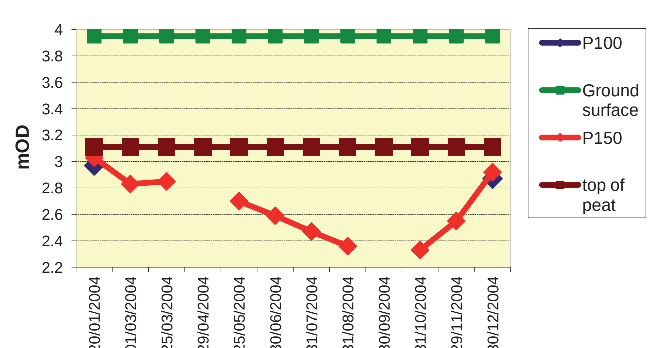


Figure 148. Water table at Station 1.

Figure 149. Looking north along the ditch which divides Meare Lake Village West.

condition of the reed noted in Trench 3 does however suggest that preservation conditions are significantly better *c*. 0.3–0.4m below the basal occupation layers. This suggests that there is still the potential for organic preservation in possible middens off the edge of the site and for deeply set vertical posts in the occupation areas themselves.

11. Glastonbury Lake Village fieldwork

Somerset HER 23637; SM406

Previous fieldwork

The site is located in a pasture field on Common Moor 1km north of Glastonbury at ST 493408, immediately to the east of the road between Godney and Glastonbury. To the east of the site is Great Withy Drove, an extremely sinuous minor road, whose morphology reflects the fact that it follows the former course of the River Brue towards the Axe valley before it was diverted in the medieval period.

The site was discovered by Arthur Bulleid in 1892 after a 4-year search for prehistoric lake villages in Somerset. The owner donated the site to the Glastonbury Antiquarian Society and excavations were carried out by Bulleid between 1892 and 1898 and by Bulleid and Harold St George Gray between 1904 and 1907 (Figures 14 and 150). The results of the excavations were published in two volumes (Bulleid and Gray 1911; 1917). The site has been subject to recent re-analysis and reinterpretation by Prof. John Coles and Steve Minnitt (Coles and Minnitt 1995) using the evidence from the original site records. The environmental setting of the settlement has been investigated by the Somserset Levels Project and subsequently by Housley (Housley 1988; 1995; Housley *et al.* 2000; 2007).

In 1968 and 1969 Michael Avery of Queen's University, Belfast, opened three small trenches on the north-western side of the site (locations shown in Coles *et al.* 1988, fig. 62) in an attempt to locate the palisade (Somerset HER PRN28534). In this he seems to have failed but these excavations have never been written up.

In 1984 the Somerset Levels Project carried out further investigation on the site (Coles *et al.* 1988). This involved three trenches, one on the north to recover environmental samples from outside the settlement, one on the west to explore a possible entrance though the palisade and one on the east to examine the landing stage (Figure 154). The latter trench was the only one to encounter extensive structural remains.

The settlement extended over an area roughly 118m north–south and 103m east–west. It was built at the edge of a patch of wet woodland in a very wet environment that included reed and sedge swamp and patches of open water. The foundations of the settlement comprised layers of logs, brushwood, peat, clay, stone and rushes. It was partly held in place by palisades of roundwood stakes around the perimeter, which appear to have been replaced several times in some locations but barely existed elsewhere. A total of 90 artificial mounds were built within the perimeter but recent reassessment suggests that only 40 roundhouses (Figure

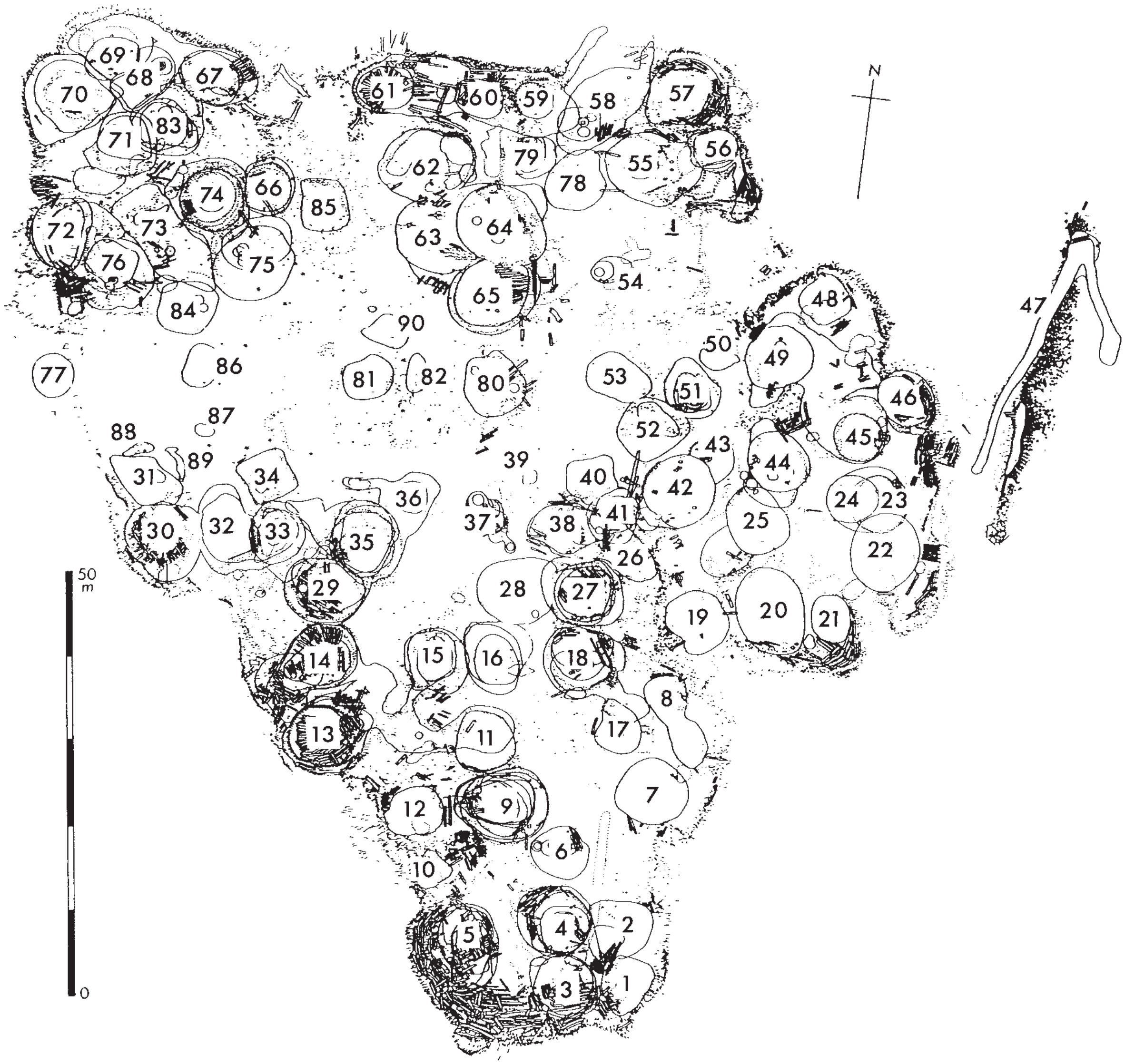


Figure 150. Plan of Glastonbury Lake Village excavations from Coles and Minnitt 1995.

151) were ever created, the other areas representing unenclosed working areas (Coles and Minnitt 1995). The floors and central hearths of the houses were frequently rebuilt, probably because of settlement of the foundations (Figures 15 and 152). Sheds, animal pens and paths appear to have existed within the settlement and on the east side was a stone and timber causeway, which probably functioned as a landing stage.

The most recent reassessment of the site (Coles and Minnitt 1995) suggests that it was occupied between *c*. 250 BC and 50 BC, although the evidence for this is problematic (see below). The material culture recovered from the village included enormous quantities of pottery and considerable evidence for craft production in the form of antler, bronze, bone, wood and iron working. Large quantities of wild and domestic animal bones (including fish) were recorded in addition to plant material. Middens appear to have existed around the edge of the settlement.

Preservation conditions

The site is roughly 1ha or 2 acres in size and is currently in permanent pasture, protected from cultivation by Scheduled Monument status. Bulleid and Gray's excavation records clearly record an excellent level of preservation of wooden remains, especially in the foundations of the settlement (Figure 153). This is

Figure 151. Reconstruction of Glastonbury Lake Village by A. Forestier 1911.

Figure 152. Bulleid and Gray excavation showing superimposed roundhouse hearths in section.

Figure 153. Wattle panel in the foundations of the settlement revealed in the Bulleid and Gray excavations (Bulleid on right).

supported by the evidence of the photographs, which suggest that conditions were far more conducive to the survival of organic materials than they experienced at Meare. This is consistent with their need to pump water out of the excavations to explore the lower levels of the foundations. The wood that remained *in situ* may have been exposed for several months during the summer excavations, which must have adversely affected the preservation of the highest remaining deposits. The Somerset Levels Project excavations in 1984 showed that palaeoenvironmental data was still in a good state of preservation and that organic remains, in the form of oak timbers, still existed alongside the causeway where Bulleid and Gray had previously exposed them (Coles *et al.* 1988). No sapwood remained on the timbers but this may have been removed in prehistory from the heavily worked radial planks.

MARISP excavation results

It was possible to trace the limits of Bulleid and Gray's excavations in the field by identifying a slight but sharp dip in the ground surface from the unexcavated to the excavated areas. Where this could be traced it appeared to correspond very well to the published limits with sharp right angled corners (Figure 154). It had previously been thought that the published limits may have been a cosmetic device to tidy up the irregular trenches (Coles and Minnitt 1995, 21) but this evidence seems to suggest otherwise.

The brief examination of the ground surface in the field also located a previously unrecorded earthwork, named the 'Faxon Mound', at the northern edge of the field, 15m in from the northern field boundary. It consisted of a very low mound *c*. 45m east–west and 9.5m north–south at its widest point. The small Somerset Levels Project trench opened to enable palaeoenvironmental sampling was visible as a slight 2m by 2m depression *c*. 12m north-west of the mound. A core through the feature revealed 0.2m of crumbly brown topsoil overlying 0.13m of brown clay. This was above 0.23m of a mixed grey-yellow-brown clay containing numerous very small charcoal flecks. Under the clay was at least 0.2m of the detrital mud deposits observed elsewhere on the site. This earthwork appears to represent an artificial mound created at a distance from the main settlement.

Two trenches were excavated. Trench 1 was 6m by 2m and was located over the south-west perimeter of the settlement in an area excavated previously in 1897 (Figure 155). A prominent hump in the ground surface to the north-east of the trench represented mound 5 as it was reconstructed by Bulleid after the excavations in that area (Figure 154).

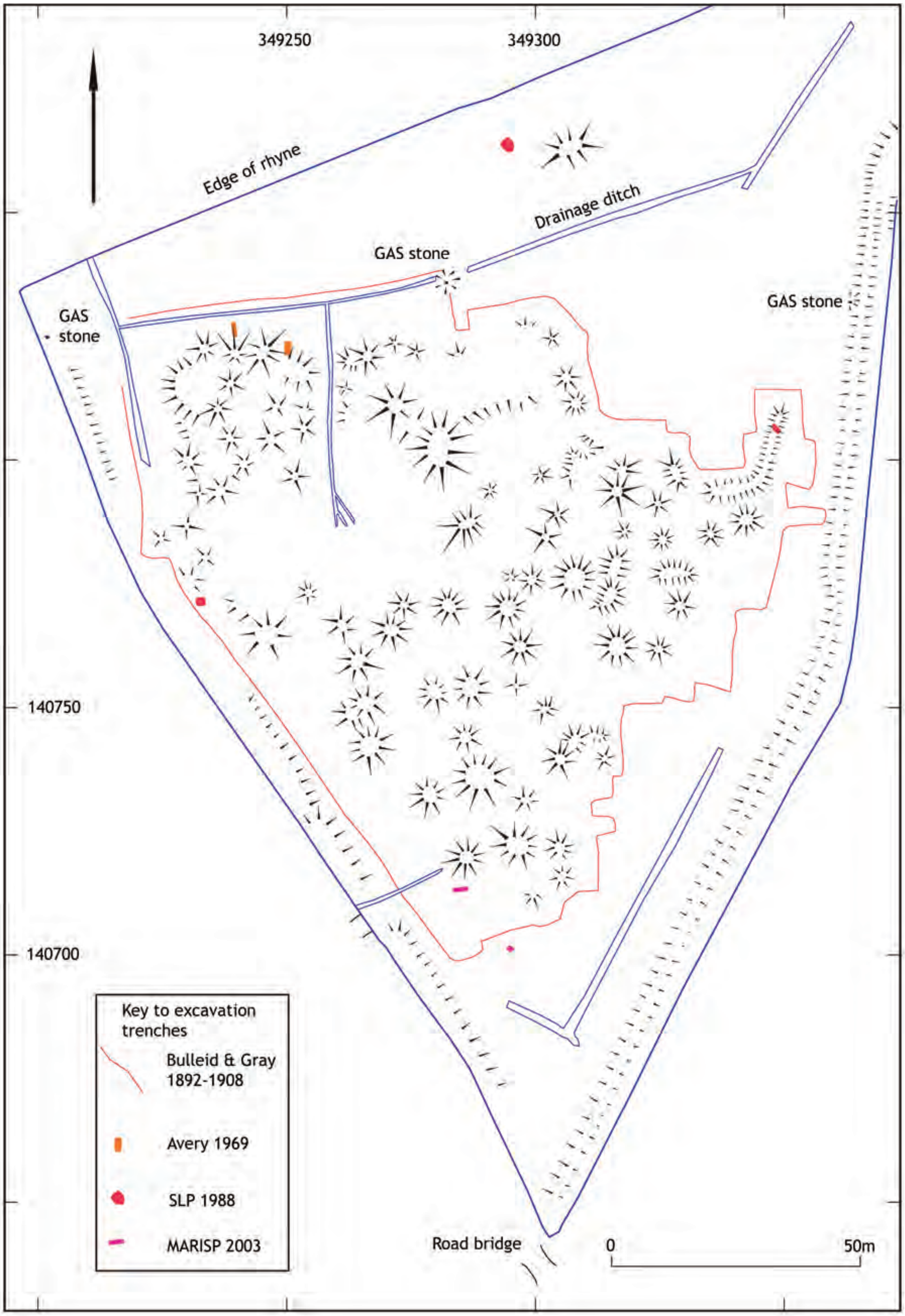


Figure 154. Plan of the extant earthworks in the Lake Village field showing reconstructed mounds and the edge of the various excavations (H. Riley).

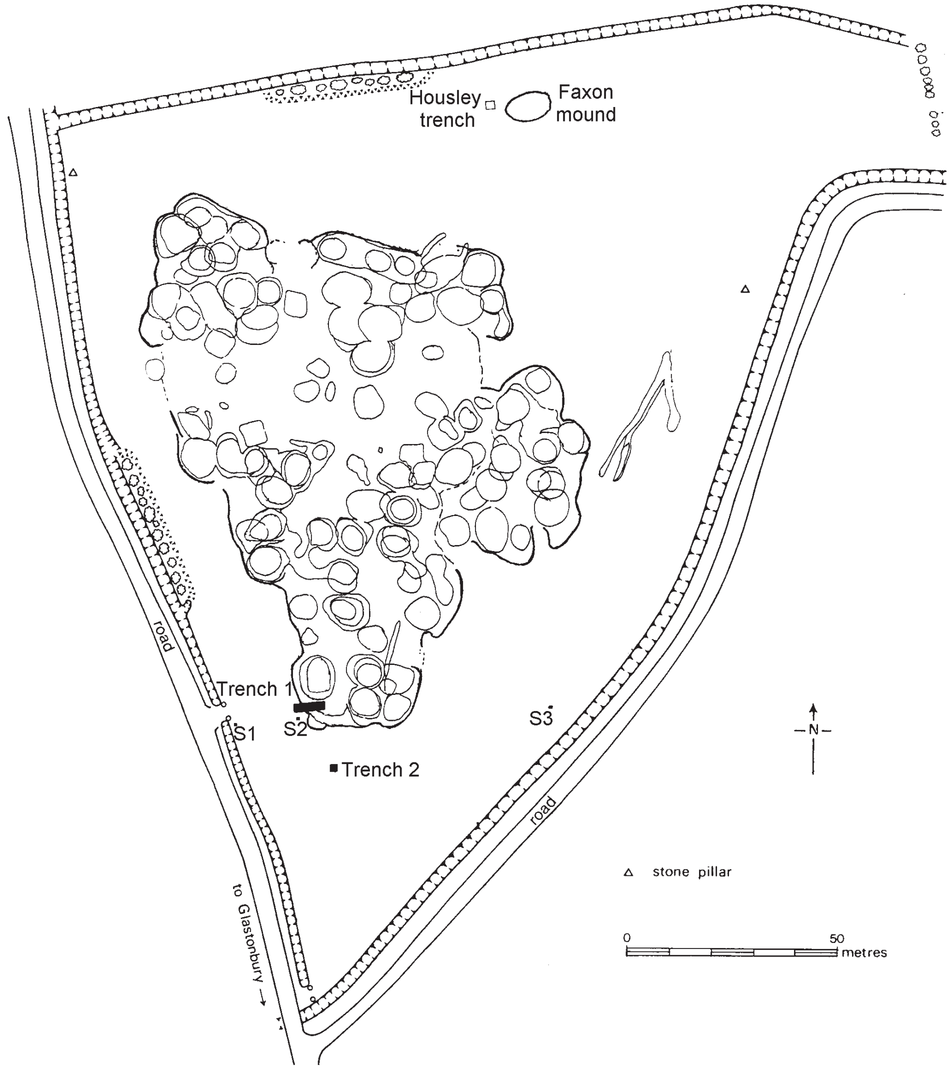


Figure 155. Glastonbury Lake Village trench and monitoring stations.

Trench 1

The earliest features in the trench were the remains of the wooden foundations and outer palisade of the settlement, which were set in a dark grey detrital mud (context 5). Under the terms of the agreement with the Glastonbury Antiquarian Society, the only wooden timbers that could be removed were those that were being sampled. This prevented a complete wood record being established for the structural remains and measurements were restricted to observable dimensions. In addition it was not possible to examine the stratigraphic relationship of the differing wooden elements or determine the depth of the surviving structural layers.

From what could be observed from the surface of the structural layers the wooden remains could be divided into four components:

- outer palisade stakes
- perimeter 'walkway'
- settlement foundations
- other stakes

The earliest of the above components were the small stakes recorded within the foundation timbers. Six of these (wood nos 48, 54, 56, 57, 59, and 62) existed in a roughly north–south line across the middle of the trench, roughly parallel to the outer palisade and on the inside of the 'walkway' timbers (Figure 156). Only the tops of these stakes were visible but it was clear that they were consistently dipping down towards east north-east, an orientation they shared with the main palisade posts. The tops of the stakes underlay both the 'walkway' timbers and the other foundation material on the inside of the walkway. The diameters of two of the stakes (54 and 62) were recordable at

Figure 156. Trench 1, lower levels (stake 54), looking south. Scale 0.5m.

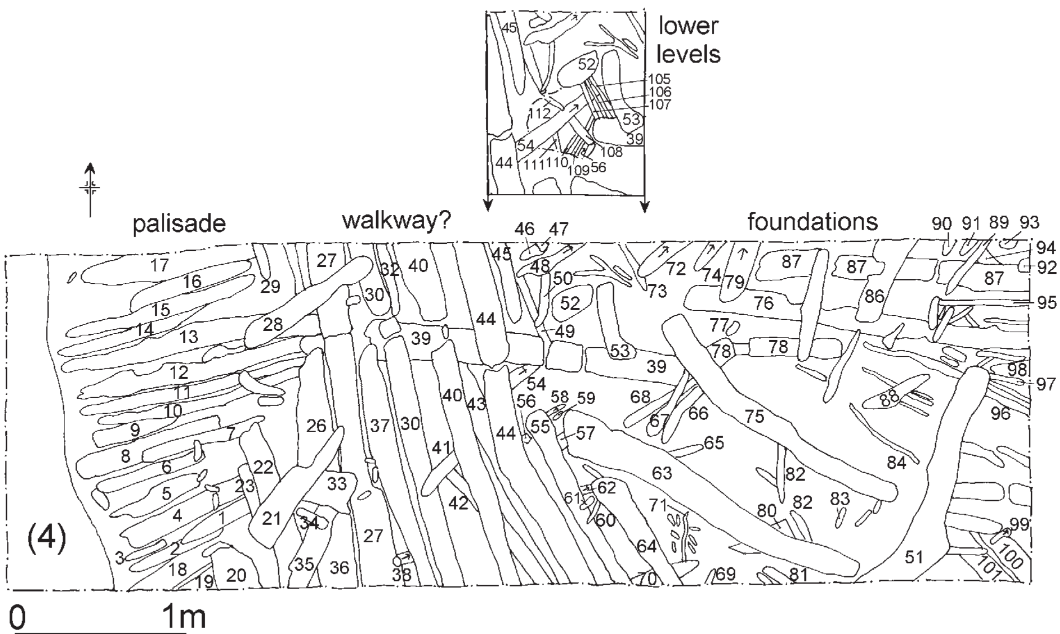


Figure 157. Trench 1 plan, Glastonbury Lake Village.

73mm and 68mm respectively. Several other pieces of wood may also have been stakes in the same line (e.g. 46, 58 and 60).

The tops of two other stakes (31 and 38) were recorded just inside the western edge of the 'walkway' (see below and Figure 157). These may represent another palisade line or a stake line that once helped to secure the walkway timbers. Bulleid's excavation plan of this part of the settlement shows several lines of partially collapsed stakes, suggestive of sequential palisade lines.

The outer palisade (Figures 158 and 159) consisted of 19 densely packed roundwood stakes (wood nos 1–2 and 4–19) with diameters ranging from 68mm to 155mm, with an average of 92mm. The palisade line had slumped to the west and the stakes were lying at

Figure 158. Trench 1, looking west. Palisade at top, walkway below, foundations foreground. Scales 1m.

c. 45° to the horizontal. Presumably the outer palisade had once retained all the foundation material behind it. The tops of the stakes were badly decayed and in many cases the tops had snapped, possibly because of pressure applied during the original backfilling.

On the inside of the outer palisade were 10 timbers aligned roughly north–south but curving slightly to the east at the southern end of the trench, mirroring the general curve of the outer palisade. These timbers may represent a walkway, 1.2–2m wide, immediately inside the palisade (Figure 159). Before the palisade, and the timbers it retained, slumped to the west the width of the walkway may have been slightly smaller and the gaps between the timbers less than those observed in the excavation. The walkway material included roundwood of 58–88mm diameter and converted timbers with widths of 85–160mm and thicknesses of 48–60mm.

The walkway timbers overlay the middle of the palisade stakes and the tops of some of the inner lines of stakes. One of the lower timbers (39) of the general foundations underlay three of the walkway timbers (30, 40, 44) that had all broken over it.

The general foundation material to the east of the 'walkway' consisted of a variety of timbers. Two general orientations in the upper foundations could be discerned, a north-east–south-west trend among the timbers from the northern side of the trench and an east–west trend for most of the remaining material (Figure 157). The north–south timbers overlay several of the east–west timbers suggesting that they were a later addition to the structure. This variety in orientation corresponds well with the pattern recorded by Bulleid (Figure 160). His excavation plan suggests that the

Figure 159. Trench 1, looking north, with walkway (right) and palisade (left). Scales 1m.

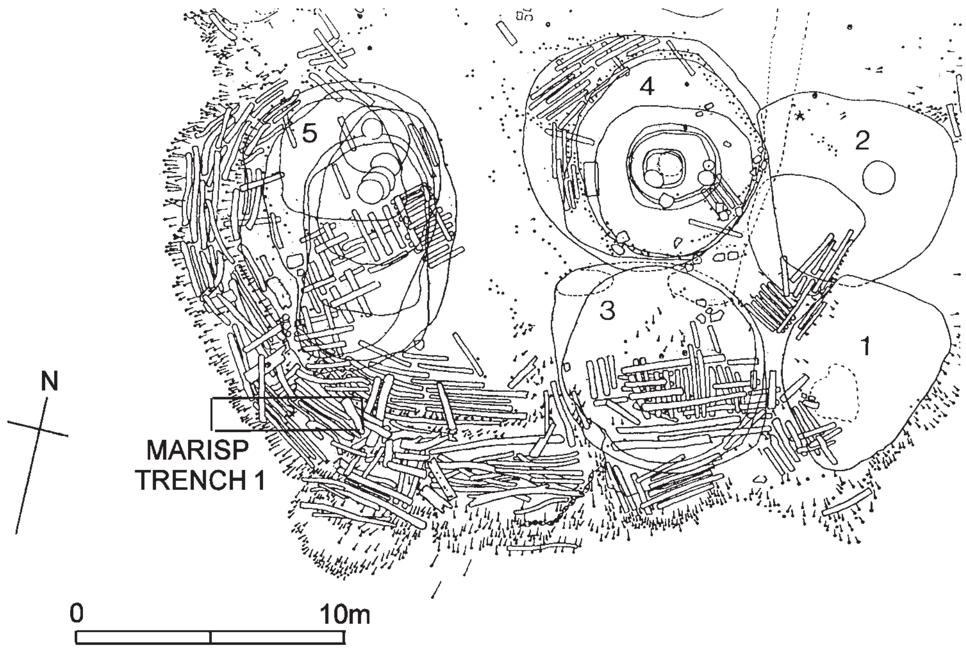


Figure 160. Trench 1 location superimposed on Bulleid's plan.

Figure 161. Trench 1, looking south. Upper palisade levels. Scale 0.5m.

Figure 162. Trench 1, looking south. Lower palisade levels. Scale 0.5m.

north–south timbers may be related to the southern extension of mound 5, built over the top of the general foundation layers.

The character of the foundation timbers was not fully ascertained because of their poor condition and because of the enforced limitations of the excavation. The east–west orientated foundations included roundwood of 169mm to 200mm diameter and converted timbers, 110–220mm wide and 35–90mm thick. Only two of the north–south foundation timbers had measurable widths and thicknesses, one of 70mm by 45mm and the other 110mm by 60mm.

In one place a small area of the lower foundations were exposed to permit the removal of a sample of stake 54 for decay analysis (Figure 156). This revealed numerous pieces of roundwood clustered in varying orientations. They ranged in diameter from 19mm to 58mm, much more slender than the upper foundation timbers.

Above the *in situ* wooden remains there was a clear and sharp boundary to a dark grey clay (4) containing numerous charcoal flecks. This easily peeled off the wood and contained patches of blue-grey clay. This appears to represent the first layers of backfill from

Figure 163. Trench 1, Bulleid's backfill, looking west. Scales 1m.

Bulleid's excavations that had been fairly carefully placed between and over the exposed timbers before the remaining backfill was placed in the trench (Figure 163). The main backfill (contexts 2 and 3) consisted of extremely mixed dark and light grey clay up to 0.45cm deep containing much orange mottling and some patches of light blue-grey clay and yellow clay. All the backfill layers ran the whole length of the trench. They extended to a depth of roughly 0.4m–0.45m below ground. The ground surface in the area of Trench 1 varied from 5.46m OD at the south-east corner, to 5.55m OD at the south-west corner.

At the base of the main backfill layers was an unworked knotty oak log (51) over 1.2m in length and *c.* 0.25m in diameter. This was the only piece of wood that appeared to have been placed back in the excavation along with the backfilled material. If other structural wood was removed during Bulleid's excavations it was either put back somewhere else in the area excavated that year or was not reburied. The similarity of the excavated timbers to those planned by Bulleid suggests that hardly any of the timbers he planned were actually removed during the excavations and that his investigations on this part of the site were limited to the upper visible timber layers under the habitation mounds (Figure 164 and 165). This is perhaps hardly surprising because in 1897 Bulleid excavated the five mounds at the southern end of the site and uncovered a large quantity of wooden structural remains.

The backfill layers yielded a few fragments of animal bone, six Iron Age and one medieval pottery sherds, some charcoal and daub and numerous lumps

Figure 164. 1897 excavation photo, looking west. Palisade at far end of trench.

Figure 165. Trench 1 photo of the same area, looking west. Palisade at far end of trench.

Figure 166. Unbaked slingshots and roughly moulded clay lumps from Trench 2.

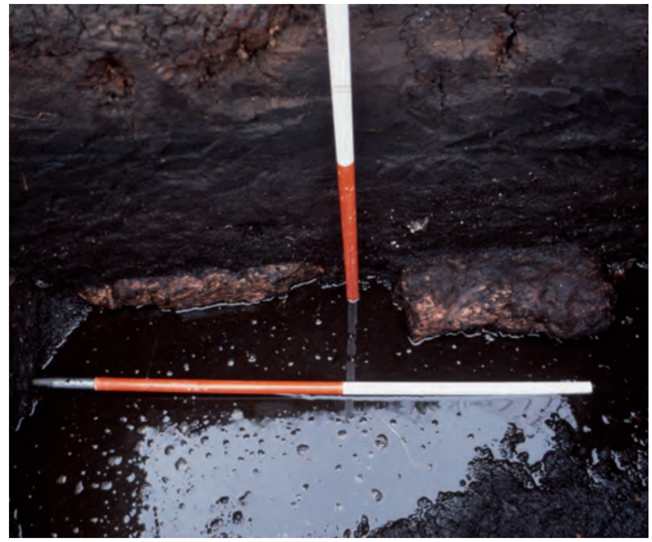


Figure 167. Trench 2 showing wood blocks 103 and 104, looking north. Scales 1m.

of stone, mainly lias and sandstone, some of which was burnt. A small number of possible sandstone polishing/rubbing stones were present (see Table 122 for full finds list).

Trench 2

Trench 2 was a small trench 2m by 2m located immediately outside the southern edge of Bulleid and Gray's excavations (Figure 155) to permit the removal of a complete environmental sample column. The trench was 1.18m deep, and a full description of the stratigraphy is given in the environmental section below. Between 80cm and 110cm below the ground surface (4.78–4.48m OD) several cultural items were recovered including pieces of bone and stone, worked wood and unfired clay sling-shots (Figure 166).

Although Bulleid and Gray recorded the presence of unbaked sling shots on the site, none were retained in the site archive. These finds offer a rare example of the process of clay sling shots manufacture from the shaping of crude lumps to the finely shaped finished product.

The smaller pieces of wood included two pieces of roundwood and a tangential woodchip. The woodchip (127) was 78mm by 25mm by 10mm, with a well preserved axe mark at one end. The shorter roundwood (126) was 100mm long and tapered from 26mm diameter at its complete end to 20mm at the other, broken, end. The reduction in size was due to numerous narrow cuts on all its sides. This suggests that the object had been deliberately formed to act as a stopper or peg. The second piece of roundwood (125) was 195mm long and 50mm in diameter and was broken at both ends but retained its bark on one side. Near one end was a 4mm wide and 4mm deep indentation that was observable over three quarters of the circumference of the object. This may represent wear caused by abrasion of a string or fine rope tied around the timber.

Two blocks of wood (103 and 104) were exposed in the northern section of the trench (Figure 167), the tops of which were at 4.53m OD and 4.50m OD. Timber 103 displayed axe cuts on its upper face, suggesting that humans probably deposited both the timbers in the wetlands surrounding the settlement. This is consistent with the cultural material recovered from above them and with Bulleid's records of cultural material from well outside the palisade. Four other pieces of roundwood were sampled for species identification from the layers containing the anthropogenic material. They were all *Salix* sp. (willow) or *Populus* sp. (poplar) with diameters ranging from 12mm to 22mm and aged between 4 and 13 years old. Beavers had removed the bark of these pieces. Willow is a popular food for beavers. This provides the first evidence for beaver activity in the immediate vicinity of the lake village. Beaver bones had been found on the settlement so it appears that the inhabitants were hunting the species.

Wood species identification

Rowena Gale

Wood species identifications are shown in Table 121.

Table 121. Glastonbury Lake Village: wood species.

Wood No.	Diameter or width × thickness (mm)	Species	Function
Alnus glutinosa =alder; *Betula* sp. = birch; *Corylus avellana* = hazel; *Quercus* sp. = oak; *Populus* sp. = poplar; *Salix* sp. = willow			
1	68	willow or poplar	outer palisade
2	90	birch	outer palisade
3	24 × 24	too degraded and compressed	fragment
4	155	alder/hazel/ willow or poplar	outer palisade
5	90	alder	outer palisade
6	80	alder or hazel	outer palisade
7	92	alder or hazel	outer palisade
8	106	alder	outer palisade
9	89	birch	outer palisade
10	64	too compressed	outer palisade
11	80	alder	outer palisade
12	120	too compressed	outer palisade
13	105	willow or poplar	outer palisade
14	113	alder/hazel/ willow or poplar	outer palisade
15	106	hazel	outer palisade
16	90	too degraded	outer palisade
17	117	alder	outer palisade
18	–	birch	outer palisade
19	100	alder	outer palisade
20	–	willow or poplar	walkway timber
21	176 × 42	–	walkway timber
22	–	willow or poplar	walkway timber
23	–	alder	walkway timber
24	–	willow or poplar	fragment
25	68	oak	fragment
26	–	alder	walkway timber
27	130 × 48	alder	walkway timber
28	–	alder or hazel	timber over walkway
29	–	willow or poplar	walkway timber
30	120 × 50	willow or poplar	walkway timber
31	–	willow or poplar	early palisade?
33	178 × 45	willow or poplar	walkway timber
35	–	oak	walkway timber
36	–	willow or poplar	walkway timber
37	130 × 30	willow or poplar	walkway timber
38	58	alder or hazel	early palisade?
39	200	alder	E–W foundation
40	110 × 38	–	walkway timber
41	–	willow or poplar	walkway timber
42	–	alder/hazel/ willow or poplar	walkway timber
43	85 × 60	willow or poplar	walkway timber
44	160 × 48	alder/hazel/ willow or poplar	walkway timber
45	–	willow or poplar	walkway timber
46	–	alder/hazel/ willow or poplar	early palisade?
49	–	willow or poplar	lower foundation
51	89	–	–
53	–	alder	upper foundation
54	73	alder or hazel	early palisade?
55	59 × 58	alder	walkway timber
56	–	alder	early palisade?
57	30	alder	early palisade?
58	–	alder	early palisade?
59	50	alder	early palisade?
60	30 × 25	alder or hazel	early palisade?

Table 121. continued.

Wood No.	Diameter or width × thickness (mm)	Species	Function
61	40	too compressed for ID	walkway timber
62	68	alder	early palisade?
63	220 × 82	alder or hazel	E–W foundation
64	88 × 78	alder	walkway timber
65	–	alder or hazel	lower foundation
66	–	alder	lower foundation
67	–	alder	lower foundation
68	–	alder	lower foundation
69	–	alder or hazel	lower foundation
72	57 × 25	alder/hazel/ willow or poplar	N–S foundation
74	50	alder	N–S foundation
75	158 × 90	alder	E–W foundation
76	120 × 38	alder	E–W foundation
77	–	alder	fragment
78	110 × 35	too compressed	fragment
79	–	alder	lower foundation
80	–		lower foundation
81	–	alder	lower foundation
82	40	alder or hazel	lower foundation
83	–	alder	lower foundation
84	30	alder or hazel	lower foundation
85	70 × 45	alder	N–S foundation
86	110 × 60	alder or hazel	N–S foundation
87	174 × 95	alder	E–W foundation
88	–	alder	fragment
89	–	alder	N–S foundation
90	–	alder	N–S foundation
91	–	too degraded	N–S foundation
92	–	alder	E–W foundation
93	–	too degraded	N–S foundation
94	–	alder	E–W foundation
95	–	willow or poplar	E–W foundation
96	–	alder or hazel	E–W foundation
97	–	alder	E–W foundation
98	169	alder	E–W foundation
99	58	alder	stake
100	140	alder	lower foundations
101	–	alder	lower foundations
103	–	alder	trench 2 block
104	–	birch	trench 2 block
105	24	willow or poplar	lower foundations
106	17	willow or poplar	lower foundations
107	29	willow or poplar	lower foundations
108	58	alder	lower foundations
109	19	willow or poplar	lower foundations
110	24	willow or poplar	lower foundations
111	34	willow or poplar	lower foundations
112	38	willow or poplar	lower foundations
113	70	birch	–
125	50	willow or poplar	trench 2 cut roundwood
126	20	willow or poplar	trench 2 cut roundwood
127	25 × 10	alder	trench 2 woodchip

Table 122. Finds from Glastonbury Lake Village.

Trench	Context	Ceramics	BM	Lithics	Animal bone	Fe object	Other
1	1		1 baked clay/ daub?				
1	2	2 Iron Age sherds	4 baked clay/ daub?	20 sandstone lumps, 2 sand-stone rubbers/ polishers? 9 burnt sandstone, 16 Lias lumps, 2 burnt Lias frags, 1 burnt limestone prob. Lias?, 1 limestone poss. Lias? 5 calcite/quartzite? lumps 4 slate frags	9 bone and teeth	Iron staple	Plastic ruler frag.
			3 small baked clay/ daub/burnt stone?				3 charcoal lumps
			1 brick/tile frag.				
1	3			2 sandstone frags, 3 Lias frags, 2 limestone frags			
1	4	5 Iron Age sherds, 1 rim	16 baked clay/ daub?	30 sandstone frags, 5 burnt/ stained? sandstone, 1 sand-stone rubber/polisher? burnt?, 1 sandstone rubber/polisher?, 9 Lias, 1 Lias with ammonite impression, 5 burnt Lias frags, 1 limestone prob. Lias, 4 calcite/quartzite?, 1 Inferior oolite? 1 conglomerate	24 bone and teeth frags.		
		1 medieval sherd 14th–15th C?			4 burnt bone		1 Slag
							14 charcoal lumps
1	5				1 bone		
2	6	1 baked clay/daub					
2	7	1 Iron Age rim		4 sandstone, 3 burnt sand-stone, 15 Lias	5 bone and teeth		SF1, 7 × unfired clay sling shots? 1x unfired clay object

Other finds

Keith Faxon

The finds are summarised in tabular form (Table 122). With the exception of a single bone fragment all the finds recovered from Trench 1 were derived from Bulleid's backfill from the 1897 excavations.

The sling shots

Richard Brunning

Four lumps of roughly shaped clay were discovered in the same context as the sling shots. The largest piece was 56mm by 40mm by 40mm. One flat triangular shaped piece, 40mm by 35mm by15mm, may represent a 'blank' ready to be moulded into a shot. Five finished clay sling shots were present in addition to a broken fragment from another one. The shots were all oval shaped. Three of them were very similar in dimensions being 40mm long and 24–26mm in diameter at their widest point. The two smaller ones were 38mm by 25mm and 37mm by 22mm. None of the clay sling shots had been baked.

Radiocarbon dating

P. D. Marshall, W. D. Hamilton, R. Brunning,
G. Cook and C. Bronk Ramsey

Sequence

The samples of waterlogged macrofossils (SUERC-9828) and peat (OxA-16233 and OxA-16234) from the base of the sequence came from a poorly humified peat associated with worked wood, bone and clay sling stones that are presumably from activity in the Lake Village. The three measurements are not statistically consistent (T'=98.0; T' (5%)=6.0; ν=2; Ward and Wilson,

Table 123. Glastonbury Lake Village: radiocarbon results.

Lab. no	**Sample Depth m OD**	**Material**	**$\delta^{13}C$ (‰)**	**Radio-carbon age (BP)**	**Weighted mean**	**Calibrated date (95% confidence)**
SUERC-9828	4.44.–4.45	Plant macrofossils; *Cladium mariscus* × 6; *Carex* × 5; *Hydroclyle vulgaris* × 1; *Rumex* × 1; *Alnus glutinosa* × 2; *Oellauthe aquatica* × 1	-27.3	2455±35		770–400 cal BC
OxA-16233	4.44–4.45	Peat; humin	-27.5	2861±30	2865±21 BP (T′=0.1; T′ (5%)=3.8; ν=1),	1125–940 cal BC
OxA-16234	4.44–4.45	Peat; humic	-28.4	2869±30		
SUERC-9829	4.80–4.81	Plant macrofossils; *Carex* × 9; *Betula* × 1; *Ranunculus liugua* × 3; *Cladium mariscus* × 4; *Sclioeoplectus lacustris* × 2; *Methua aquatica* × 6; *Urtica dioica* × 1; *Salix* bud × 1	-25.5	2615±40		840–670 cal BC
OxA-16235	4.80–4.81	Peat; humin	-28.9	2393±30	2376±22 BP (T′=0.7; T′ (5%)=3.8; ν=1),	510–395 cal BC
OxA-16236	4.80–4.81	Peat; humic	-29.2	2355±33		
OxA-16237	5.01–5.02	Peat; humin	-30.3	2122±29	2118±21 BP (T′=0.0; T′ (5%)=3.8; ν=1),	200–50 cal BC
OxA-16238	5.01–5.02	Peat; humic	-29.7	2114±29		
OxA-16245	5.12–5.13	Peat; humin	-30.5	1850±33	1872±23 BP (T′=0.9; T′ (5%)=3.8; ν=1),	cal AD 70–225
OxA-16246	5.12–5.13	Peat; humic	-29.6	1893±32		

1978), although the two measurements on the humic and humin peat fractions are (T′=0.1; T′ (5%)=3.8; ν=1; Ward and Wilson 1978). This suggests that the sample of plant macrofossils (SUERC-9828) contains some intrusive, younger material and therefore does not provide an accurate date for this level. The samples of waterlogged macrofossils (SUERC-9829) and peat (OxA-16235 and OxA-16236) from 4.80–4.81m come from the top of the poorly humified peat towards the base of the sequence. The three measurements are again not statistically consistent (T′=28.5; T′ (5%)=6.0; ν=2; Ward and Wilson 1978), although the two measurements on the humic and humin peat fractions are (T′=0.7; T′ (5%)=3.8; ν=1; Ward and Wilson 1978). This suggests that the sample of plant macrofossils (SUERC-9829) contains some possibly older material and therefore does not provide an accurate date for this level (Table 123).

The sample from 5.01–5.02m comes from the interface of the underlying detritus peat and organic silty mud and is indicative of a change in environmental conditions. The two measurements (OxA-16237 and OxA-16238) are statistically consistent (T′=0.0; T′ (5%)=3.8; ν=1; Ward and Wilson 1978) and allow a weighted mean to be calculated (2118±21 BP). The uppermost sample came from the top of the organic silty mud and below the very disturbed overlying sediments. The two measurements (OxA-16245 and OxA-16246) are statistically consistent (T′=0.9; T′ (5%)=3.8; ν=1; Ward and Wilson 1978) and allow a weighted mean to be calculated (1872±23 BP).

Results

The model shown in Figure 168, excluding SUERC-9828 and SUERC-9829, shows good agreement between the radiocarbon results and stratigraphy ($A_{overall}$=97.8%) as presented in the previous section. The results suggest that peat dating to the period of occupation of the site do remain intact (Figure 169).

Palaeoenvironmental analysis

Heather Tinsley and Julie Jones

The first palynological work was carried out in the 1940s by Godwin, who produced a pollen diagram from sediments beneath Mound 5. He concluded that the village had been built as a raft on a ‘floating fen carr’ with open water beside it (Godwin 1955). In 1984 new excavations were undertaken as part of the Somerset Levels Project (Coles *et al.* 1988); in conjunction with these Housley undertook a major palaeoenvironmental survey of the peat moors around the village site, involving an extensive programme of coring, stratigraphical recording, macrofossil and pollen analyses (Housley 1988). Housley (1988; 1995) also undertook the re-expression of the pollen data

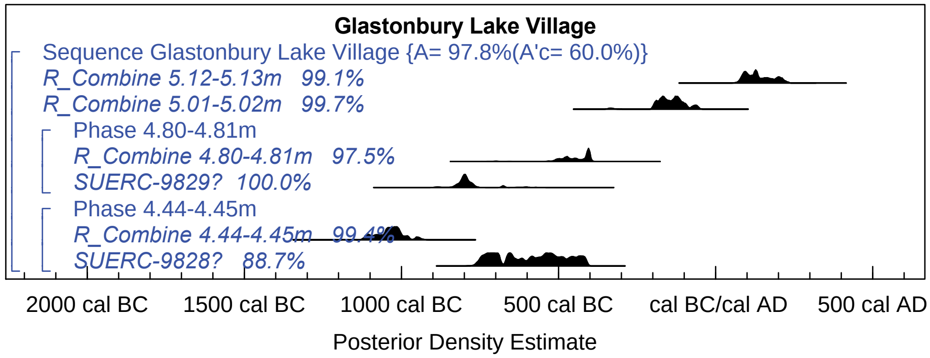


Figure 168. Probability distributions of dates from Glastonbury Lake Village (MARISP). Each distribution represents the relative probability that an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. A question mark (?) indicates that the result has been excluded from the model The large square brackets down the left hand side along with the OxCal keywords define the model exactly.

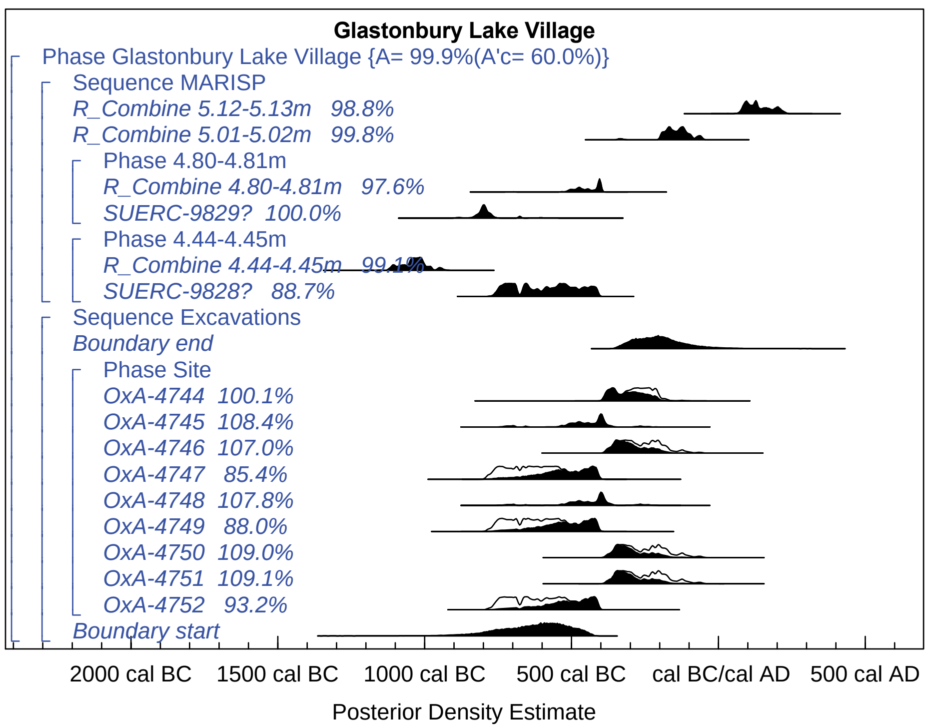


Figure 169. Probability distributions of dates from Glastonbury Lake Village (MARISP; Coles and Minnitt 1995). Each distribution represents the relative probability that an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. A question mark (?) indicates that the result has been excluded from the model The large square brackets down the left hand side along with the OxCal keywords define the model exactly.

produced by Godwin (1955), so that it could be directly compared with his own diagrams.

Trench 2 was located to permit environmental assessment and analysis from outside the area excavated by Bulleid and Gray. Trench 2 was less than 20m from the site cored by Godwin for his 1955 pollen diagram. It extended down through 1.18m of rather variable sediments, ranging from wet, coarsely fibrous detritus peat at the base, to drier detritus peat higher up the profile. Above 4.97m OD there was a gradual transition from detritus peat to a completely humified organic mud; this became drier and siltier above 5.12m and was

Table 124. Glastonbury Lake Village (GLV 03): stratigraphy, sampling locations and calibrated radiocarbon date ranges.

Depth (mOD)	Stratigraphy	Pollen	Macros beetles and snails	Depth/calibrated radiocarbon date range
Ground surface at 5.59m OD				
5.21–5.59	Grey-brown fine-grained mottled clay Diffuse boundary			
5.11–5.21	Red-brown organic mud, with some silt and clay and frequent rusty mottles. Occasional fibres may be modern. Diffuse boundary	5.12–5.13		5.12–5.13 cal AD 70–225
5.03–5.11	Red-brown organic mud. Diffuse boundary	5.09–5.10 5.05–5.06	5.05–5.10 macros	
4.97–5.03	Brown organic mud, becoming increasingly peaty with depth. V. gradual boundary	5.01–5.02 4.98–4.99	5.01–5.02 diatoms 4.97–5.02 macros	5.01–5.02 200–50 cal BC
4.83–4.97	Dark brown well-humified detritus peat, becoming wetter towards the base. Rare fragments of herba-ceous plants. V. gradual boundary	4.95–4.96 4.90–4.91 4.85–4.86	4.88–4.93 macros, beetles	
4.43–4.83	Black coarsely fibrous poorly/ moderately humified peat with rare frags herbaceous and woody plants. Worked wood at 4.49m OD and below. Snails present throughout. Occasional small stones. Clay sling stones	4.81–4.82 4.74–4.75 4.71–4.72 4.64–4.65 4.57–4.58 4.51–4.52 4.44–4.45	4.79–4.84 macros, snails 4.69–4.74 macros, snails 4.49–4.54 macros, beetles, snails	4.80–4.81 510–395 cal BC 4.44–4.45 1125–940 cal BC

extensively mottled with iron staining. A layer of grey-brown blocky clay with orange mottles, 0.38m deep sealed the organic sediments, reaching up to the ground surface at 5.59m OD. During the excavation, cultural material (worked wood, bone and clay sling stones) was recovered from the lower detritus peat. The top of the worked wood blocks were found at 4.50–4.53m OD. The stratigraphy and sampling scheme for pollen, plant macrofossils, insects, snails and radiocarbon is shown in Table 124.

The deposits sampled from the 2003 site extend from 1125–940 cal BC at 4.45m OD to cal AD 70–225 at 5.13m OD. Though the exact dating of the settlement remains somewhat problematic, the period before the village was constructed, the occupation phase, and the period of abandonment are all covered in this time span (Coles and Minnitt 1995).

The pollen assemblage zones

Heather Tinsley

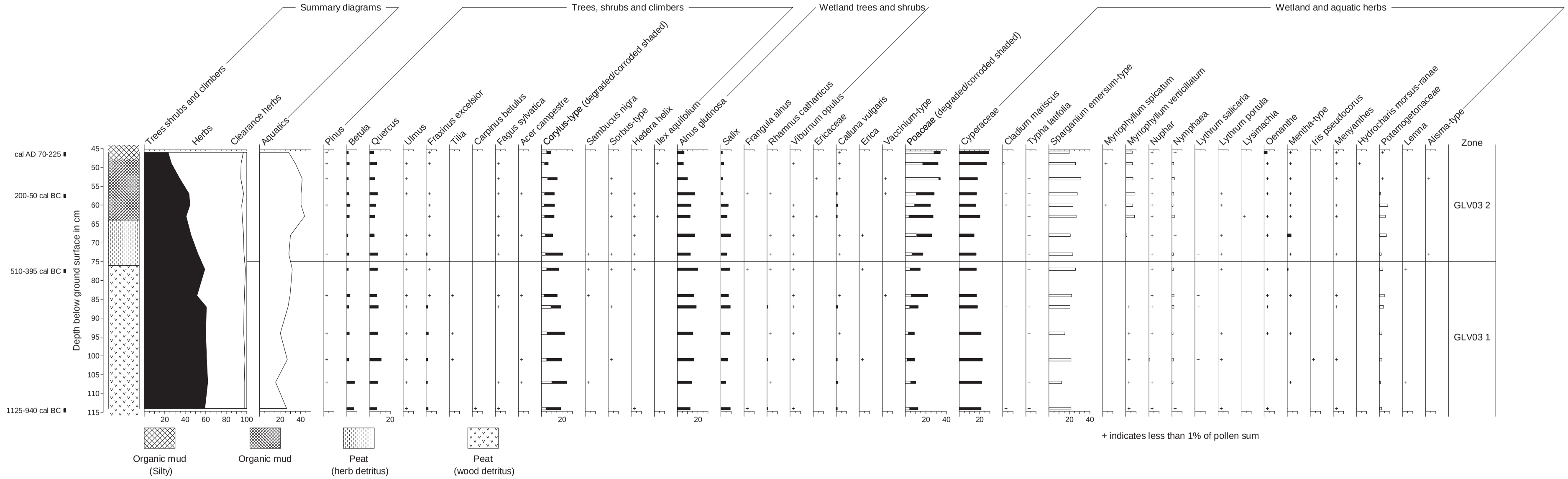
The pollen diagram for these samples is shown in Figure 170.

GLV03 1 (Below 4.84m OD; 75–115cm below the ground surface): Tree pollen forms 51–62% TP, principally *Corylus*-type (15–25% TP) and *Alnus* (13–20% TP). *Quercus* is present at 7–11% TP, *Betula* at 2–8% TP and *Salix* at 5–9% TP. *Pinus*, *Ulmus*, *Fraxinus* and *Rhamnus catharticus* are consistently present at very low frequencies. Herbaceous pollen is dominated by Cyperaceae (17–23% TP) and *Sparganium emersum*-type (12–26% TP+aquatics). A wide range of aquatic taxa are present at low frequencies including *Nymphaea* (1–2% TP+aquatics) and Potamogetonaceae (2–5% TP+aquatics). Pollen of clearance taxa is present throughout at low frequencies and includes *Plantago lanceolata* (1–2% TP) and cereal-type (<1% TP). Pteropsida (undifferentiated) form 16–25% TP+ferns and spores of *Pteridium* and of *Thelypteris palustris* are consistently present at low frequencies. Unknown and indeterminable grains form 2–4% TP+indeterminables. The majority of *Corylus*-type grains show no biochemical deterioration. Pollen concentrations are moderately high throughout the zone. Microscopic charcoal concentrations are very low, with no charcoal found in some samples.

GLV03 2 (4.84–5.13m OD; 45–75cm below the ground surface): Tree pollen declines steadily from the start of this zone to the end, forming 52–23% TP. *Corylus*-type falls from 21–7% TP, *Alnus* falls from 17% TP mid-zone to 6% TP at the zone end, and *Salix* forms 1–7%

Glastonbury Lake Village 2003

Part 1
Percentages of total pollen minus aquatics



Part 2
Percentages of total pollen minus aquatics

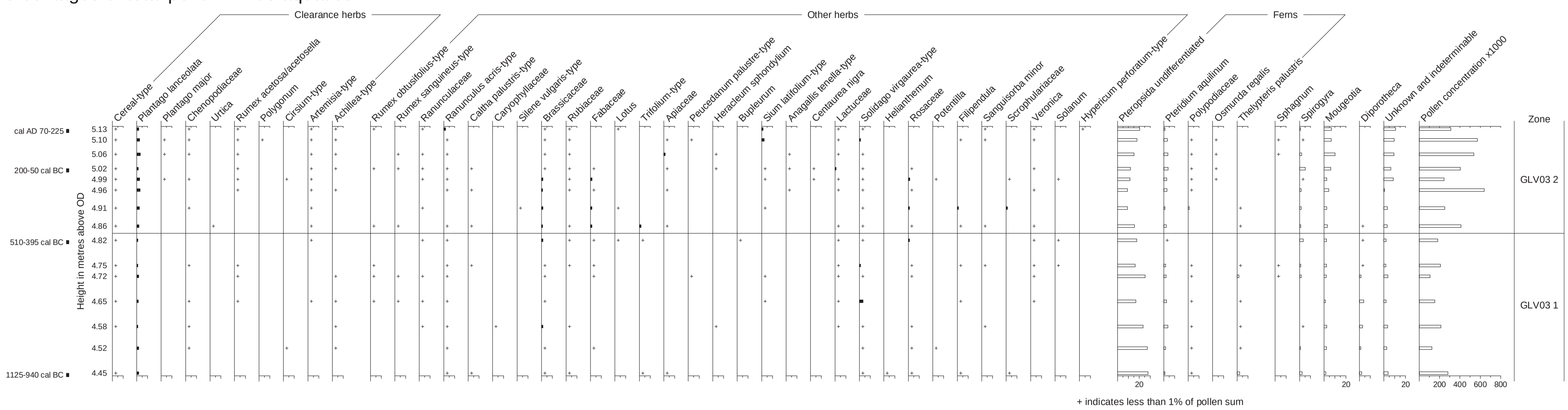


Figure 170. Glastonbury Lake Village pollen diagram.

TP. Frequencies of *Quercus* pollen vary from 4–8% TP. *Fraxinus* and *Fagus* are consistently present at very low frequencies. Of the herbaceous pollen taxa, Cyperaceae form 14–28% TP and Poaceae increase throughout the zone forming 17–34% TP. *Sparganium emersum*-type contributes 19–31% TP+aquatics and other aquatic herbs form small peaks including *Myriophyllum verticillatum, Nymphaea* and Potamogetonaceae. Pollen of *Plantago lanceolata* increases to 2–3% TP and overall the diversity of herbs increases. Frequencies of spores of Pteropsida fall slightly compared to GLV03 1. Towards the top of the zone unknown and indeterminable grains rise to 10% TP+indeterminables. The majority of grains of *Corylus*-type and Poaceae are not biochemically deteriorated, though the frequency of decayed grains increases towards the zone end. Pollen concentrations increase markedly at the start of this zone. Microscopic charcoal concentrations increase at the start of the zone and rise significantly at its end.

Plant macrofossils

Julie Jones

The four bulk plant macrofossil samples, initially taken during the excavation, were targeted at the deposits at the base of the sequence in the poorly humified peat where cultural material associated with occupation of the village occurred and from the overlying detritus peat (Table 124). These artefacts must have sunk through the poorly consolidated detritus, after being discarded from the platform on which the village stands, as subsequent radiocarbon dating has shown that these lower deposits accumulated prior to occupation of the Lake Village. Therefore two additional samples were taken from the pollen monolith, in the brown organic mud which appears to correspond to the period of occupation and from the overlying unit, to complete the sequence.

In addition to the plant macrofossil table, which lists all taxa counted (Table 125) a second table (Table 126) shows percentages of the different habitat groups represented, with a further section to show zonation of aquatic taxa to indicate the position of the macrophytes within the water body, to aid interpretation of the data.

4.49–4.54m OD, 4.69–4.74m OD and 4.79–4.84m OD: These three samples were from the basal unit of black coarsely fibrous peat, associated with occasional small stones, clay sling stones and worked wood at 4.49m OD. The samples are dominated by aquatic taxa with an increase from 66% at the base of the unit (4.49–4.54m OD) to 73% at the top (4.79–4.84m OD). The most prominent group in this basal unit are the submerged taxa, including *Myriophyllum* and *Najas*, typical of deeper water, but dominated by *Chara* (60–80%). The second major group is the rooted aquatics that occur in both the margins or in deeper water (19–35%), with the most significant taxa *Potamogeton*, plus a small group of unrooted plants which float on the water's surface (*Lemna* and *Ceratophyllum*). Swamp taxa form a smaller group (6–10%), mostly *Typha* which increases from 1% to 9% through the unit, but also *Cladium* (reduces from 4%–1%) and a trace of *Sparganium erectum*. Marsh taxa remain fairly consistent (15–10%), with Cyperaceae and other herbaceous taxa such as *Mentha aquatica*, *Lythrum salicaria* and *Ranunculus lingua*. Evidence for *Alnus* only occurs at low levels, but is most significant in the basal sample (11%) reducing to 6% at the top of the unit. There is a small, but consistent presence of disturbed ground taxa including *Urtica dioica*, *Rumex* and *Stellaria media*.

4.88–4.93m OD: This sample from the dark brown well-humified detritus peat is again dominated by aquatic taxa, although there is a reduction from the underlying unit (60%). Of the group of submerged taxa, numbers of *Chara* decline (60%) although there is a small peak of *Myriophyllum*. Both *Potamogeton* (28%) and *Nymphaea alba* (3%) increase. There is a significant increase of swamp taxa, largely *Typha* which increases from 9% in the underlying unit to 24%. Marsh taxa remain fairly consistent at 10% and there is a marked reduction in *Alnus* (2%). The disturbed ground element persists at low levels.

4.97–5.02m OD: In the organic mud there is a reduction of aquatics to 43%, with a decrease of *Chara* (54%), although *Myriophyllum* remains consistent (4%). *Potamogeton* also increases (32%) and there is a small increase in *Nymphaea* and *Ranunculus* subg. *Batrachium*. There is a further marked change with an increase of swamp taxa, again largely *Typha* (37%) with a slight increase of *Cladium*. Marsh taxa remain consistent and alder further reduces (1%). The disturbed ground element increases slightly (3%) with a greater number of taxa represented.

5.05–5.20m OD: In the red-brown organic mud, there is a further reduction of aquatics (40%) and the range of species is reduced with the assemblage dominated by *Chara* (66%) and *Potamogeton* (33%), other taxa only occurring as a trace. *Typha* is increasingly significant (55%) and there is a reduction of the marsh group (4%) and *Alnus* no longer occurs. The disturbed ground element reduces to a trace (<1%).

Insect remains

Harry Kenward

4.49–4.54 m OD: Invertebrates were moderately abundant (Table 127). There were an estimated 128 individuals of 90 adult beetle and bug taxa, but also quite large numbers of chironomid midge larvae, mites,

Table 125. Glastonbury Lake Village: plant macrofossil remains.

	Height (m OD)	4.49–4.54	4.69–4.74	4.79–4.84	4.88–4.93	4.97–5.02	5.05–5.10	Habitat
	Sample size (g)	**500**	**500**	**500**	**500**	**350**	**450**	
Characeae								
Chara spp	Stonewort	456	1016	698	341	148	296	A
Dennstaedtiaceae								
Pteridium aquilinum (L.)Kuhn (pinnules)	Bracken	1f	1f	2f	1	–	–	WEad
Nymphaceae								
Nuphar lutea (L.) Smith	Yellow Water-lily	4	–	–	–	–	–	AP
Nymphaea alba L.	White Water-lily	17	15	25	17	12	1	AP
Ceratophyllaceae								
Ceratophyllum c.f. *demersum* L.	Rigid Hornwort	4	9	1	2	–	–	PR
Ceratophyllum spp.	Hornwort	13	7	–	1	4	–	P: mostly near sea
Ranunculaceae								
Caltha palustris L.	Marsh Marigold	–	–	–	–	2	–	MP
Ranunculus acris/repens/ bulbosus	Meadow/Creeping/ Bulbous Buttercup	7	–	–	3	–	–	DG
Ranunculus flammula L.	Lesser Spearwort	1	–	–	–	–	–	MPRw
Ranunculus lingua L.	Greater Spearwort	8	12	2	4	1	–	M
Ranunculus subg. *Batrachium* (DC.) A. Gray	Water Crowfoot	8	19	16	11	11	1	APR
Urticaceae								
Urtica dioica L.	Common nettle	9	6	5	3	6	2	DGHWp
Urtica urens L.	Small nettle	–	–	–	1	–	–	CDl
Myricaceae								
Myrica gale L.	Bog-myrtle	20	12	6	2	2	–	E(w)F
Fagaceae								
Quercus sp. (bud)	Oak	3	–	–	–	–	–	HSW
Betulaceae								
Alnus glutinosa (L.) Gaertner (fruit)	Alder	26	18	36	8	3	–	RWw
Alnus glutinosa (L.) Gaertner (cone)	Alder	–	1	1	–	–	–	
Betula sp.	Birch	17	10	6	3	1	–	WEla
Corylus avellana L (catkin)	Hazel	2 f	–	–	–	–	–	
Chenopodiaceae								
Atriplex spp.	Orache	–	1	1	1	2	–	CDn
Chenopodium. ficifolium Smith	Fig-leaved Goosefoot	–	–	1	–	1	1	CD
Caryophyllaceae								
Lychnis flos-cuculi L.	Ragged Robin	3	–	–	–	1	–	GMSw
Stellaria media (L.)Villars	Common Chickweed	–	1	1	2	4	–	CD
Polygonaceae								
Fallopia convolvulus (L.) A. Love	Black-bindweed	–	–	–	–	1	–	CD
Persicaria hydropiper (L.) Spach	Water-pepper	–	1	–	–	–	–	w
Rumex spp.	Dock	6	3	1	–	–	–	DG
Clusiaceae								
Hypericum sp.	St. John's Wort	–	–	–	–	1	–	various
Salicaceae								
Salix spp. (bud)	Willow	14	1	–	–	1	–	w
Salix spp. (capsule)	Willow	2 f	1	–	–	–	–	
Brassicaceae								
Rorippa nasturtium-aquaticum (L.) Hayek	Water-cress	–	–	2	–	–	–	BPR
ROSACEAE								
Alchemilla spp	Lady's-mantle	–	–	–	1	1	–	GW – damp
Potentilla anserina L.	Silverweed	–	–	–	1	–	–	DG
Rubus sect. *Glandulosus* Wimmer and Grab	Bramble	1	–	1	–	–	–	DHSW

For habitat codes, see Appendix 1.

Table 126. Glastonbury Lake Village: plant macrofossils; habitat groups and aquatic macrophyte zonation.

		Fibrous peat – herbaceous and woody			**Detritus peat**	**Brown organic mud**	**Red-brown organic mud**	
4.44–4.45m 1125–940 cal BC				***4.80–81m 510–395 cal BC***		***5.01–02m GLV 200–50 cal BC***		***5.12–5.13m cal AD 70–225***
mOD	**Water depth**	**4.49–4.54**	**4.69–4.74**	**4.79–4.84**	**4.88–4.93**	**4.97–5.02**	**5.05–5.10**	
Aquatics		66	79	73	60	43	40	
Swamp/bankside		6	8	10	26	40	56	
(Typha)		*1*	*5*	*9*	*24*	*37*	*55*	
(Cladium)		*4*	*2*	*1*	*<1*	*2*	*1*	
(Sparganium)		*1*	*<1*	*0*	*<1*	*<1*	*0*	
Marsh		15	7	10	10	11	4	
Alder carr		11	5	6	2	1	0	
Disturbed ground		2	<1	1	1	3	<1	
Grasses					1	2		
Submerged/rooted in mud		62	81	78	66	58	66	
Myriophyllum	up to 1m	<1	<1	1	6	4	0	
Najas	1–4m	2	<1	<1	<1	0	0	
Chara	4cm+/up to 20m	60	80	76	60	54	66	
Float on surface, no roots		3	<1	0	<1	1	0	
Lemna	variable	<1	<1	0	<1	0	0	
Ceratophyllum	up to 1m	2	<1	0	<1	1	0	
Floating/rooted in mud; Margins and deeper		35	19	22	33	41	34	
Nuphar	up to 5m	<1	0	0	0	0	0	
Nymphaea	up to 3m	2	1	3	3	4	<1	
Potamogeton	variable	31	15	17	28	32	33	
Ranunculus Batrachium	variable, often shallow	1	2	2	2	4	<1	
Sagittaria	up to 45cm	0	<1	<1	0	0	0	
Alisma	shallow	<1	<1	<1	<1	1	<1	
Menyanthes	shallow	<1	<1	<1	<1	<1	<1	

Table 127. Main statistics for assemblages of adult beetles and bugs (excluding aphids and scale insects) from Glastonbury Lake Village.

Site	**GLV04**	**GLV04**
	4.88–4.93m OD	**4.49–4.54m OD**
S	67	90
N	105	128
ALPHA	79	134
SEALPHA	15	24
SOB	53	69
PSOB	79	77
NOB	89	103
PNOB	85	80
ALPHAOB	55	91
SEALPHAOB	11	18
SW	26	30
PSW	39	33
NW	58	57
PNW	55	45
SD	11	17
PSD	16	19
ND	15	22
PND	14	17
SP	12	18
PSP	18	20
NP	15	20
PNP	14	16
SL	1	1
PSL	1	1
NL	2	1
PNL	2	1
SRT	7	12
PSRT	10	13
NRT	7	15
PNRT	7	12
SRF	2	4
PSRF	3	4
NRF	2	4
PNRF	2	3
SSA	1	3
PSSA	1	3
NSA	2	3
PNSA	2	2
SSF	1	2
PSSF	1	2
NSF	2	2
PNSF	2	2
SST	0	1
PSST	0	1
NST	0	1
PNST	0	1

For explanation of abbreviations, see Appendix 2 and insect immatures including beetle larvae. Aquatics predominated, contributing 45% of the adult beetles and bugs (57 individuals of 30 taxa). Most abundant among these was *Ochthebius minimus* (10), followed by the little surface-walking bug *Microvelia reticulata* (4). There were also other aquatic invertebrates, including water fleas, caddis larvae, water boatman nymphs, and statoblasts of the bryozoan *Lophopus crystallinus*. Damp ground and waterside taxa, added another 17% of the fauna (22 individuals of 17 taxa). These two components indicate swamp and open water with rich vegetation. Notably, there were three *Oulimnius* sp., indicative of moving well aerated water, presumably from a stream inflow. Further species doubtless exploited waterside litter (*Corylophus cassidoides* and *Psammoecus bipunctatus*, for example, are characteristic of such places and not uncommonly found together).

4.88–4.93m OD: An estimated MNI of 105 adult individuals of 67 beetle and bug taxa were recorded, and there were large numbers of mites and fragments of immature insects. Chironomid midge larvae were moderately numerous, and there were smaller numbers of hymenopterans, with various other remains including a fragment of a flea. The last might be suspected to be a processing contaminant (from a sample from an occupation site, in which fleas are sometimes numerous), but it did not appear to be one of the species normally present in such deposits, being rather larger, so that it may in fact be contemporaneous with the rest of the fauna. The degree of erosion of the fossils was estimated to be a little worse than during assessment; whether this reflects further oxidation in storage (a phenomenon observed in other material on a number of occasions), or the inevitable vagaries of recording, is uncertain.

Aquatic insects were predominant, with 26 taxa and 58 individuals of adult beetles and bugs (55% of the assemblage), and the chironomids, three corixid (water boatman) nymphs and a single caddis larva. The fragments of insect immatures almost certainly belong in this category, too. All of the more abundant beetles and bugs have aquatic or waterside habitats: *Ochthebius minimus* (10), the weevil *Litodactylus leucogaster* (8), corixids (6), *Helophorus* sp. (4), *Anacaena* sp. (3) and the mud-dwelling *Dryops* sp. (3). Of the ten taxa represented by two individuals, only the woodworm *Anobium punctatum* did not fall in this category (many aleocharine staphylinids are found by water). Waterside and damp-ground taxa were rather abundant (15 individuals of 11 taxa, 14% of the adult beetles and bugs).

Decomposers were very uncommon (single individuals of seven taxa, 7% of the assemblage), and the only species flagged as synanthropic was *A. punctatum*, common in nature as well as in buildings. There was little sign of dry-land habitats beyond two *Aphodius* dung beetles.

Overall, this is the fauna of swamp with open water which was not too far from neutral, probably with a rich submerged and emergent flora. There was perhaps some dead wood nearby, perhaps just twigs, though *Anobium punctatum* flies well and may have originated some distance away. While the assemblages from 4.49–4.54m OD and 4.88–4.93m OD samples had much in common, there were significant differences: the former has more evidence of waterside litter and perhaps openings between plants, as well as of flowing water, in other words a more diverse environment. This is reflected in the figures for the index of diversity for the whole assemblages (alpha = 134, SE 24 for sample 4.49–4.54m OD, 79, SE 15, for sample 4.88–4.93m OD).

Diatom assessment

Nigel Cameron

A qualitative assessment of the main species found in the Glastonbury Lake Village sample is presented in Table 128. A diatom assemblage of high quality is present in the Glastonbury Lake Village sample.

The well-preserved and diverse diatom assemblage from the Glastonbury Lake Village sample reflects freshwater conditions. There is no indication of direct contact with brackish water. However, a small component of halophilous diatoms was found. These halophilous diatoms have optimal growth where there are slightly higher levels of dissolved (non-marine) salts. The halophilous diatoms present include: *Cyclotella meneghiniana*, *Melosira varians*, *Navicula oblonga* and *Rhopalodia gibba*. Their presence probably reflects a geological source of dissolved salts rather than any estuarine influence. The majority of the diatom assemblage reflects freshwater conditions with only moderate or low levels of dissolved salts. Indeed a number of the diatoms are halophobes that are typical of more oligotrophic, slightly acidic conditions, for example *Eunotia formica*, *Eunotia pectinalis*, *Eunotia pectinalis* var. *minor*, *Tabellaria flocculosa*, *Cymbella cesatii*. These attached species may for example reflect a source of diatoms from shallow water on peatland. The dominant component of the Glastonbury Lake Village diatom assemblage is of circumneutral, non-planktonic (and therefore shallow-water) species. These diatoms include epiphytes such as *Cocconeis placentula*, *Cymbella aspera*, *Epithemia adnata*, *Epithemia sorex*, *Synedra ulna*, *Synedra capitata* and *Gomphonema acuminatum* var. *coronatum*. Benthic, mud-surface, diatoms include *Navicula laevissima* and *Stauroneis smithii*. The freshwater centric species *Aulacoseira crenulata* that is common here is a semi-planktonic diatom (tychoplankton) and also begins its lifecycle in the benthic habitat, later forming part of the plankton. *Aulacoseira crenulata* is therefore consistent with a relatively shallow water depth. The diatom assemblage contains no aerophilous diatoms and does not therefore show any evidence for drying out of the lake or erosion from the catchment at this stage. There is no evidence for nutrient enrichment (eutrophication) for example as a result of organic pollution. The diatom assemblage reflects only moderate levels of nutrients available for algal growth.

Molluscan analysis

Paul Davies

Three samples of 'picked' shell and operculae were provided by Julie Jones. Preservation was good, though the number of shells was low.

4.49–4.54m OD: *Valvata piscinalis*: 2; *Bithynia tentaculata*: 6; *Bithynia* operculae: 27.
4.69–4.74m OD: *Bithynia tentaculata*: 8; *Valvata piscinalis*: 5; *Bithynia* operculae: 100+.
4.79–4.84m OD: *Bithynia* operculae: 36.

The species present plus the preponderance of operculae indicate that all 3 samples are indicative of the wash-zone of a substantial water-body. The water body was permanent and reasonably well-oxygenated. It is impossible to say what the depth was other than probably it was greater than *c*. 0.2m.

Environmental interpretation

Heather Tinsley and Julie Jones

In contrast to the sites at Sharpham and at Harter's Hill, which are either on the margin of the wetland of the Somerset Levels, or in the case of Harter's Hill 1997, just 50m out into Queen's Sedgemoor, the Glastonbury Lake Village 2003 site lies more than 1km from the nearest dry ground at Glastonbury island. It is well established that the environment of the area around the site was very swampy. Godwin's examination of the stratigraphy beneath Mound 5 in 1946 and 1947 recorded detritus muds beneath a 'mouldered brown peat with abundant wood fragments' which led him to suggest that the village had been built on an area of 'floating fen carr' (Godwin 1955). The sequence of detritus peats and organic muds revealed in the trenches excavated in 1984, in association with the Somerset Levels Project, and in the 2003 sampling trench, testify to this waterlogged environment.

Pollen and plant macrofossils from the 2003 site are well preserved throughout the sampled section. Pollen frequencies of degraded *Corylus*-type and Poaceae grains are generally less than 30% of the counted taxon, though degraded Poaceae do increase in the upper most samples. Indeterminable grains are at very low levels, though they also increase towards the top of the diagram.

Below 4.84m OD in LPAZ GLV03 1, the pollen assemblage is very uniform, suggesting little change in conditions between the start of the zone at 1125–940 cal BC and its end just after 510–395 cal BC. Tree pollen percentages and macrofossils indicate that *Alnus* and *Salix* were growing on peat relatively close to the site, the percentages of *Salix* pollen suggesting that willow was a co-dominant with alder, probably along with some *Betula*. The poorly preserved birch fruits are likely to be *Betula pubescens* (downy birch) which, like *Myrica gale*, the fruits of which were also recovered, favours wetter, peatier soils. On the basis of morphology, a proportion of the *Corylus*-type pollen in this zone is likely to be *Myrica.* Occasional pollen grains of *Rhamnus catharticus* and *Viburnum opulus* are evidence of the presence of these shrubs in what must have been a mixed wet carr community with an understorey including *Urtica dioica*.

At the site itself the wetland ground flora at the water's edge was made up of a relatively rich swamp community including beds of Cyperaceae, *Sparganium*, Poaceae and *Typha*, many of these dominants forming a mosaic, where the ground would have been covered with water for most of the year. There was also a wide range of flowering herbs associated with the reed-bed dominants, perhaps at a greater distance

Table 128. Glastonbury Lake Village, common diatom species in the assessment sample.

Diatom species	**+ species present; ++ species common**
Achnanthes minutissima	+
Aulacoseira crenulata	++
Cocconeis placentula and var. *euglypta*	++
Cyclotella meneghiniana	+
Cymbella aspera	+
Cymbella cesatii	+
Cymbella minuta	+
Epithemia adnata	++
Epithemia sorex	+
Eunotia formica	+
Eunotia pectinalis	+
Eunotia pectinalis var. *minor*	+
Fragilaria capucina var. *mesolepta*	+
Gomphonema acuminatum var. *coronatum*	+
Melosira varians	+
Navicula laevissima	+
Navicula oblonga	+
Nitzschia amphibia	+
Rhopalodia gibba	+
Stauroneis smithii	+
Synedra acus	+
Synedra capitata	+
Synedra ulna	+
Tabellaria fenestrata	+
Tablellaria flocculosa	+

from the water's edge, but where ground conditions remained wet. These are represented consistently, but at low frequencies, in both the pollen diagram and the macrofossil record and included *Lythrum salicaria*, *Mentha aquatica*, *Rumex* spp., Ranunculaceae (buttercup family), *Iris pseudacorus* (yellow iris) and others.

It is clear from the invertebrate fauna and aquatic taxa which dominate the macrofossil record, and are present at low frequencies in the pollen diagram, that there were open pools or channels between the swampy vegetation mats and these provide an indication of local water conditions. The invertebrates indicate swamp and open water with rich vegetation, with some suggestion from three *Oulimnius* species of moving well-aerated water, possibly from a stream inflow. However, the most significant group of aquatic plant macrofossils appear to be those which generally occur submerged and rooted in the mud, in waters of varying depths, particularly *Chara*, but also *Najas*, *Myriophyllum* and some *Potamogeton* species. *Chara* is a macroscopic green alga which anchors to soft muddy substrata in shallow clear water in depths from 4cm, although they can also occur in depths up to 20m (Moore 1986). *Najas* (likely here to be *Najas flexilis* – slender-leaved naiad), also occurs completely submerged in depths of 1–4m (but seldom less than 1m) and *Myriophyllum verticillatum* occurs in shallow water up to 1m. Both prefer mesotrophic to eutrophic conditions in still to slow moving waters (Haslam *et al.* 1975).

Other identified aquatics are those that float freely on the water's surface with no roots attaching them to the substrate and again an indication of water depth is given by *Ceratophyllum demersum* (rigid hornwort) which occurs in shallow water with a stable level, in depths up to 1 metre. *Lemna* is found on almost any water surface as its free-floating habit, often carpeting the surface in still water conditions, means it is not affected by depth. Other floating-leaved plants, rooted in the mud in water of varying depths, occur both at the margins and further out into the water body, but with leaves either floating on the surface or standing out of the water. These include *Sagittaria sagittifolia*, some species of *Potamogeton*, *Ranunculus* subg. *Batrachium*, *Menyanthes trifoliata*, *Nymphaea alba*, which roots on muddy bottoms in depths up to 3m where there is little or no water movement and *Nuphar lutea* in depths up to 5m.

The eutrophic conditions of the water body at the Glastonbury Lake Village site clearly supported a dense growth of macrophytes, algae (including *Spirogyra* and *Mougeotia*, the spores of which were found in the pollen preparations) and freshwater invertebrates. These included cladoceran ephyppia (water-flea egg-cases), chironomid midge larvae, leech cocoons and caddis fly larvae, plus a small assemblage of fish bones and scales, with freshwater snails, particularly *Bithynia tentaculata*, indicative of the wash zone of a substantial water-body.

Above 4.83m OD, there is a stratigraphic change to a finer detritus peat, with a reduction in the concentration of plant remains. This marks the start of LPAZ GLV03 2, and at this level pollen concentrations increase suggesting that the upper sediments accumulated more slowly than the coarser detritus below. This is followed by organic mud deposition contemporary with occupation of the lake village. GLV03 2 is characterised by a gradual but steady increase in Poaceae pollen, although there is no corresponding evidence for grasses in the macrofossil record. This increase of Poaceae pollen occurs at the expense of the pollen of tree and shrub taxa; initially this affects *Corylus*-type and to a lesser extent *Alnus* and *Quercus*, while the frequencies of *Salix* pollen are maintained. However, above 5m OD *Salix* pollen is greatly reduced and this is followed by a further decline in *Alnus* pollen and corresponding absence of alder macrofossils. It appears that from soon after 510–395 cal BC both the carr woodlands and the dry land woods began to open up. Changes were gradual at first and do not appear to have greatly affected the wet woodland adjacent to the 2003 trench. However, from just before 200–50 cal BC, in the organic mud, the local *Salix* carr was reduced, followed by a decline in *Alnus* and it seems likely that this represents the clearance of the adjacent village site.

The pollen evidence suggests that, at the start of GLV03 2, when the well humified herb detritus peat was forming, the swamp community continued to support Cyperaceae. The spread of grasses may indicate an extension of reed beds in the wider area. The evidence from the macrofossils indicates that locally *Typha*, another member of the reed bed community, was spreading. The pollen curve for *Sparganium emersum*-type includes *Typha angustifolia* (lesser bulrush) as well as bur-reeds. All of the more abundant beetles and bugs have aquatic or waterside habitats and an open water habitat supporting both submerged and rooted aquatics appears to have persisted, but there were local changes in the dominant taxa reflected in increases in macrofossils of *Potamogeton* and *Myriophyllum* and a decline in *Chara*. Possibly the water was becoming deeper, at least in places; a depth of at least 3 metres is indicated by the continued presence of macrofossils and pollen of *Nymphaea* and pollen of *Nuphar*.

The change in stratigraphy to organic muds above 4.97m OD is evidence that this trend to deeper water conditions continued, at least until after 200–50 cal BC, and therefore was characteristic of the period during which the village was occupied. The decline in the macrofossil record for *Chara* continues in the lower unit of organic mud, while in the pollen diagram there is an expansion of *Myriophyllum verticillatum* which persists through the upper sediments; *Myriophyllum* macrofossil remains are also present. Water-milfoils grow in base-rich ponds, lakes and slow rivers; *M verticillatum* is now quite rare (Rodwell 1995), but it is still found growing in rhynes on the Somerset Levels including South Moor, Glastonbury (Green *et al.* 1997).

Both the pollen and macrofossil records suggest that *Nymphaea* was making an increasing contribution to the aquatic community in the lower organic mud, which is added support for the continuance of deeper water. This mud contained a well preserved and diverse diatom assemblage reflecting a freshwater, circumneutral environment. The dominance of benthic, epiphytic and epilithic diatoms in the assemblage suggest that the water depth was relatively shallow however, according to Cameron this could certainly be up to 3m. A number of the diatoms found were typical of oligotrophic, slightly acid conditions and may reflect a source of diatoms from shallow water on peatland. This could reflect input of drainage water from the raised bog to the west of the Lake Village. In the upper red-brown organic mud, above 5.03m OD, there is some evidence of a return to shallower conditions as the macrofossils of *Chara* increase, perhaps associated with a further expansion of the reed-bed community marked by increased numbers of bulrush macrofossils. This episode appears to have culminated in increasingly silty deposition above 5.11m OD, which was taking place by cal AD 70–225.

Pollen taxa indicative of clearance are present at relatively low frequencies throughout the diagram (particularly *Plantago lanceolata*, but also cereal-type and the Asteraceae); these represent the habitats created by human activity on the dry land in the wider region from the late Bronze Age onwards. After 510–395 cal BC, at the start of LPAZ GL03 2, there was a small expansion in *Plantago lanceolata* and the representation of pollen of other herbs associated with disturbed dry land sites in the pollen diagram increases in this zone to include *Plantago major* (greater plantain), *Centaurea nigra* (knapweed) and *Artemisia* (mugwort) and there is a small peak in pollen of Lactuceae. This must reflect the spread of agricultural activities associated with the increasing Iron Age population of the area. However, considering the close proximity of the palisade to the environmental sampling trench, it is notable that there is no obvious peak in ruderal pollen during GLV03 2, which might be associated with the start of the occupation of the village site. There is also a small disturbed ground element in the macrofossil record which persists throughout all samples at low frequency, but shows a slight increase associated with the period of village occupation. Many of these taxa, such as *Stellaria media* (chickweed) and *Atriplex* (orache), are opportunists that occur in disturbed waste ground areas, with some like *Chenopodium ficifolium* (fig-leaved goosefoot) preferring soil enrichment, often associated with manure heaps. However these are mainly single occurrences and it seems that the environment on the wood platform between the huts was simply too wet and too worn by trampling to support weed communities. The increase in the Iron Age population of the region is reflected in higher values for microscopic charcoal which occur in the sediments above the horizon dated to 510–395 cal BC. Frequencies increase steadily through to the top of the sequence at cal AD 70–225.

Discussion

Earlier environmental work examined various locations around the Lake Village, using studies of stratigraphy, pollen and plant macrofossils, with some sites also providing radiocarbon dates (Coles *et al.* 1988; Housley 1988). The overall picture of the landscape at the edge of the Lake Village, derived from the 2003 environmental trench, for the period prior to construction through to its abandonment, largely agrees with the interpretations from these earlier investigations.

In the initial excavations by Bulleid, bases and roots of *Salix* and *Alnus* trees were found *in situ* on the village site (Bulleid and Gray 1911). In Godwin's (1955) pollen diagram from the south-western edge of the village, beneath Mound 5 (re-expressed by Housley 1988), frequencies of *Salix* pollen are relatively high (for an insect pollinated, under-producing taxon) indicating the importance of willow in the local area prior to the village construction and this is also clear from the 2003 pollen diagram. However, it is difficult to make any direct comparisons between Godwin's diagram and that from the 2003 trench, even though the sites are only 20m or so apart. Godwin's (1955) diagram was not radiocarbon dated and there must undoubtedly have been disturbance and loss of sediment from beneath Mound 5, associated with the construction of the village, so the pollen diagram is unlikely to extend up to the period of occupation; how much is lost remains a matter of conjecture. However, despite not being able to relate the pollen records from the two sites directly, it is obvious that the pollen frequencies of *Alnus* and *Corylus* in the sediments beneath Mound 5 are significantly higher than those found anywhere in the 2003 diagram (Godwin distinguished *Myrica* from *Corylus* morphologically; this has not been systematically attempted in the current analysis). This must reflect the contrast between the patch of carr woodland which became the village site and the more open swamp vegetation with channels and pools which immediately surrounded it.

On the margins of the western side of the village the stratigraphy and macrofossils from undisturbed deposits were investigated by Housley (Coles and

Minnitt 1995, 125–6), at a point where a break in the timber palisade occurred between Mounds 31 and 76 (SLP 1). Unfortunately this sequence is also undated but a change can be seen from a wet *Alnus*/*Betula* fen carr with some aquatics, to a sedge fen environment with aquatic taxa indicating areas of open water. A sharp transition to a silty clay deposit with inclusions of charcoal fragments occurs at *c*. 4.51m OD, dominated by *Typha* and *Juncus*, with the sequence truncated above this, perhaps associated with construction of the village. Also close to the village on the north-eastern side, two sequences from deposits associated with the 'Causeway', suggested to have been a landing stage for boats, were examined for plant macrofossil remains (SLP 3). The monolith (3B) from beneath the Causeway shows a high concentration of *Alnus* macrofossils in a sedge fen environment, in contrast to the monolith abutting the Causeway bank (3A) which was of a less woody nature with increased aquatics. Housley (1995, 127) suggested that builders of the Causeway may have made a deliberate decision to choose a firmer substrate for the construction.

In contrast to the position of the MARISP 2003 site at the southern extremity of the site, Housley's trench SLP 2 looked at the natural sequence of deposits *c*. 40m to the north of the northern palisade. This sequence is well dated and starts around 1168–995 cal BC with a wet *Alnus* and *Salix* fen carr environment with open water indicated by a range of aquatics, including some brackish indicators. This is succeeded by wetter conditions with peaks of *Cladium* and increased aquatics, then a short-lived phase which saw the deposition of a blue-grey estuarine clay associated with the establishment of *Phragmites* beds, dated 730–525 cal BC, which Housley (1995, 125) has associated with the *Phragmites* layer beneath the Village. Colonization by *Typha* followed, and charcoal levels increased, probably associated with occupation of the village.

The various investigations described above, including the most recent MARISP analyses, suggest variations in the wetland environment surrounding the Lake Village, with areas of open water and channels of varying depths, with slow to negligible flow supporting a mosaic of swamp and fen communities. Housley (1995, 136) concluded his investigations around the Lake Village site by stating that:

> the settlement is perhaps best described as a mire or swamp settlement ... and would have been sited on a clump of alder-willow fen whilst *Carex* and *Cladium* sedge fen encircled the palisade. Surrounding both would have been a shallow, open freshwater lake.

Housley's (1988) investigations of peat stratigraphy, pollen and plant macrofossils, also involved an extensive programme of coring in order to survey the stratigraphy across the wetlands to the north-west, north and north-east of the village site, towards the Godney– Garslade ridge, and to the south-east towards Glastonbury island. In transects from the Common Moor and Glastonbury Moor area he recorded a variety of detritus muds, some woody and some herbaceous, and he noted that these deposits were 'especially difficult to characterise' (Housley 1988, 66), a difficulty also encountered in the stratigraphic description of the Glastonbury Lake Village 2003 site. Towards the top of many of his profiles Housley (1988) recorded a change in stratigraphy to a fine detrital lake mud that he interpreted as representing deeper water conditions. The upper organic muds found above 4.97m OD at the 2003 site are likely to be the same stratigraphic unit. Housley (1988) analysed four of his cores for pollen, the one nearest to Glastonbury Lake Village is from Long Run Farm (GV 34), around 500m to the north. There are strong similarities between the upper part of the Long Run pollen diagram and the pollen record from the 2003 site.

The stratigraphy, pollen and plant macrofossils from the 2003 excavation all indicate that the area around the site on which the Lake Village was built was very wet and swampy by 1125–940 cal BC. A rise in the water table in the Glastonbury region has been associated with the marine incursion which affected the Axe valley in the early part of the first millennium cal BC and entered the Brue valley through the Panborough gap, depositing the Upper Wentlooge marine alluvium (Housley 1988; Brown, 2006; Aalbersberg *et al.* in press). This is the same formation which Godwin (1955) called the 'Romano-British clay'. Calibrated dates for the regressive contact of this clay, north of Glastonbury show close agreement, falling within the range 810–440 cal BC (Housley *et al.* 2000). Aalbersberg (1999) obtained a somewhat later date which calibrates to 400–110 cal BC (V. Straker pers. comm.) for the end of clay deposition in the Back Wear and Godney Moor area.

The Upper Wentlooge alluvium was traced by Housley (1988) to within 40m north of the Lake Village in Trench SLP2, where it was represented by a thin clay band, no more than 1cm, thick dated to 730–525 cal BC (Coles and Minnitt 1995, 124), before the building of the village. The alluvium was not found in the Somerset Levels Project Trenches 1 and 3, from the west and east margins of the village site, nor was it found in the 2003 trench, on the southern margin of the village, so it appears that these locations were beyond the limits of the marine transgression. There are no convincing indicators of brackish water conditions in the pollen diagram, macrofossils or diatoms at the 2003 trench, to suggest that estuarine conditions reached so far inland. The pollen curve for Chenopodiaceae (a genus which includes many halophytic species as well as some herbs typical of disturbed ground) is constant throughout the pollen diagram at frequencies of <1% TP. The diatom assemblage from the lake mud at 4.97–5.03m OD had a small component of halophilous diatoms, but their presence probably reflects a geological source of dissolved salts rather than any estuarine influence and there was no indication of direct contact with brackish water.

The Lake Village was abandoned around 50 BC (Coles and Minnitt 1995), therefore before the horizon dated to cal AD 70–225 at 5.13m OD at the 2003 site. There are no clear indicators in the pollen or macrofossil record to suggest an environmental trigger for this event; the increased wetness in the swamp on the edge of the village site began well before the village was built. A change in the sedimentary environment is indicated by the more mineral rich mud right at the top of the sequence above 5.11m OD, and this might have significance in terms of the end of the occupation. The mud was distinguished by marked rusty iron staining, probably related to recent water table fluctuations. The increased clay and silt content could reflect silting of open water channels, a factor that was suggested by Coles and Minnitt (1995) as possibly implicated in the abandonment of the Lake Village site. Such silting could have resulted from increased overland flow and consequent erosion associated with later Iron Age clearance of woodland and cultivation on the higher land. As channels silted up, passage from the Lake Village to the adjacent dry islands may have been inhibited, or possibly the access between the village and the main rivers draining to the sea became difficult.

The small decline in the pollen curve for the obligate aquatics, which occurs right at the top of the 2003 pollen diagram, could be a response to shallower, more turbid water. Some 8cm above the dated horizon of cal AD 70–225 at the 2003 site, the silty mud was replaced by grey brown clay, which reached to the ground surface. Housley (1988) obtained a much earlier date of 332–430 cal BC for a similar stratigraphic boundary at SLP 2 and he linked this change in sedimentation to alluviation associated with persistent seasonal flooding by the local rivers. Housley (*ibid.*, 78) commented on the difficulties of dating this stratigraphic change as the material available for radiocarbon dating was 'mouldered and disturbed due to drainage', this may possibly account for the differences between the two dates, or it maybe that alluviation commenced earlier on the northern side of the village.

Fieldwork conclusion

The fieldwork at Glastonbury Lake Village was very successful. From a research perspective it proved that, in part of the settlement at least, the majority of the foundations were left *in situ* by Bulleid and Gray and still survive to the present day. This, in combination with the apparent sequential building and collapse of multiple palisades suggests that considerable quantities of waterlogged cultural material may still exist on the site within and under the foundations and underneath the collapsed palisade(s).

The excavations have supported the accuracy of Bulleid's excavation plans and have hinted at the chronological complexity of the site. The minimalist excavation strategy imposed on the fieldwork prevented a thorough characterisation of the wooden structure and establishment of a complete stratigraphic framework. The limited evidence gathered suggests that there may have been several phases of development of the palisades around the settlement. The outer palisade has also clearly slumped outwards. This suggests that cultural material deposited immediately outside the palisade should still be present *in situ*. The cultural material recovered from Trench 2 reinforces the results of Bulleid's investigations beyond the borders of the settlement, and suggests that cultural material exists throughout the present field and possibly beyond. The new mound observed on the northern edge of the field also suggests that significant activity took place beyond the palisade and casts a slight doubt on Housley's interpretation of his findings in his northern trench.

The palaeoenvironmental analysis has added great detail to what was previously known about the site and has provided a much needed chronological framework for the wetland deposits on the southern side of the settlement. It is particularly significant that the occupation takes place when the water depth in the swamp increases and is abandoned when it shallows, possibly leading to the silting up of the main water communication channels. Further chronological enhancement of the occupation and the palaeoenvironmental evidence is required to fully understand this relationship between human activity and the changing natural environment.

Glastonbury Lake Village assessment and monitoring

Assessment of preservation

Visual assessment of wood

The wood in Trench 1 that had previously been exposed in Bulleid's excavations, was in a poor state of preservation with evident decay, cracking and loss of surface detail. This poor condition was confirmed by the difficulties encountered in species identification on the site. Examination of Bulleid's excavation photographs from the same area reveal that the palisade and foundation material were in a similar condition at that

Table 129. Glastonbury Lake Village: moisture content values and state of degradation.

Timber no.	% Moisture content	Timber condition
10	854	Heavily degraded
12	908	Heavily degraded
13	1041	Heavily degraded
28	241	Medium degraded
54	859	Heavily degraded
75	272	Medium degraded
89	301	Medium degraded

Table 130. Glastonbury Lake Village: wood species, % moisture content (MC) and density values.

Timber no.	Wood species	% MC	Original density	Present density
10	Willow?	854	0.42	0.1
12	Willow?	908	0.42	0.1
13	Willow	1041	0.42	0.09
28	Alder	241	0.48	0.32
54	Willow?	859	0.42	0.1
75	Alder	272	0.48	0.29
89	Alder	301	0.48	0.27

time. This may have been a result of previous decay, a product of exposure to the summer sun during the excavations, or a combination of the two. The continuing survival of this upper material to the present day is somewhat surprising. In the limited locations where the upper material was removed the surface condition and colour of the lower material appeared excellent.

Detailed examination of wood structure

Mark Jones

The state of degradation, as given by the moisture content taken from an average of three samples is shown in Table 129. The condition of the timber samples range from heavily degraded for the willow to medium degrade for the alder. All willow samples had moisture content values above 854% and range up to 1041%. Alder samples had a relatively narrow range of 241–301%.

Table 130 lists the original and present density values for each timber samples. The density values recorded for willow was extremely close to zero indicating substantial losses of original cell wall material. Timber 13 had the lowest density value of 0.09. Alder samples were classified as medium degrade with density values that ranged between 0.32 and 0.27.

Willow samples examined by microscopy were highly decayed with no secondary wall layers intact. Cellular framework was maintained by the middle lamella. Alder samples examined were of medium degrade with cells exhibiting different stages of degradation. Totally degraded fibres are found among partially degraded ones.

The picture of decay of Glastonbury Lake Village timbers is further elaborated by chemical changes to the cell wall components (Figures 171–2). Visually there appears little difference amongst the two spectra for ancient alder. Although hemicellulose has been lost, all lignin peaks are very prominent. Other notable changes include slightly decreased absorptions at 897cm^{-1} and 1370cm^{-1}, which suggests that the degree of crystallinity and cellulose content has been reduced. In this condition the timbers at the Glastonbury Lake Village would collapse upon drying if not stabilised with a consolidant.

Pollen evidence

Heather Tinsley

The five samples for environmental assessment came from a trench just outside the palisade of the settlement. They extended through 0.8m of rather variable sediments, ranging from wet, poorly humified peat at the base, to drier organic silts towards the top of the section. A layer of buff-orange blocky clay 0.3m deep sealed the organic sediments, reaching up to the ground surface at 5.59m OD. Cultural material (worked wood, bone and clay sling stones) was recovered from sediments below about 4.79m OD. Samples from 4.51–4.52m OD, 4.71–4.72m OD and 4.81–4.82m OD came from the very wet, poorly-humified peat towards the base of the section, a sample from 4.90–4.91m OD came from drier, better-humified detritus peat higher up the stratigraphy, and the upper sample came from the overlying organic silt at 5.12–5.13m OD.

Pollen preservation

At 4.51–4.52m OD, in the wet, poorly humified peat, 50% of grains were well preserved (Table 131). There were four indeterminable grains. 12% of grains identified were poorly preserved, mainly due to corrosion of *Corylus*-type, *Betula* and *Alnus*. Slight degradation affected a range of taxa, and just two grains, one of *Alnus* and one of *Betula,* were extensively thinned. Four pollen grains showed some mineral infilling, this was extensive in the case of single grains of *Ulmus* and *Corylus,* but it did not impede grain recognition. The biochemical preservation index was 0.69 and the mechanical preservation index was 0.18. Fern spores were largely well preserved.

The samples from 4.71–4.72m, 4.81–4.82m and 4.90–4.91m OD, which had similar pollen spectra, also had similar preservation characteristics. Overall

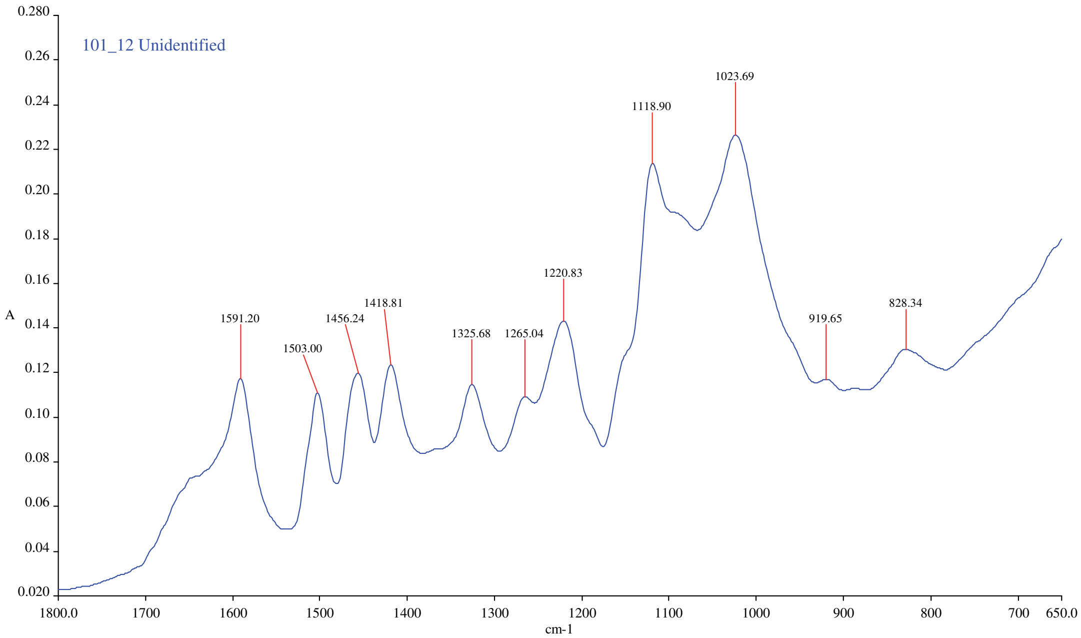


Figure 171. FT-IR spectra of Glastonbury Lake Village timber sample 12.

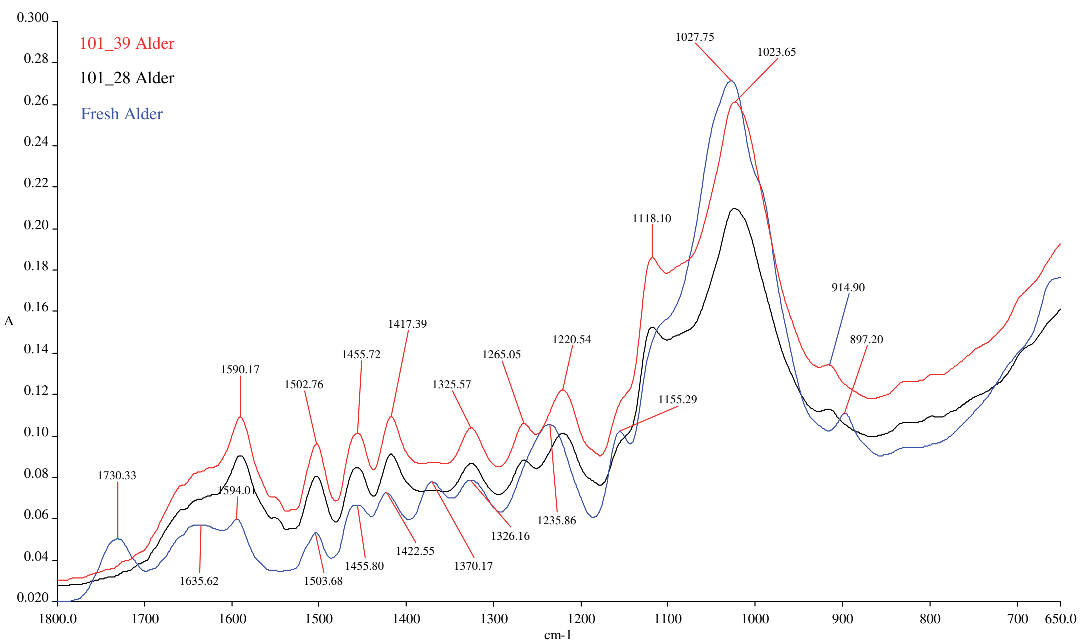


Figure 172. FT-IR spectra of Glastonbury Lake Village timbers 28 and 89 (both alder) and modern alder.

pollen preservation was better than in the basal sample. 54–71% of grains were well preserved. The numbers of indeterminable grains ranged from one to five. The percentages of identified grains with poor preservation ranged from 2–7%, with both corrosion and degradation deterioration-types contributing. Slight-moderate corrosion was apparent in a few grains in all samples and partial degradation also affected a range of taxa. One grain (*Corylus*) from 4.81–4.82m OD showed some mineral infilling. 9–12% of grains showed some mechanical damage. Biochemical preservation indices ranged from 0.26–0.45, the highest value being associated with an increase in partial degradation at 4.81–4.82m OD. Mechanical preservation indices ranged

Table 131. Glastonbury Lake Village: pollen preservation summary.

	4.51–52m OD	4.71–72m OD	4.81–82m OD	4.90–91m OD	5.12–13m OD
Total identified pollen grains	100	100	100	100	100
Pollen concentration	86,960	49,700	132,500	397,500	347,800
Number of pollen taxa	18	19	17	20	15
Total indeterminable grains	4	3	1	5	21
Total identified extensively corroded grains (a)	9	2	1	1	0
Total identified extensively degraded grains (b)	2	0	4	1	40
Total identified extensively crumpled grains (c)	0	0	0	0	0
Total identified extensively broken grains (d)	1	0	1	0	0
Total identified grains with poor preservation (a+b+c+d)	12	2	7	2	40
Total well-preserved grains	50	71	54	65	20
Total grains of resistant taxa	1	1	0	0	1
Total ferns	34	62	19	11	31
Biochemical preservation index	0.85	0.36	0.6	0.49	1.44
Mechanical preservation index	0.18	0.15	0.21	0.17	0.32

from 0.15–0.21. Fern spores were in a good state of preservation in all samples.

The poorest preservation in this sequence was found at 5.12–5.13m OD where only 20% of grains were well-preserved. There were 21 indeterminable grains. This was mainly the result of degradation and/or crumpling. 40% of identified grains were poorly preserved. In contrast to the basal sample, this was almost entirely due to extensive degradation (exine thinning), which affected more than half of all Poaceae, *Sparganium emersum*-type and Cyperaceae grains. 15% of all grains exhibited some mechanical damage, both breakage and crumpling, though this was not extensive. The biochemical preservation index was 1.23 and the mechanical preservation index was 0.32. 25% of all fern spores in this sample showed some etching of the surface.

It is not clear why pollen preservation should be poorer in the basal sample than it is in the peat immediately above. The site stratigraphic descriptions (Appendix 5) show that the lower peat was highly waterlogged, yet the deterioration type which is most prevalent in this sample is corrosion, which is characteristic of high biological activity, usually associated with drier sites. The corrosion evidence is so clear, that it seems likely that there must have been some local, temporary lowering of water table after the peat at 4.51–4.52m OD had accumulated, before the site again became wet. However, there was no clear stratigraphic evidence, such as increased humification, to support this interpretation, indeed the reverse was the case, as the lower peat appeared poorly humified.

The three samples from between 4.71m OD and 4.91m OD exhibited far less corrosion than the basal sample, and consequently overall preservation was better. Preservation was markedly poorer in the uppermost sample, from 5.12–5.13m OD. The process of degradation had resulted in many thinned pollen grains at this level where the sediment is an organic silt. It is possible that partial drying out of this more mineral-rich deposit may have promoted chemical rather than biological oxidation. However, this distinction in deterioration type between the base and the top of the sequence at Glastonbury Lake Village could also be in part a consequence of the differing taxa which dominated the assemblages: *Corylus*-type, *Alnus* and *Betula* were substantially reduced at 5.12–5.13m OD compared with the basal sample.

With the exception of the upper sample from 5.12–5.13m OD, full analysis could be confidently undertaken on the sequence from Glastonbury Lake Village, there is no evidence of differential accumulation of resistant types and the processes of deterioration do not appear to have advanced to the state where the integrity of the results would be compromised. The top sample is more marginal, principally because of the relatively large number of indeterminable grains (17% of TP + indeterminables) but nevertheless full analysis could still be recommended.

Plant macrofossils

Julie Jones

Three of the samples (4.49–4.54m OD, 4.69–4.74m OD and 4.79–4.84m OD) were from the peat at the base of the trench associated with the worked wood and cultural debris, with one sample from the overlying detritus peat (4.88–4.93m OD) (Table 132).

Table 132. Glastonbury Lake Village: stratigraphy and samples.

Stratigraphy	Plant macrofossil/ beetle samples
5.24–5.59m OD Buff–orange/grey mottled clay, blocky structure	
5.13–5.24m OD Organic silt, with some clay. No visible plant remains. Reddish rusty patches of iron drying out on the exposed sediment surfaces. Gradual boundary	
4.97–5.13m OD Organic silty mud, becoming wetter to the base. No plant remains visible	
4.85–4.97m OD Detritus peat with frequent visible plant remains, becoming wetter towards the base. Snails visible	4.88–4.93m
4.43–4.85m OD Poorly humified peat with many plant remains, very wet at the base. Top of cultural layer at 4.79m OD. Occasional small stones. Clay sling stones. Worked wood at 4.49m OD and below.	4.79–4.84m 4.69–4.74m 4.49–4.54m

Preservation

In view of the similarity between the fruits/seeds recovered from each location, descriptions of the criteria used to determine the state of preservation are given for a few examples from each sample. The preservation results are shown in Table 133.

4.49–4.54m OD: The lowest sample examined from the base of the trench was associated with worked wood occurring at 4.49m OD. Macrofossils were abundant here with an estimated 1000+ seeds/fruits in the sample and 21 taxa recorded, with at least seven additional taxa noted in a scan of the remaining float. The sample also contained abundant wood fragments, occasional small leaf fragments, leaf abscission pads as well as mollusca and fish scales. 46% of seeds/fruits were entire, with 32% <25% fragmented. Overall degradation was minimal so preservation is regarded as high overall (index 1.21).

Pondweed (Figures 15 and 16: Appendix 4) were the most commonly occurring taxa, the laterally flattened fruits, semi-circular in outline easily recognisable, although no attempt was made to identify these to species. Approximately 50% of the fruits were whole in many cases retaining spines. Where fragmentation had occurred the ventral margin was lost (recorded as <25% fragmented). The surface of the fruits is of a spongy texture and some erosion of this had occurred in several examples.

The tiny oosporangia of *Chara* (stonewort), between 0.4–0.9mm long, are of elliptic shape with a rounded apical pole and truncated basal one and have diagnostic spiral cells originating from a basal pore that coil up to the apex. They appear to be surprisingly resilient with 85% well-preserved whole examples, showing no degradation of the surface structure.

Preservation index 1.21. Twenty-one taxa in 100 counted. Analysis recommended

4.69–4.74m OD: Species diversity and abundance were good from this sample associated with the cultural material around 4.79m OD. There were an estimated 1000+ seeds/fruits in the sample with 20 taxa recorded plus at least six more noted in further scanning of the sample. Much of the float was woody material with leaf fragments, occasional charcoal, moss and freshwater life including caddis fly larvae, leech cocoons and statoblasts of *Lophopus crystallinus*, a freshwater bryozoan.

Pondweeds and stonewort are again the most commonly occurring, 73% of pondweeds were entire with stonewort also well preserved. The achenes of the subgenus *Batrachium* of *Ranunculus* (water crowfoot), *c.* 1–2mm long, are characterised by the presence of transverse ridges on the achenes, which show no sign of deterioration in any of the examples recorded from this site. Two examples were entire and two >50% fragmented, showing the typical splitting of these achenes into two halves.

The small cylindrical fruits of bulrush (*Typha*), approximately 1 × 0.3mm are easily recognisable with a tapering lower end and upper truncated end with a small point of attachment for the down that forms the means of seed dispersal. All the seeds recorded in this sample were <25% fragmented, determined by the loss of this upper truncated end. The seed epidermis is brown although one example showed slight erosion of this surface to reveal a yellow layer beneath (<25% eroded).

Preservation index 0.88. Twenty taxa in 100 counted. Analysis recommended.

Table 133. Glastonbury Lake Village: plant macrofossil preservation.

At level of wood

		Fragmentation				Erosion		
4.49–4.54m OD (105–110cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alnus glutinosa	1	1	0	0	0	0	0	0
Betula spp.	2	0	2	0	0	0	0	0
Carex paniculata	3	1	1	0	1	0	0	1
Carex pendula	8	2	1	2	3	0	0	0
Carex spp.	7	1	3	1	2	0	0	0
Ceratophyllum demersum	9	0	5	4	0	3	0	3
Chara spp.	20	17	2	0	1	0	0	0
Cirsium palustre	2	1	1	0	0	0	0	0
Cladium mariscus	2	0	2	0	0	0	0	0
Glyceria spp.	1	0	0	0	1	0	0	0
Lycopus europaeus	1	0	0	0	1	0	0	0
Mentha aquatica	4	4	0	0	0	0	1	2
Nuphar lutea	1	1	0	0	0	0	0	0
Nymphaea alba	1	0	1	0	0	0	0	0
Oenanthe aquatica	1	1	0	0	0	0	0	0
Poaceae indet	1	1	0	0	0	0	0	0
Potamogeton spp.	31	16	11	1	3	7	0	0
Rumex spp.	1	0	1	0	0	0	0	0
Sparganium erectum	1	0	0	1	0	0	0	0
Typha spp.	2	0	1	0	1	0	0	0
Urtica dioica	1	0	1	0	0	0	1	0

Other macrofossils: abundant wood frags, occasional small leaf frags, leaf abscission pads, rare charcoal, frequent fish scales, occasional snails and statoblasts of *Lophopus crystallinus*

Cultural layer

		Fragmentation				Erosion		
4.69–4.74m OD (85–90cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Betula sp.	1	0	1	0	0	0	0	0
Carex paniculata	5	2	2	0	1	2	1	1
Carex pendula	3	0	2	1	0	0	0	0
Carex spp.	1	0	1	0	0	0	0	0
Ceratophyllum spp.	2	0	0	2	0	2	0	0
Chara spp.	22	18	4	0	0	0	0	0
Cladium mariscus	4	4	0	0	0	0	0	0
Hydrocotyle vulgaris	1	1	0	0	0	1	0	0
Lemna spp.	1	1	0	0	0	0	0	0
Lycopus europaeus	1	0	0	0	1	0	0	0
Lythrum salicaria	2	2	0	0	0	0	0	0
Mentha aquatica	7	6	1	0	0	1	2	0
Najas spp.	2	0	0	1	1	0	0	0
Nuphar lutea	1	1	0	0	0	0	0	0
Oenanthe aquatica	2	0	2	0	0	1	0	1
Potamogeton spp.	34	25	4	1	4	8	0	0
Ranunculus subg. *Batrachium*	4	2	0	0	2	0	0	0
Rumex spp.	1	0	1	0	0	0	0	0
Typha spp.	4	0	4	0	0	1	0	0
Urtica dioica	2	2	0	0	0	1	0	0

Other macrofossils: abundant wood/twig frags, occasonal leaf frags, charcoal, fish scales/vertebrae, frequent snails, occasional statoblasts of *Lophopus crystallinus*, caddis fly larvae, and leech cocoons

Table 133. continued.

Above cultural layer

		Fragmentation				Erosion		
4.79–4.84m OD (75–80cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alnus glutinosa	2	1	1	0	0	0	0	0
Berula erecta	1	1	0	0	0	0	1	0
Betula sp.	1	0	1	0	0	0	0	0
Carex paniculata	3	1	1	1	0	1	0	1
Carex pendula	1	1	0	0	0	0	0	0
Carex spp.	2	1	0	1	0	0	0	0
Ceratophyllum demersum	3	1	0	2	0	2	0	0
Chara spp.	23	14	9	0	0	0	0	0
Chenopodium album	2	2	0	0	0	0	0	0
Epilobium hirsutum/roseum	1	1	0	0	0	0	0	0
Eupatorium cannabinum	1	0	1	0	0	0	0	0
Lythrum salicaria	2	1	1	0	0	0	1	0
Mentha aquatica	8	7	1	0	0	1	0	5
Myriophyllum alterniflorum/ verticulatum	3	3	0	0	0	2	0	0
Nuphar lutea	1	1	0	0	0	0	0	0
Poaceae indet	1	0	1	0	0	0	0	0
Potamogeton spp	37	35	1	1	0	0	0	0
Ranunculus subg. *Batrachium*	1	1	0	0	0	0	0	0
Ranunculus flammula	1	1	0	0	0	0	0	0
Stellaria media	1	1	0	0	0	0	0	0
Typha spp.	5	4	1	0	0	0	1	0

Other macrofossils: occasional moss with attached leaves, *Pteridium aquilinum* pinnules, charcoal, fish scales, and statoblasts of *Lophopus crystallinus*

Detritus peat overlying cultural layer

		Fragmentation				Erosion		
4.88–4.93m OD (66–71cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Carex paniculata	1	0	1	0	0	0	0	1
Carex pendula	2	0	0	2	0	0	0	1
Carex spp.	16	8	4	1	3	1	1	3
Ceratophyllum demersum	2	0	2	0	0	0	0	0
Chara spp.	15	8	3	3	1	0	0	0
Chenopodium ficifolium	2	1	0	1	0	0	0	0
Cladium mariscus	3	2	0	1	0	0	0	0
Eleocharis palustris/uniglumis	1	1	0	0	0	0	0	0
Leucanthemun vulgare	1	0	1	0	0	0	0	0
Mentha aquatica	5	5	0	0	0	0	0	2
Myriophyllum alterniflorum/ verticulatum	5	4	1	0	0	0	0	0
Nymphaea alba	1	0	1	0	0	0	0	0
Poaceae indet	1	1	0	0	0	0	0	0
Potamogeton spp.	27	20	4	1	2	0	0	0
Ranunculus subg. *Batrachium*	3	3	0	0	0	0	0	0
Stellaria media	3	3	0	0	0	0	0	0
Typha spp.	10	2	8	0	0	5	1	1
Urtica dioica	2	0	2	0	0	0	1	0

Other macrofossils: occasional wood frags, moss with no attached leaves, *Pteridium aquilinum* pinnules, charcoal

Table 134. Glastonbury Lake Village: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
4.88–4.93	Smallish flot, herbaceous detritus and appreciable component of invertebrate fragments. Aquatics important and diverse, including an elmid (flowing water). Remaining fauna indicative (or tolerant of) swampland, with some indication of trees or shrubs.	Larger sub-sample (3kg) would give detailed local ecological recon-struction, but probably of limited value. P1B
4.79–4.84	Smallish flot, mainly fragments of immature stages of insects. Aquatic and terrestrial beetles, but in small numbers, often reduced to very small fragments. One wood-associated taxon (*Anobium* sp.).	Larger sub-sample (3–5kg) would give useful local ecological reconstruction, perhaps of more interest than other samples in this sequence. P1B
4.69–4.74	Fairly small flot, plant tissue and invertebrates (50:50). Filmy objects, probably cladocerans. Aquatics important, most of remaining fauna at home in swampland. One dead wood taxon (*Anobium* sp.).	Larger subsample (3kg) would give useful local ecological reconstruction, but probably of limited value. P1B
4.49–4.54	Moderately large flot, some plant detritus and seeds but mainly invertebrate remains, mostly immature stages of insects. Varied aquatic component including a flowing water taxon (*Oulimnius*). Remaining fauna all able to exploit swamp habitats.	Larger sub-sample (3kg) would give detailed local ecological reconstruction, but probably of limited value. P1B

4.79–4.84m OD: Preservation in this sample above the cultural layer was again very good with an estimated 1000+ seeds/fruits and 21 taxa recorded. As well as the recorded macrofossils there were occasional fragments of bracken (*Pteridium aquilinum*) pinnules, small branched moss fragments with leaf attached and occasional fish scales. In addition to well preserved pondweed and stonewort, a few rigid hornwort fruits were recorded (Figure 9: Appendix 4). These are biconvex, oval in outline, *c*. 4–5mm long and are smooth or slightly warty. They are apiculate to long spined at the apex often with two long spines at the base and of brownish-olive colour. There was a single well preserved example, with two further examples 25–50% fragmented; here the fruit had split exactly into two halves. Degrees of erosion of the thick wall of the testa revealing darker colouration beneath were also estimated.

The distinctive black pillar-shaped 5-sided achenes of hemp-agrimony (*Eupatorium cannabinum*) seem to be fairly resistant to decay. The diagnostic cell pattern of wavy rows of perforations can be identified from surprisingly small fragments although little further deterioration of this surface seems to occur. A single fragment (<25%) was recorded here.

Preservation index 0.58. Twenty-one taxa in 100 counted. Analysis recommended.

4.88–4.93m OD: The uppermost sample came from the detritus peat overlying the worked wood and cultural debris. Overall abundance seems to be lower here although with an estimated 500+ seeds this remains high. About 50% of the float comprised unbroken down sediment. A similar range and frequency of taxa occurred as in the other samples.

Several different taxa occurred in this sample more typical of disturbed, drier habitats. The black circular seeds with domed upper and lower sides of fig-leaved goosefoot (*Chenopodium ficifolium*) show distinctive surface sculpturing with a network of hexagonal mesh on one side and radially arranged long and narrow meshes on the other side. Of the two seeds recorded here one was entire and one was 25–50% fragmented; no damage was noted to the surface sculpturing.

The seeds of common chickweed (*Stellaria media*) are circular in outline with the surface covered in concentric rows of warty protruberances. All examples recorded here were entire and well preserved.

Preservation index 0.98. Eighteen taxa in 100 counted. Analysis recommended.

Recommendations

Preservation was excellent from all samples assessed at Glastonbury Lake Village, with both species diversity and abundance high, although there was some deterioration in the frequency of macrofossils in the uppermost sample. However preservation indexes remains low, between 0.58 and 1.21 and the deterioration which does occur seems to be due to slight fragmentation rather than damage to patterning or sculpturing of the seed testa. There is therefore good potential in all the samples for further analysis.

Coleoptera

Harry Kenward

Four samples were assessed from the sample column at 4.88–4.93m OD, 4.79–4.84m OD, 4.69–4.74m OD and 4.49–4.54m OD (Table 134). Anthropogenic artefacts were found at the depths covered by the lowest three

Table 135. Glastonbury Lake Village: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical Erosion				Fragmentation				Colour change					Other properties
	range		mode	str	range		mode	str	To	range		mode	str	
4.88–4.93	1.5	2.5	2.0	W	2.0	5.5	4.0	W	–	–	–	–	–	
4.79–4.84	1.5	4.0	3.0	W	2.5	5.0	3.0	W	Pale	1	3	2	W	
4.69–4.74	1.5	2.5	2.0	W	2.5	3.5	2.5	W	–	–	–	–	–	
4.49–4.54	1.5	3.5	1.5 3.0	D D	1.5	3.0	2.0	W	Pale	0	3	0 3	D D	

samples. Chemical preservation was fairly good in all of the deposits, although there were some more eroded fossils at 4.69–4.74m OD (Table 135). The upper two sampled layers (4.79–4.84m OD and 4.69–4.74m OD) both contained a proportion of very fragmented remains, however (some at F 5.0 or 5.5). This may be the result of distortion during an episode of dehydration, or of loading of the deposits by machinery or even humans. Erosion in the lowest deposit (4.49–4.54m OD) was recorded as bimodal (modes at 1.4 and 3.0); this is likely to be the result of events during deposition rather than recent change, the deposit being described as 'poorly humified' and containing worked wood and stones.

Monitoring of burial environment

David Hogan

Site description

Monitoring stations: A transect of monitoring stations was established from the drain near the gate (Station 1) eastwards to the excavation (Station 2) with Station 3 located close to the drain to the east (old river course).

Land-use: Permanent pasture of mesotrophic grassland, grazed by sheep at time of visit. No rush was visible due to removal by management, according to the farmer. Rush is prominent in surrounding fields.

Station 1: (Table 136) Instrumentation: piezometers at 50cm, 100cm and 150cm depth.

Station 2: (Table 137) Instrumentation: piezometers at 50cm, 100cm and 150cm and redox probes at 30cm, 50cm and 70cm depth.

Station 3: (Table 138) Instrumentation: piezometers at 50cm, 100cm and 150cm depth.

Table 136. Glastonbury Lake Village: Station 1.

Horizon depth (cm)	Description
0–10	Very dark greyish brown (10YR 3/.2) slightly moist silty clay loam
10–35	Dark grey (10YR 4/1) silty clay loam with many fine mottles of yellowish red (5YR 4/6); moist
35–50	Grey (10YR 5/1) clay with many fine mottles of yellowish red (5YR 5/6); moist
50–90	Dark reddish brown (5YR 3/2) loamy peat with common medium mottles of yellowish red (5YR 4/6); very moist
90–120+	Dark reddish brown (5YR 3/2) amorphous peat (H7) with woody fragments; wet

Table 137. Glastonbury Lake Village: Station 2.

Horizon depth (cm)	Description
0–10	Very dark greyish brown (10YR 3/.2) silty clay loam with many fine and medium mottles of yellowish red (5YYR 4/6)
10–50	Greyish brown (10YR 5/2) silty clay with many fine and medium mottles of yellowish red (5YR 5/6); water table at 20cm depth in auger hole
50–84	Black (10YR 2/1) waterlogged humified peat (H8)
84–110	Dark grey (10YR 4/1) very wet humose silty clay loam with many fine mottles of yellowish red (5YR 4/6) and fragments of woody material
110–180	Dark reddish brown (5YR 3/2) semi-fibrous peat (H6) containing little free water
180–200+	Dark reddish brown (5YR 3/2) amorphous woody peat (H8) containing little free water

Results

The water table (Figures 173, 175 and 176), initially a little below the topsoil in winter 2004, began to decline in April and remained low throughout the summer, with recharge occurring in October resulting from autumn rains, and returning by the end of the year to a level equivalent to that at the start of monitoring in

January. At Station 2, where the remains are found, the seasonal fall in the water table brought it to between the upper and lower depth limits of the archaeology for the summer half year (Figure 173). The response by the redox potential (Figure 174) to water table fluctuations indicated no obvious seasonal pattern, but rather a general increase in anoxic conditions with depth. Within the 50cm thickness of superficial silty clay, redox was mainly *slightly reduced* at 30cm, and *slightly* becoming *moderately reduced* at 50cm. Waterlogged humified peat at 70cm remained *moderately to highly reduced*, the water table dropping as far as the top of this horizon (to about 60cm depth) during the summer months. Groundwater taken from piezometers beside the structure had a pH of 6.7, while a pH of 7.1 was recorded from water from the ditch on the west side of the field.

Table 138. Glastonbury Lake Village: Station 3.

Horizon depth (cm)	Description
0–18	Dark grey (10YR 4/1) clay with many fine rusty mottles; dry
18–35	Grey (10YR 5/1) silty clay with common fine mottles of yellowish red (5YR 4/6); slightly moist
35–50	Greenish grey (5BG 6/1) clay with common medium mottles of yellowish red (5YR 4/6); moist
50–75	Greenish grey (5BG 5/1) clay with very many fine mottles of yellowish red (5YR 4/6); moist
75–110	Very dark grey (10YR 3/1) greasy silty peat
110–120+	Dark reddish brown (5YR 2/2) amorphous woody peat (H9)

Conclusions

Only the lower part of the timbers remained permanently waterlogged, the water table falling below the level of the upper portion from April to October. Though a wetting front is likely to remain above the level of the water table, redox potential within the upper part of the depth range for the remains was only *slightly reduced* or *moderately reduced*. Immediately above the remains, only *slightly reduced* or occasionally *oxidised* conditions were established from May until the end of the year. The indications are that only the lower part of the archaeology is likely to remain sufficiently anoxic to prevent degradation of organic material.

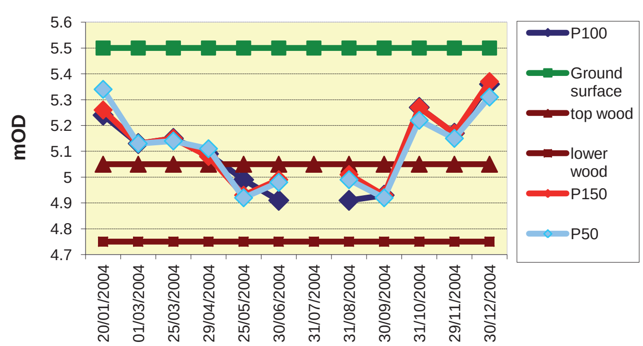


Figure 173. Water table at Station 2.

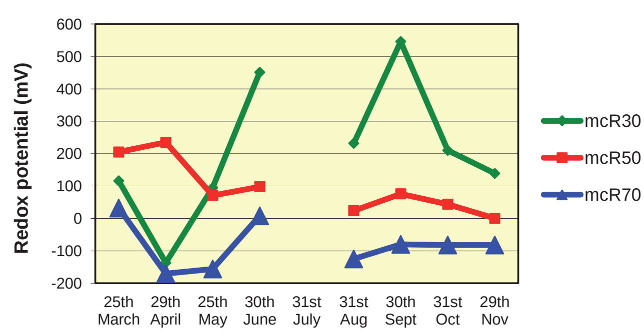


Figure 174. Redox potential at Station 2.

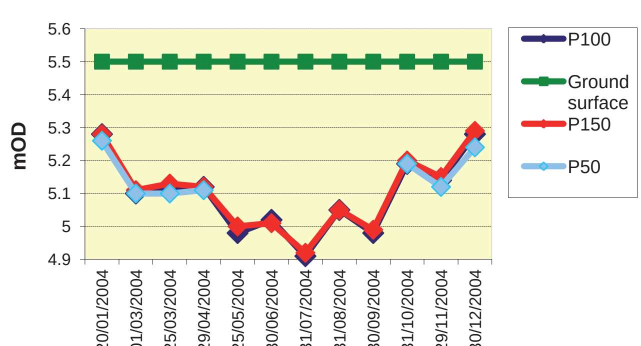


Figure 175. Water table at Station 1.

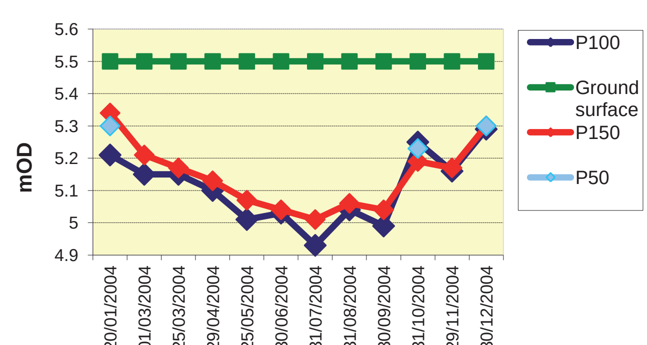


Figure 176. Water table at Station 3.

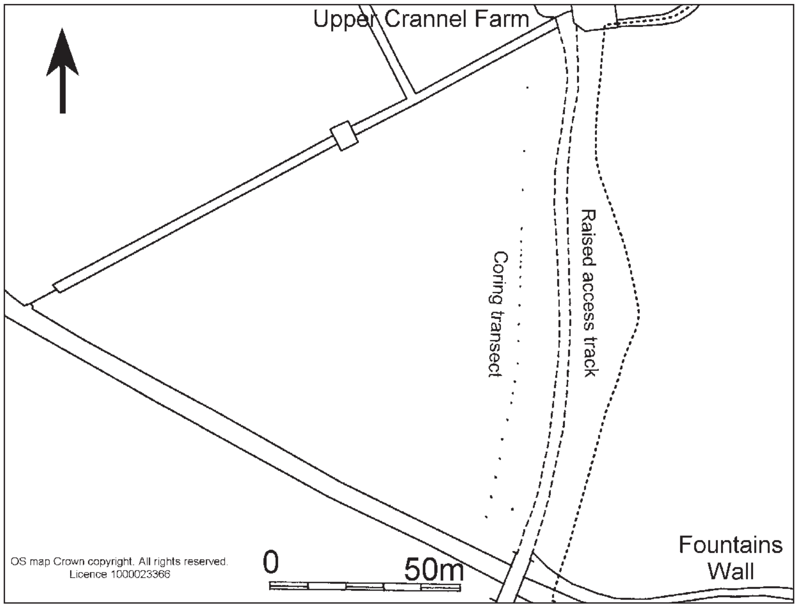


Figure 177. Crannel Farm coring transect location.

Preservation conclusion

Detailed analysis showed that the structural timbers had suffered moderate to severe decay, thus potentially making them vulnerable to desiccation and destruction. Hydrological analysis demonstrated a small but significant threat to the continued preservation of the waterlogged remains because of drawdown of the water table during the summer months. More extensive monitoring is needed to determine the hydrological conditions across the site and the relationship with the surviving archaeology.

12. Cranel Farm fieldwork

Somerset HER 23638

Previous fieldwork

The site was discovered in 1893 during the construction of a road across two fields leading to Crannel Farm (ST499415). Dr Arthur Bulleid conducted a small excavation 10ft [30.5m] square, '*exposing an arrangement of hurdle-work and mortised beams similar to that which bordered the causeway at Glastonbury Lake-Village*' (Bulleid 1924, 17). The only finds were '*a few fragments of coarse unornamented pottery and some pig bones*' (*ibid*., 17). The tenant of the farm informed Bulleid that '*in the adjoining field piles had occasionally appeared above the surface, and that he had sawn them off level with the ground when the field was reserved for mowing grass*' (*ibid*., 17).

The pottery and animal bone could not be traced in the County Museum, so the date of the structure is still uncertain. A photograph of the excavation confirms Bulleid's description and shows the use of treenails to secure split planks. The available information suggests that a significant wooden structure is present in the area and is probably of prehistoric date.

Discussion with local farmers suggests that the fields to the east of the discovery were ploughed during World War II, but proved to be difficult because of the enormous number of bog oaks that were brought up by the plough. If this is the field described as containing the piles it is possible that they were removed at that time and were not recorded because of their similarity to bog oaks and the urgent nature of the work. If the tops were sawn off before 1893 it seems unlikely that anything still survives of these features.

MARISP fieldwork

A series of 27 cores failed to detect evidence of the previously reported structure (Figure 177). Conversation with the farmer suggested that the remains were probably located under the present farm access track that was composed of many metres of imported hardcore. The landowner reported that there had been numerous unreported attempts by 'various Universities' to locate the structure, all of which had failed.

Fieldwork conclusion

It seems likely that the wooden structure observed by Bulleid only is only likely to survive under the present causeway to the farm. This area is likely to be inaccessible for archaeological investigation for the foreseeable future.

6. Medieval Causeway

Richard Brunning

13. Street–Glastonbury Causeway fieldwork

Somerset HER25522: SM27984

Previous fieldwork

The site of the causeway (ST 487375) is located in the three fields immediately to the east of the present A361 between Street and Glastonbury where the road crosses the floodplain, a distance of *c.* 650m (Figure 178). A stone and timber causeway crossing the wetland between Street and Glastonbury was discovered 'a few years' before 1880 when a series of shallow land drains were cut across the meadows east of the present road (Morland 1881). These only encountered the top of the structure but it was also seen in both banks of the River Brue and in the main east–west drain which divides the two fields to the south of the river. Observation at this time recorded a lias stone construction, with wooden piles and transverse and longitudinal timbers (*ibid.*, 44).

John Morland used workmen to excavate a section of the causeway immediately south of the Brue in 1879. In 1921 a severe drought led to the line of the causeway showing as a parch mark on the ground surface straight towards the market cross road junction in Street but diverging slightly to the west on the north side of the River towards the end of the old road at the foot of Wearyall Hill (Morland 1922). Two narrow excavations took place in the same year, one on the north bank of the River opposite the earlier investigation and the other where the causeway was thought to meet dry land.

The 1879 excavation took place approximately 7m south of the river Brue and was *c.* 12.2m long across the causeway and 3m wide along it (Figure 178; Morland 1881). This revealed the presence of a complex structure, thought at the time to represent a bridgehead. The road was built directly on a peat deposit *c.* 2.13m below the surface of the field. The base of the road consisted of transversely laid logs, mostly alder but also a few pieces of oak and fir, up to 3.7–4.3m long. With additional brushwood, this formed a layer 0.45m deep and 4.5m wide, which was overlain by a thin spread, reportedly of concrete but possibly of mortar.

On this foundation was built a wooden framework of large squared timbers, 230mm by 180mm in cross-section, laid longitudinally (Figure 178). Each timber was up to 2.14m in length and they were laid three to four deep at the sides of the structure, forming a trough up to 0.76–0.84m deep. The upper oak timbers were much decayed (Morland 1881, 46) and it was thought likely that another timber originally existed to bring the trough up to the top of the piles. A blind peg hole and another hole filled with an oak treenail *c.* 4cm in diameter, were noted on one of the side timbers, suggesting that some of the timbers were reused from another structure. The side timbers were held in place by oak piles, 2.14m long and 150mm by 130mm in cross-section, some of which displayed redundant mortise holes. Seventeen of these piles were recorded over the 10m excavation, some on either side of the oak side timbers to hold them in place but others up to *c.* 0.6m outside the trough. Two large oak logs, 0.6m in diameter, were placed across the trough and sat in notches in the side timbers.

The space between the timbers and above was filled with lias and rhaetic limestone, which appeared to be placed at the sides and '*shot in promiscuously*' in the centre (Morland 1881, 47). The surface was levelled with smaller stones forming a road surface 1.83m wide. The lias and limestone was noted to be of the same character as that obtained from surface quarries at Marshall's Elm on the Polden hills just south of Street, but observation in some of the drainage cuttings had noted later lias stone, more characteristic of deposits from Glastonbury, in the upper layers (*ibid.*). This suggests that the causeway was built from the Street end but that stone for repairs were derived from the Glastonbury end. One unnamed observer of the road exposed in the drainage ditches recorded the presence of wheel ruts in the surface (*ibid.*, 44).

The structure was further strengthened by the addition of embankments of stones, logs and brushwood, sloping down from the road surface for a distance of *c.* 9m each side. These embankments were exposed but not totally excavated so their lower limits on the published section (Morland 1881, opp. p. 45) are probably hypothetical. On the eastern (upstream) side of the causeway the some unconsolidated vegetable matter was recorded amongst the lower foundations of the embankment. On the downstream side a brackish deposit containing *planaorbis*, *valvata* and *cyclas* shells, overlay the embankment. The whole structure was overlain by 0.6–1.1m of clay, thought to be deposited from later flooding episodes. The stonework '*disappeared suddenly*' immediately to the north of the timber shown on the excavation plan, but large quantities of stonework were noted on both banks of the river (*ibid.*, 49).

The finds from this first excavation included two iron nails, a horseshoe, a piece of coal, some pieces of pottery resembling '*modern drain-pipes*' and a few bones including one or two human bones (Morland 1881, 49). The nails are noted as being derived from the surface of the road but the context of the other finds is less certain as it seems they may have been recovered by Morland keeping 'careful watch ... for any remains in the rubbish' (*ibid.*). The rubbish presumably represents the spoil thrown out of the trench by the workmen.

Although Morland thought the finds to be of no importance the presence of human bones is intriguing and, in light of the dates obtained from the MARISP excavations, there is a chance that the pottery resembling modern drain-pipe might actually have been imported Mediterranean amphorae. There is a very close visual similarity between the two, especially for people who have never seen such amphorae. As the drainage works in the meadow that led to the discovery of the causeway were apparently the first recent attempts to drain it, the existence of a drain-pipe is unlikely.

Stephen Morland, John Morland's grandson, oversaw the 1921 excavations on the north bank of the river. At the site just north of the river the road surface was encountered made of rough lias blocks, thought to be from quarries near Street, which were roughly levelled with no binding material (Morland 1922, 66). The foundations consisted of alder brushwood supporting half split alder logs, of 50–80mm diameter, laid transversely with the flat side down. Above this were the poorly preserved remains of an oak structure 'rotted almost to a pulp' (*ibid.*, 67). This appeared to

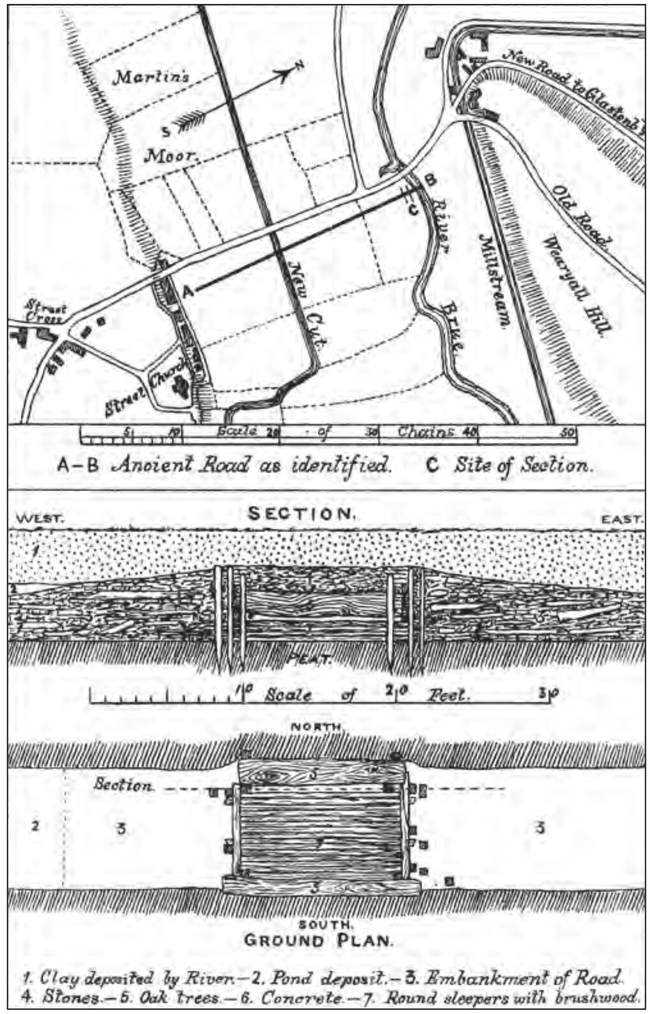


Figure 178. Plan and section of the Morland excavations. Reproduced courtesy of Somerset Archaeology and Natural History Society.

consist of oak planks laid along the edges of the road supporting transverse oak sleepers upon which the stones were laid. Split oak piles, *c.* 0.9m long and up to 0.23m wide, and alder stakes, *c.* 0.75m long and 40mm in diameter, helped to hold the structure and its associated embankment together and survived to just under the stones of the road. Their positions showed 'little order or arrangement' however. This work provided the first dating evidence from the site. The road surface was overlain by 0.97m of clay. The finds included a fragment of Roman pottery from *c.* 0.3m under the base of the foundations, an iron punch and gouge among the causeway stones and a late 12th or early 13th century AD spur from the surface of the road.

The other 1921 trench examined the point where the causeway met the dry land (Figure 178: B) where there was no substructure to the stones of the causeway.

Figure 179. View along the causeway, looking north from Street to Wearyall Hill.

It was thought to have joined up with the line of a trackway previously discovered nearby at Northover Nurseries (Morland 1922, 68–9).

Downstream of the causeway is its replacement that was carried over the River Brue by Pons Perilis or Pomparles Bridge and over the millstream by Bumbaley Bridge. A modern bridge over the Brue was erected in 1912, replacing a structure built in 1826, which itself replaced a medieval predecessor. That early bridge is illustrated (Figure 180) in a woodcut in Phelps's *History of Somersetshire* (1836) and from the style of the arches has been dated to the 12th century with an extra arch added in the 14th or early 15th century (Morland 1922, 72–4).

A watching brief and excavations in the Magdalene Street, Fairfield and Convent areas of Glastonbury between 1984 and 1988 established the existence of a canal running along the 10m contour line between Northover Mill and a presumed terminal at the market place in Glastonbury beside the Abbey (Hollinrake and Hollinrake 1992). A sharpened timber revetment stake from the canal was dated to cal AD 690–1030 (HAR-9207 1120±80 BP) (*ibid.*, 90). This suggests that the canal and the causeway were probably in existence at the same time, which begs the question how the canal terminal, and Northover millstream related to the open water body known to exist on the downstream side of the causeway. Morland recorded that water from Northover millstream 'was conveyed in a canal still in existence under the northern side of Wyrral Hill to the Abbot's fish pond at Glastonbury' (Morland 1922, 74). Morland thought that the canal and the new causeway and bridge were both created in the 12th century AD, which we now know not to be correct (see below).

MARISP excavation results

A single trench, 13.5m long by 3m wide, was excavated across the causeway a short distance to the south of the 1880 excavation (Figures 181 and 182). The environmental sequence of peats and detrital muds below the causeway predates its construction and is fully described in the environmental analysis section below. The causeway itself was built upon an organic silty detrital mud (contexts 6 and 8) that has been dated to a period 660–950 years before the causeway construction (see below). It is extremely unlikely that no deposits were formed in the floodplain during this time so it appears that any deposits that did accumulate were removed by later erosion or, less likely, by human activity related to the causeway construction.

The first part of the causeway construction appears to have been the insertion of two rough lines of split oak and ash piles, *c*. 4m apart (Figures 183–5). The ash pile (23) was the exception in that it was the only roundwood (44m diameter) pile. The other 11 piles were all oak heartwood. Nine of these had been radially split, one tangentially and one a tangential timber that had been sub-divided. The surviving lengths of the timbers varied considerably from 340mm to 830mm, the longest

Figure 180. The 1836 engraving of Northover Bridge. Reproduced courtesy of Somerset Archaeology and Natural History Society.

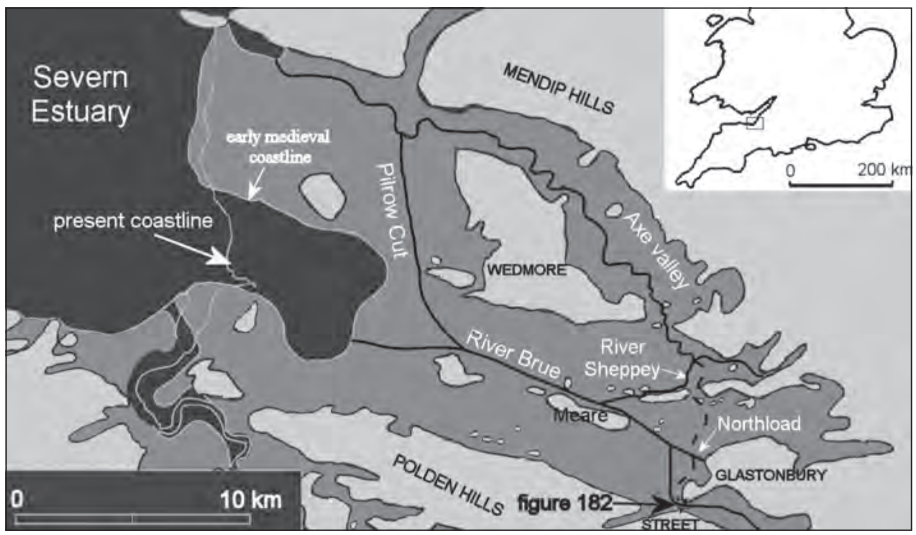


Figure 181. Street causeway location map.

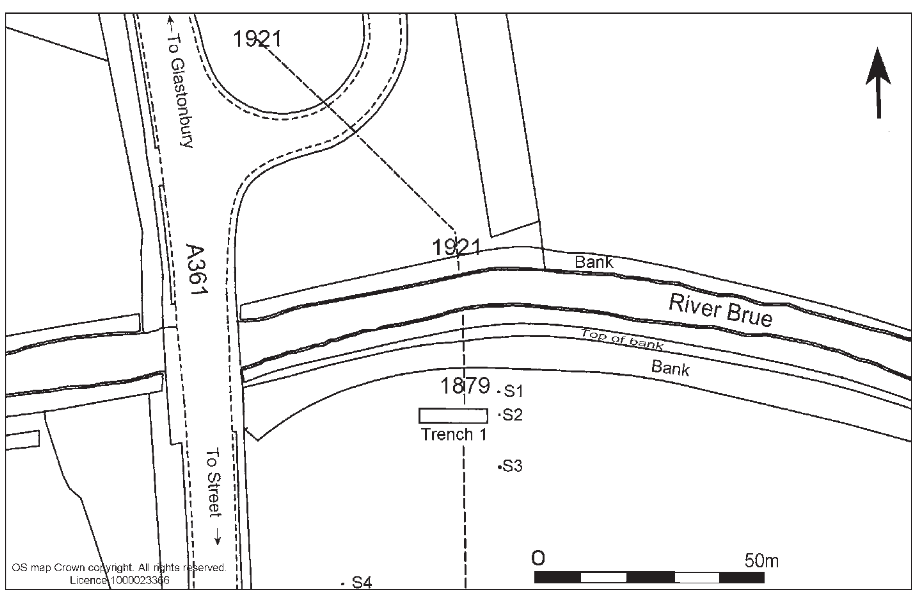


Figure 182. Trench and monitoring station locations at Street Causeway.

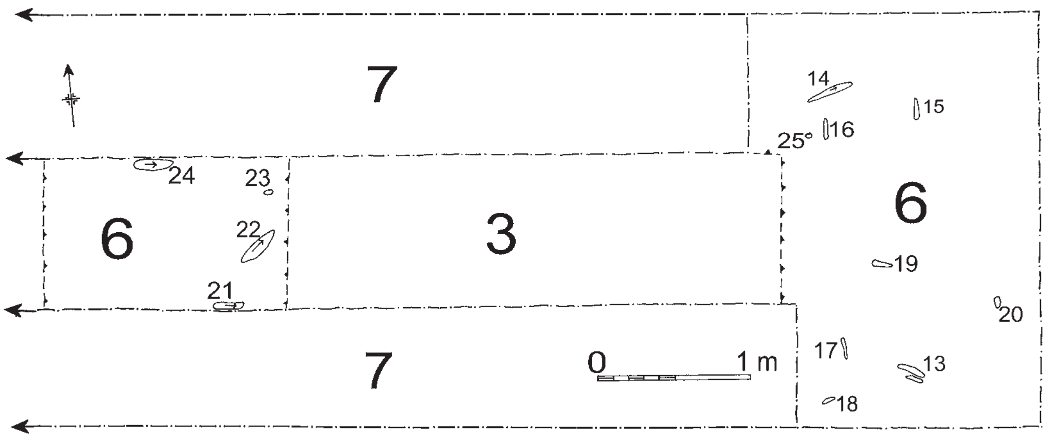


Figure 183. Plan of the two pile rows in and under Street Causeway.

Figure 184. Central piles after removal of causeway stones, looking north. Scale 0.5m.

Figure 185. Three of the oak piles after removal. Scale 1m.

Figure 186. Wood in context 10, looking east. Scales 1m.

Figure 187. View across the causeway looking west, with stones and piles not yet exposed at east end (foreground). Scales 1m.

being in the eastern line. Three of the piles (15, 16 and 19) were substantially larger than the others with widths of 120–138mm and thicknesses of 30–54mm. The other oak piles had widths of 37–73mm and thicknesses of 26–65mm.

The stones of the roadway overlay the tops of most of the piles, many of which were leaning upwards towards the west at angles between 45° and 88°. This orientation would be consistent with the piles being pushed over by the force of floodwater and suggests that they may have been exposed to such force before the stone causeway surface was created. A horizontal split oak timber (13) may represent a collapsed pile. The surviving tops of the piles varied between 4.35–4.60m OD in the eastern line and 4.21–4.35m OD in the western line.

On the downstream (western) side of the causeway worked timber offcuts and small pieces of roundwood were being deposited as a thin layer (context 10) above the earlier detrital muds at 4.05–4.13m OD (Figure 186). This deposit was only exposed at the western end of the causeway, *c*. 7m west of the western pile line. There were no similar deposits of horizontal worked wood around either of the pile lines or in a sondage excavated 3.5m west of the western pile line. The deposit included some short (163–400mm) radially split oak timber fragments. These could be debris created by the splitting and finishing of oak planks or they may represent broken pieces of oak timbers washed up at the edge of the causeway. One piece (11) had the poorly preserved remains of a possible lap joint, 50mm wide, on one face, providing some support to the latter interpretation. A 'floating' site tree-ring chronology has shown that the two pile lines and a worked fragment from context 10 are all broadly contemporaneous (see below).

The causeway itself was composed of lias blocks and gravel packed with grey clay (context 3) covering a width of 13m (Figure 187). Over the western third of this width the clay among the stones was slightly redder and so it was given a different context (11; Figure 188). The top of context 11 rapidly increased from 4.21m OD at the western end to a height of 4.37–4.38m OD over most of its length. The top of the stones of context 3 varied between 4.39m OD and 4.50m OD, with the highest levels on the eastern (upstream) side. The stratigraphic relationship between the two layers was not conclusive but it appeared that context 11 might underlay context 3. As context 10 was sealed by context 11 and did not extend under context 3 it seems more likely that context 3 represents the initial road surface construction with worked wood debris thrown on the downstream side (context 10) and subsequently covered by a *c*. 3m extension of the stone embankment (11).

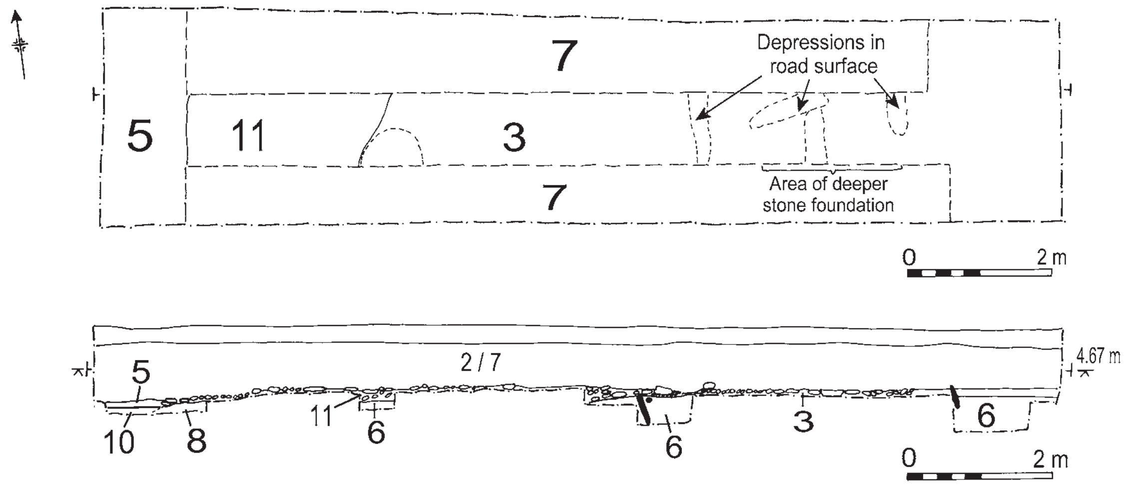


Figure 188. Plan and section of Street Causeway.

Figure 189. Two wheel ruts in the surface of the causeway, looking north. Scale 1m.

The stones of the causeway appeared somewhat worn, but possibly rather by weathering than by traffic on the road. The stone layer was only one course thick at the western side but increased to several courses thick (*c*. 0.25m) over the central *c*. 5.5m and even more between the two lines of posts. Some slight depressions in the road surface between the two lines of piles may represent wear by wheeled vehicles although they were not all aligned along the causeway (Figure 189). Another depression was recorded by the junction of contexts 3 and 11.

On the downstream (western) side of the causeway was a strand deposit of dark grey silt (context 5) containing lias blocks numerous snail shells and pieces of worked and unworked wood that accumulated between *c*. 4.00m and 4.19m OD (Figures 190 and 191). The deposit included three oak timber fragments (1, 2 and 4) up to 854mm long, 50–85mm wide and 21–45mm thick. These may represent the broken and eroded remains of structural oak timbers that washed up at the edge of the water body. Timber 2 was tangentially split and may have broken along its rays on one edge, where the possible remains of half of a peg hole was visible. The hole would originally have been 34mm in diameter and the plank appeared to have broken across it.

Context 5 covered the tail of the stone causeway (11) and was separated from it by a thin (*c*. 20mm) layer (7) of grey clay with orange mottles. The boundary between this thin skim of clay and the clay deposit above it was not apparent and if context 5 had not interleaved the two it would not have been possible to distinguish the difference. As context 5 indicates the presence of a freshwater body on this side of the causeway (see below) it is a possibility that the thin skim of clay represents a deliberate attempt to create a water retaining bund of puddled clay along the western side of the causeway. Context 5 overlay context 10 from which it could be distinguished only by the absence of snail shells in the latter context.

The causeway was sealed by *c.* 0.9m of grey alluvium (context 2) with orange mottling towards its base (context 7), above which was a clayey topsoil (context 1) with a ground surface at 5.18–5.28m OD. These contexts produced no artetacts and nothing that could be radiocarbon dated. The alluvium was removed by machine until the top of the causeway became visible, after which all excavation was by hand.

A floating tree-ring site chronology has shown that the two pile lines and the lower strand deposit are all broadly contemporary (see tree-ring dating section below). Absolute dates are available from two radiocarbon samples (see below). One sample was obtained from an ash pile (23) from the western pile line and dates to cal AD 650–900 (GU-6040 1250±50 BP). A sample of field maple roundwood (200) from the upper strand deposit beside the causeway (context 5) dates to cal AD 640–780 (GU-6041 1320±50 BP). As the pile was put in place before the stone road surface, and context 5 was deposited after the causeway was built, chronological modelling suggests that construction of the causeway took place between in cal AD 640–720 (68% probability).

Woodworking evidence

The use of large oak trees for timber production is evidenced in both the piles and in the timber fragments in contexts 5 and 10. The lack of sapwood makes the age of the trees impossible to estimate but none of the evidence suggests ages far beyond 100 years. The majority of the oak timbers were radially split which is easier than tangential splitting and produces timbers with more inherent strength. The tangentially split timbers may be derived from trees whose moderate girth could not produce radially split timbers of adequate size. The growth rates of the trees suggest that they were growing in dense woodland rather than in hedgerows or wood pasture.

The piles had been cut to a point over 250mm to over 342mm at angles of 1–25°, producing pencil or wedge shaped points. The facets left on the wood were flat with clean edges 28–36mm wide and up to 150mm long. The width of the toolmarks was largely determined by the small size of the timbers and the numerous intercutting facets. This makes it hard to estimate the original width of the iron axe used.

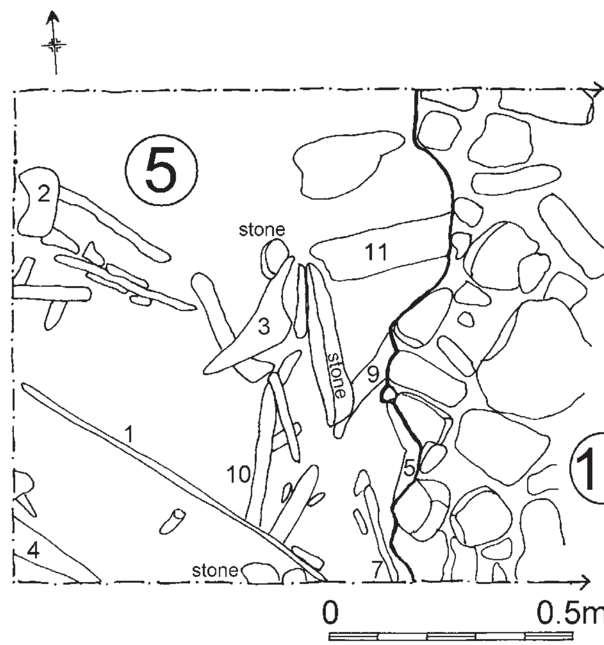


Figure 190. Detail plan of west end of Trench 1.

Figure 191. Context 5 (foreground), looking east. Scales 2m and 1m.

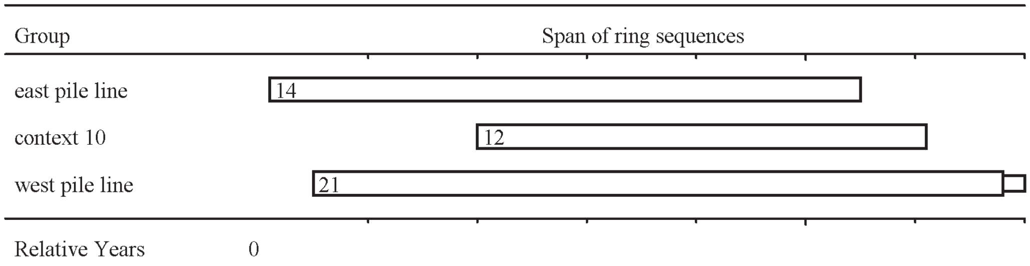


Figure 192. Bar diagram showing the relative positions of the dated sequences included in the Street-Glastonbury causeway site master sequence STC-T_3. Narrow bars are unmeasured heartwood, wide bars measured heartwood.

Wood species identification

The oak timbers were identified by Richard Brunning in the field. The radiocarbon samples were identified by Rowena Gale.

Other finds

Keith Faxon

The only non-wooden finds were two tile and one flint fragment (context 3) and four iron objects (Table 139). These were a square headed nail from the strand line (context 5), a small (68mm long, 32mm diameter) cone resembling a plumb bob, a 30mm long handle and an unidentified object (134mm long *c*. 45mm diameter) all from the road surface (context 3). None could be securely dated on typological grounds.

Dendrochronological dating

Cathy Tyers and Christine Locatelli

A total of 11 samples were submitted for analysis from the Street–Glastonbury causeway (Table 140). Five samples were from the east pile line, two samples from the west pile line, and four samples were from offcuts associated with contexts 5 and 10 which represent material washed up or dumped adjacent to the causeway. The single offcut from context 5, sample 4, was rejected as unsuitable for analysis as it contained too few rings. Samples 21 and 22 were slightly crushed causing some possible distortion to the growth rings, though these were considered suitable for analysis. The ring sequences of the ten measured samples were compared with each other. Three were found to crossmatch, and these were combined to produce a site master sequence, **Stc-T3**, (Figure 192; Tables 141 and 142). This site master sequence was compared with a range of dated reference chronologies from Britain and elsewhere in northern Europe. No conclusive results were obtained, thus these three timbers remain undated by dendrochronology.

The remaining unmatched samples were compared individually with a range of dated reference chronologies from Britain and elsewhere in northern Europe. No conclusive results were produced, so these samples also remain undated.

Two of the three samples incorporated into **Stc-T3** are from piles from the east and west lines, whilst the third sample is an offcut from context 10 (Figure 192). None of the samples had retained any sapwood but the dendrochronological analysis clearly has demonstrated that they are broadly contemporary indicating that both pile lines and the offcuts are of similar date.

Unfortunately the analysis has failed to provide absolute dates for any of the timbers from the Street–Glastonbury causeway. Although it has been possible to produce a site master sequence this was only 68 years long.

The inability to date this site master sequence is probably related to its length and relatively poor replication. The reference data available for the later medieval period in this region is relatively abundant but the early medieval period is dominated by material from Bristol. This lack of local reference chronologies is likely to be a contributory factor in the failure to date the causeway timbers. The overall lack of intra-site crossmatching and hence the inability to produce a well-replicated long site master sequence is probably a result of the generally short ring sequences derived from the timbers, either due to the conversion of the timber or the use of young trees. If further excavations were undertaken on the causeway, then more extensive sampling may overcome these difficulties and allow the production of a well-replicated, long site master for which the chances of obtaining a date would be substantially increased.

Radiocarbon dating

P. D. Marshall, W. D. Hamilton, R. Brunning, G. Cook and C. Bronk Ramsey

Sequence

The detrital mud/peat sample from 3.55–3.56m came from the base of the sequence below the stone causeway

Table 139. Finds from Street Causeway.

Trench	Context	BM	Lithics	Bone	Fe object	Other
1	**3**	2 tile frags	1 flint, scraper frag?	16 animal bone frags	**SF 4**, cone, poss. rod? **SF 1**, 3 obj. **SF 2**, 1 obj.	
	5			1 tooth	**SF 3**, nail	Mussel shell frags

Table 140. Detail of the tree-ring samples.

Wood no.	Sample description	Number rings	Sapwood rings	ARW	Cross-section type	Cross-section (mm)	Date of	Comments
4	context 5, horizontal offcut	<40	–	–	quartered	40 × 40	–	rejected
6	context 10, horizontal offcut	77	–	1.05	plank: radial	80 × 30	–	–
11	context 10, horizontal offcut	71	–	1.01	quartered	80 × 60	–	–
12	context 10, horizontal offcut	42	–	1.09	plank: tangential	50 × 15	–	–
14	east pile line, radial pile	55	–	1.04	quartered	65 × 60	–	–
15	east pile line, radial pile	60+2*H*	–	1.77	plank: tangential	110 × 35	–	–
16	east pile line, radial pile	67	–	1.51	quartered	105 × 55	–	–
17	east pile line, radial pile	40	–	1.13	quartered	50 × 30	–	–
19	east pile line, radial pile	80	–	1.41	quartered	110 × 40	–	–
21	west pile line, intermediate pile	64+2*H*	–	0.74	quartered	50 × 30	–	rings distorted by crushing
22	west pile line, radial pile	51	–	1.25	quartered	65 × 60	–	rings distorted by crushing

Number of rings – total number of measured rings including both heartwood and sapwood; +nn – indicates presence of unmeasured rings; H – indicates unmeasured rings are heartwood. Sapwood rings – number of measured sapwood rings only; hs – indicates presence of heartwood/sapwood transition; ?hs – indicates possible presence of heartwood/sapwood transition; ?b – indicates probable presence of bark edge. ARW – average ring width in millimetres

Table 141. Matrix showing the t-values obtained between the matching ring sequences from the Street-Glastonbury causeway included in the site master chronology Stc-T3.

	14	**21**
12	6.35	7.96
14		7.73

Table 142. Ring width data from the undated site master chronology Stc-T3.

Ring widths (units of 0.01mm)									
223	240	239	160	214	207	145	139	142	147
111	131	149	132	163	102	99	73	63	111
155	123	88	60	67	56	50	58	81	78
92	64	69	91	77	80	69	69	42	56
55	52	138	171	97	56	51	54	51	57
55	58	83	97	86	106	135	100	87	122
58	55	47	73	67	117	92	66		

(Table 143). The two measurements (OxA-16180 and OxA-16181) are not statistically consistent (T′=16.5; T′ (5%)=3.8; ν=1; Ward and Wilson 1978). As the humic acid is the product of *in situ* plant decay and unlike the humin fraction homogeneous (as it is are alkali soluble), it can be more reliably dated by AMS. Thus OxA-16181 (humic) can be expected to provide a more accurate age for the sample from 3.55–3.56m.

The sample from 4.02–4.03m came from the top of the organic silty clay onto which the stone causeway had been directly laid. The two measurements (SUERC-9827 and SUERC-9837) are statistically consistent (T′=0.2; T′ (5%)=3.8; ν=1; Ward and Wilson 1978) and allow a weighted mean to be calculated (2025±25 BP). GU-6040 was a vertical pile from one of two lines of piles that ran longitudinally under the stone surface of the causeway. They were not inserted through this surface and therefore appear to relate to the initial construction of the causeway. GU-6041, a piece of maple roundwood, formed part of an upper strand deposit beside the causeway.

Table 143. Street Causeway: radiocarbon results.

Laboratory no.	Sample ID	Material	$\delta^{13}C$ (‰)	Radio-carbon age (BP)	Weighted mean	Calibrated date (95% confidence)	*Posterior Density Estimate (95% probability)*
SUERC-9827	4.02–4.03m	Organic silty clay, humic acid	-28.4	2015±35	2025 ± 25 BP (T'=0.2; T' (5%)= 3.8; ν=1)	100 cal BC–cal AD 50	*110 cal BC–cal AD 60*
SUERC-9837	4.02–4.03m	Organic silty clay, humin fraction	-28.4	2035±35			
GU-6040	Wood no. 23	*Fraxinus excelsior*, *c*, 18 rings with sapwood and bard edge	-24.3	1250±50		cal AD 650–900	*cal AD 660–890*
GU-6041	Wood no. 200	*Acer campestre*, 17 rings	-28.3	1320±50		cal AD 640–780	*cal AD 610–820*
OxA-16180	3.55–3.56m	Detrital mud/ peat, humin fraction	-29.0	2135±29		350–50 cal BC	–
OxA-16181	3.55–3.56m	Detrital mud/ peat, humic fraction	-28.6	2299±28		410–260 cal BC	*410–350 (77%) or 290–230 cal BC*

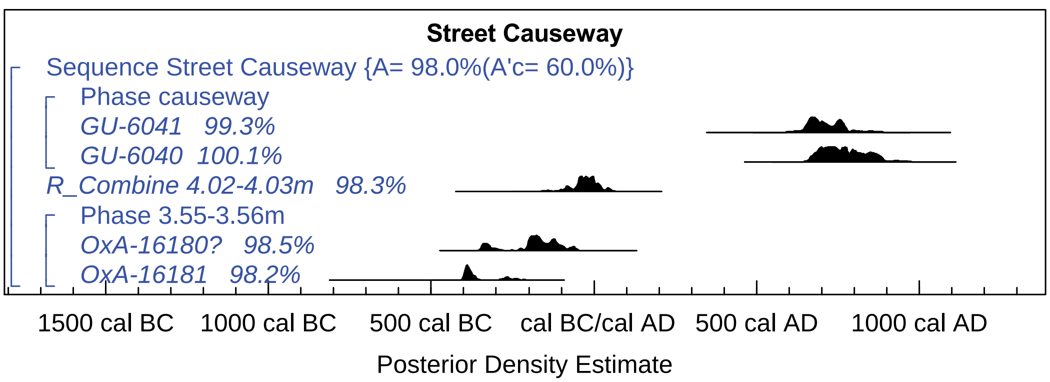


Figure 193. Probability distributions of dates from Street Causeway. Each distribution represents the relative probability that an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. A question mark (?) indicates that the result has been excluded from the model The large square brackets down the left hand side along with the OxCal keywords define the model exactly.

Results

The model (Figure 193), excluding OxA-16180, shows good agreement between the radiocarbon results and stratigraphy ($A_{overall}$=98.0%) as presented in the previous section. It provides an estimate for the initial construction of the causeway of *cal AD 660–890 (95% probability;GU–6040;* Figure 193*)* and probably *cal AD 640–720 (68% probability)*. The results therefore suggest that a considerable accumulation of sediment, estimated at between *660–950 years (95% probability; Difference = GU-6040–4.02–4.03m;* Figure 194), was removed prior to construction of the stone causeway.

Palaeoenvironmental analysis

Heather Tinsley and Julie Jones

At the eastern side of the causeway a pit some 60cm deep was dug into the underlying organic clay for environmental sampling. Below 3.83m the sediments became increasingly wet and graded into very decomposed woody detritus. On the western edge of the causeway, abutting it and extending up and over the marginal stones there was a band of dark silt about 0.12m thick, containing abundant snail shells (Context 5), this was also sampled for environmental analysis (Table 144).

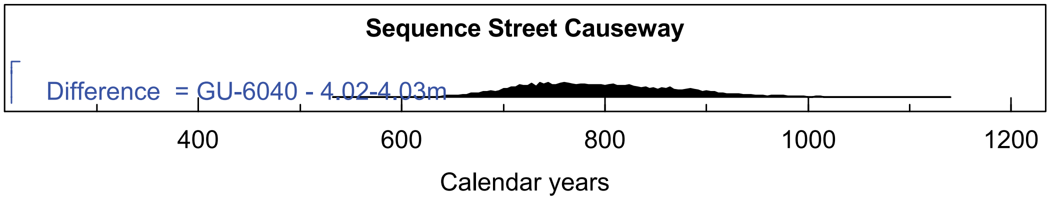


Figure 194. Probability distribution of the estimated difference between the date of construction of the causeway (GU-6040) and the date of sediment it was laid on. The distribution is derived from the model defined in the previous figure.

Table 144. Street Causeway: stratigraphy, sampling locations and calibrated radiocarbon date ranges from beneath the causeway (depths m aOD).

Depth	**Stratigraphy**	**Pollen**	**Macros and snails**	**Depth and calibrated radiocarbon date range**
Ground surface at 5.18m OD				
3.83–4.03	Very dry, mid-brown organic clay with orange mottles. Trace of fine herbaceous plants and silt. Diffuse boundary	4.02–4.03 4.00–4.01 3.99–4.00 3.93–3.94 3.88–3.89 3.83–3.84	3.98–4.03 macros assessed	4.02–4.03 100 cal BC–AD 50
3.53–3.83	Very dark brown, largely homogenous well humified woody detritus peat, with traces of fine herbaceous plants. Becoming wetter with depth	3.77–3.78 3.70–3.71 3.62–3.63 3.55–3.56	3.75–3.80 macros assessed 3.53–3.58 macros	3.55–3.56 410–260 cal BC

Table 145. Street Causeway: stratigraphy, sampling and calibrated radiocarbon date range from adjacent to the causeway (Context 5) (all depths m aOD).

Depth	**Stratigraphy**	**Pollen**	**Snails**	**Calibrated radiocarbon date range**
Ground surface at 5.18m OD				
4.05–4.17	Very dark brown organic silt with abundant snail shells and wood fragments	4.13–4.14	4.12–4.17	*Acer campestre* roundwood frag. cal AD 640–780

The sedimentary column from beneath the causeway dates from 410–260 cal BC at 3.55–3.56m OD in the woody detritus, to 100 cal BC–cal AD 50 at 4.02–4.03m OD, at the top of the dry organic clay. It is therefore clear that the underlying deposits considerably pre-date the construction of the causeway itself in cal AD 640–720 (68% probability), suggesting that either sedimentation ceased for somewhere between 660–950 years (95% probability), or more likely, that the sequence has been eroded and the top sediments lost prior to the building of the structure. The date from the roundwood in context 5 (cal AD 640–780) indicates that the pollen and snails from this horizon are generally contemporaneous with the causeway (Table 145).

The pollen assemblage zones

Heather Tinsley

The pollen diagrams for these samples are shown in Figure 195. Two pollen assemblages have been recognised on the diagram, one from the sediments beneath the causeway and one from context 5, which is contemporary with it. The two sampling locations are just less than the width of the causeway apart (about 12m). It was difficult to zone this pollen diagram, the pollen record from beneath the causeway showed gradual change throughout the period in which it accumulated and it has been designated as one LPAZ, SC 1. Above the causeway there is only a single pollen sample so this can not be regarded as a true pollen

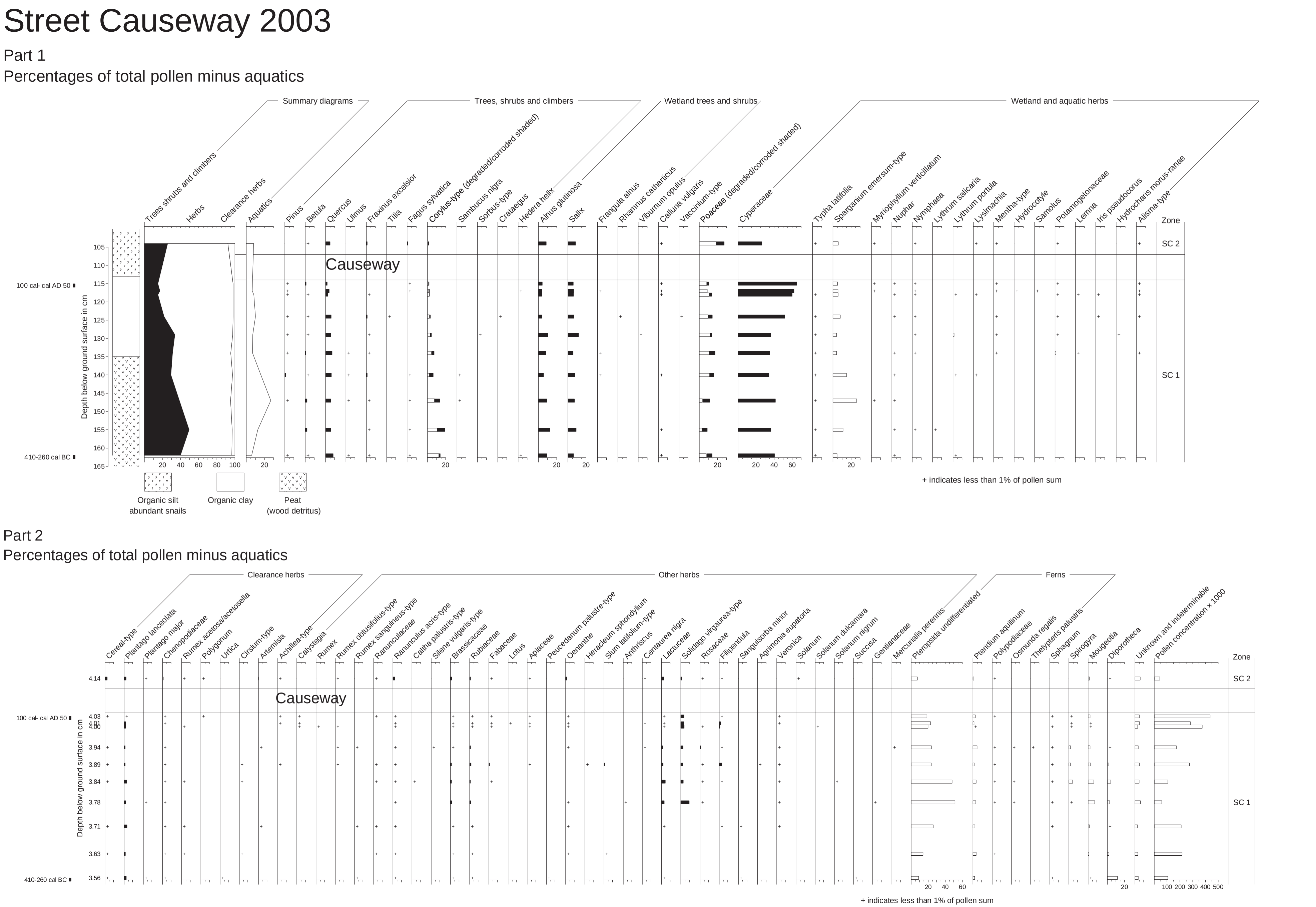


Figure 195. Street Causeway pollen diagram.

assemblage zone, however, for simplicity it has been designated as SC 2 on the pollen diagram, allowing comparison with the pollen record from the sediments below which, on the basis of the dated *Acer* wood, predate it by some 700–800 years.

SC 1 (4.03–3.56m OD; 115–162 cm below the ground surface). Tree pollen declines steadily from 40–50% TP at the start of the zone to 15% TP at the zone end. The main contributor is *Corylus*-type which declines from 19–2% TP. *Quercus* declines from 8% to 2% TP, *Alnus* fluctuates between 3–13% TP and *Salix* between 6–11% TP. *Betula* and *Fraxinus* are consistently present at low frequencies. The principal contributor to the herbaceous pollen is Cyperaceae which form 35–65% TP, Poaceae contribute 9–17% TP and *Sparganium emersum*-type 5% TP+aquatics initially, increasing to 26% TP at 3.71m OD, before declining to 6% at the zone end. Pollen of aquatic herbs such as *Myriophyllum verticillatum, Nuphar, Nymphaea*, Potamogetonaceae and *Alisma*-type are present as occasional grains, increasing in frequency towards the zone end. Pollen of clearance herbs are present throughout at low frequencies, *Plantago lanceolata* forms 1–3% TP. Pollen of Asteraceae (Lactuceae and *Solidago virgaurea*-type) form small peaks in the upper part of the zone. The diversity of herb taxa present as occasional grains increases towards the zone end. Pteropsida (undifferentiated) vary between 19–48% TP+ferns and *Pteridium* is present at 1–5% TP+ferns. Unknown and indeterminable grains form 3–6% TP+indeterminables, around 66% of grains of *Corylus*-type and Poaceae show some biochemical deterioration. Pollen concentration is good throughout, rising towards the end of the zone. The concentration of microscopic charcoal is initially very low, but then increases.

SC 2 (4.10–4.17m OD; 101–108 cm below the ground surface). Tree pollen forms 26% TP, principally *Alnus* 9% TP, *Salix* 8% TP and *Quercus* 5% TP. *Betula*, *Fraxinus* and *Fagus* are present at very low frequencies. Herbaceous pollen is dominated by Poaceae and Cyperaceae which both contribute 27% TP. *Sparganium emersum*-type forms 6% TP+aquatics. Aquatic herbs present at low pollen frequencies include *Typha latifolia*, *Myriophyllum verticillatum*, *Nymphaea*, *Menyanthes trifoliata* and Potamogetonaceae. Pollen of clearance herbs form nearly 8% TP, with cereal-type contributing 3% TP and *Plantago lanceolata* 2% TP. The diversity of flowering herbs is greater than in SC 1. Pteropsida (undifferentiated) form 7% TP+ferns, *Pteridium* and Polypodiaceae are also present. Unknown and indeterminables form 6% TP+ indeterminables; around 66% of Poaceae exhibit some biochemical deterioration. Pollen concentration is much lower than in SC 1, as is the concentration of charcoal.

Plant macrofossils

Julie Jones

The plant macrofossil results are shown in Table 146.

3.53–3.58m OD: In view of poor preservation through most of the sampled section, the only sample fully analysed was from the dark brown well humified woody peat at the base of the sequence. This horizon is dominated by *Myrica gale* (24%), with evidence for alder carr from abundant *Alnus* macrofossils (14%), including fruits, cones and buds, plus S*alix* buds (8%). Fen conditions are indicated by an abundance of *Carex* (32%) and other marsh taxa (5%) including *Lythrum salicaria* and *Berula erecta*. A small component (9%) of reedswamp taxa includes *Typha*, *Sparganium* and *Cladium*. Aquatics are represented at <1% by occasional *Potamogeton*.

3.75–3.80m OD: This sample from higher in the same unit was only assessed, with occasional *Mentha* and *Potamogeton* preserved.

3.98–4.03m OD: Similar poor preservation in the sample from the top of the mid brown organic clay beneath the causeway was composed primarily of small soft wood fragments, with occasional *Typha*, *Sparganium, Mentha, Eupatorium, Carex* and *Potamogeton*

Plant macrofossils were not sampled from context 5.

Molluscan analysis

Paul Davies

A sample from context 5 consisted mostly of *Bithynia tentaculata* operculae (several hundred) and a few (fewer than 10 in total) *Valvata piscinalis* and *Valvata cristata* and bivalve fragments, most of which were broken. Overall this is typical of a wash-zone on the edge of a reasonably sized water body, where the relatively light operculae become concentrated as a result of wave or current action.

Environmental interpretation

Heather Tinsley and Julie Jones

The deposits underlying the causeway were very dry and apart from the sample at the base of the sequence in the humified woody peat, plant macrofossil preservation was poor, with low abundances recovered, however, pollen preservation was generally fairly good with numbers of indeterminate grains low throughout. However biochemical deterioration did affect around 66% of the *Corylus*-types and Poaceae grains, though not to an extreme degree. Pollen concentrations fall in the middle of LPAZ SC 1, this is probably associated with more rapid sediment accumulation. There is

Table 146. Street Causeway: plant macrofossil remains from.

	Height (m OD)	**3.53–3.58**	**Habitat**
	Sample size (g)	1000	
Ranunculaceae			
Ranunculus lingua L.	Greater Spearwort	1	M
Myricaceae			
Myrica gale L.	Bog-myrtle	66	E(w)F
Fagaceae			
Quercus sp (bud)	Oak	5	HSW
Betulaceae			
Alnus glutinosa (L.)Gaertner (fruit)	Alder	28	RWw
Alnus glutinosa (L.)Gaertner (cone)	Alder	4	
Alnus glutinosa (L.)Gaertner (bud)	Alder	7	
Salicaceae			
Salix spp. (bud)	Willow	23	w
Lythraceae			
Lythrum salicaria L.	Purple-loosestrife	6	BMF
Onagraceae			
Epilobium hirsutum/roseum	Great/Pale Willowherb	5	CDw
Apiaceae			
Berula erecta (Hudson) Cov	Lesser Water-parsnip	2	MPw
Solanaceae			
Solanum dulcamara L.	Bittersweet	14	DHS
Lamiaceae			
Mentha aquatica L.	Water Mint	3	MPw
Potamogetonaceae			
Potamogeton sp.	Pondweed	2	APR
Cyperaceae			
Carex elata All.	Tufted-sedge	59	FPR, reedswamp
*Carex*c.f. *elata* All.	Tufted-sedge	15	
Carex pallescens L.	Pale Sedge	4	G (damp) R,W-clearings
Carex pendula Hudson	Pendulous sedge	4	Whw
Carex riparia Curtis	Greater Pond-sedge	6	PMN, w
Cladium mariscus (L.)Pohl	Great Fen-sedge	10	FRw
Sparganiaceae			
Sparganium erectum L.	Branched Bur-reed	1	MPR
Typhaceae			
Typha sp.	Bulrush	13	PR-reed swamp
	Total:	**278**	
Other remains			
Leech cocoons		4	
Wood fragments		abundant	

For habitat codes see Appendix 1

no evidence in any of the samples to suggest that differential losses of less robust taxa have occurred. Pollen concentration is much reduced in LPAZ SC 2 (context 5) and this certainly seems to be the result of rapid sediment accumulation.

Throughout the later Iron Age and early Roman period, from 410–260 cal BC to 100 cal BC–cal AD 50, the gap between Wearyall Hill and Street was occupied by a wetland fen. *Salix* and a little *Alnus* grew in places, the relative proportions of pollen of these two taxa suggest that *Salix* was the more frequent tree, and along with *Alnus* probably fringed the edges of the flat land, providing the source of the woody detritus found below 3.83m OD in the stratigraphy. Towards 100 cal BC–cal AD 50 these local trees, in particular the alders, declined a little. Some of the *Corylus*-type pollen in SC 1 displayed characteristics of *Myrica* (bog myrtle). As around 66% of the *Corylus*-type pollen showed signs of biochemical deterioration and therefore lacked ideal preservation, it is not possible to speculate on the percentage of pollen of *Myrica* as opposed to *Corylus* in the assemblage. However the dominance of *Myrica* fruits in the macrofossil assemblage suggests that it was widespread and these

Figure 196. Reconstruction picture of the Street to Glastonbury causeway in the Saxon period, looking northeast towards Wearyall Hill and Glastonbury Tor (Peter Lorimer).

low shrubs must have been growing in expanses on the open wet fen in the early part of SC 1, but then declined above 3.83m OD.

The fen area appears to have been dominated by Cyperaceae, with *Carex elata* (tufted sedge), found in eutrophic mires, suggesting seasonal flooding and with *Cladium* indicating the presence of shallow, calcareous, base-rich standing water, probably fed from the water table. These sedges must have formed part of small stands with *Typha* and *Sparganium* around open water transitions. A field layer of smaller herbaceous fen vegetation included *Mentha aquatica*, *Lythrum salicaria* and *Berula erecta* (lesser water-parsnip). Ferns also formed part of the ground flora; spore numbers increase quite markedly in the middle to upper part of SC 1, most of these are undifferentiated but some spores of *Osmunda regalis* (royal fern) and *Thelypteris palustris* (marsh fern) were found; both these species are characteristic of some of the protected fen areas on the Somerset Levels today (Green *et al*. 1997). Occasional *Potamogeton* macrofossils and pollen grains of *Nymphaea alba* and *Nuphar lutea* indicate the presence of open water and it is certainly possible that water-lilies grew within the river channel itself.

The variety of aquatic plants increased following the change in sediment type to organic clay at 3.83m OD, though the cumulative pollen frequencies of the obligate aquatics do not change greatly; largely due to a decline in pollen of *Sparganium emersum*-type towards the end of the zone as Cyperaceae pollen increases. It appears that towards the end of SC 1 sedge beds extended, as the distribution of bur-reeds or lesser bulrushes contracted. *Solidago virgaurea*-type pollen is prominent towards the top of SC 1. This taxon includes *Eupatorium cannabinum* (hemp agrimony) which grows on river banks and in fen communities (Rodwell 1995). The presence of *Potamogeton*, *Lemna* and *Alisma plantago-aquatica* suggest that overall there was no drying out of the wetland habitat, and the change in sediment type possibly indicates that the height of the water table was rising. At the Glastonbury Lake Village 2003 site, a stratigraphic change to organic mud began sometime before 200–50 cal BC and appears to have been associated with deeper water around the site. This date agrees well with the stratigraphic change at Street, which occurs sometime between the dates of 410–280 cal BC to 100 cal BC–cal AD 50.

In SC 1, the dry land trees are largely represented by *Quercus* pollen at relatively low frequencies, with occasional grains of *Ulmus*, *Fraxinus*, *Fagus* and *Tilia*. It appears that the uplands adjacent to the Glastonbury-Street gap had been quite extensively cleared of woodland by 410–260 cal BC, but copses of oak with some ash, elm, lime and beech remained. Pollen of cereal-type and of clearance herbs occurs throughout SC 1, but frequencies are not high, this is similar to the situation at the Glastonbury Lake Village site in the same period. Iron Age agriculture must certainly have been taking place on the dry land, but 200 metres out into the wetland, the signal in the pollen rain was not strong. Microscopic charcoal frequencies are low in the early part of SC 1, but they increase above 3.99m OD, towards 100 cal BC–cal AD 50, presumably reflecting rising populations.

As a result of the loss of sediment from the top of the section beneath the causeway it is not possible to speculate about the environment of the valley immediately before the structure was built in Saxon times. It seems most likely that following some change in the position of the channel of the Brue, within the narrow passage through the Glastonbury-Street gap, river erosion removed the post-100 cal BC–cal AD 50 sediments. The single pollen sample from above the causeway, from the silt of Context 5, has been designated as SC 2. The pollen spectrum suggests that at the time the causeway was in use, the valley remained a wetland environment, the dominance of the Cyperaceae, however, was less than in the later Iron Age, with Poaceae (possibly *Phragmites communis* – common reed) occupying tracts of the flat land. The diversity of flowering herbs in the wetland community was greater than in SC 1, and included Ranunculaceae, *Filipendula* (meadow sweet), Rubiaceae (bedstraw family), Lactuceae, and *Oenanthe* all represented.

The snail assemblage from context 5 suggests that there was a body of open water on the western side of the causeway. The assemblage consisted of several hundred operculae of *Bithynia tentaculata* with a few (<10 in total) *Valvata piscinalis* and *Valvata cristata,* along with bivalve fragments. This assemblage is typical of a wash zone on the edge of a reasonably sized water body, where the relatively light operculae become concentrated as a result of wave or current action. *Myriophyllum verticillatum*, *Nymphaea alba*, *Menyanthes trifoliata* and *Potamogeton*, which are present in the pollen record, would have found a habitat on the margins of this lake.

Significantly, the pollen of clearance herbs increases in SC 2, particularly *Plantago lanceolata* and cereal-type, indicating more intensive exploitation of the area by the Saxon period. It is possible that the wetlands were being used for summer grazing, as the herbaceous pollen taxa are typical of those found in damp meadows. *Alnus* and *Salix* still fringed the valley, and overall there appear to have been rather more trees than in the first millennium cal BC.

Fieldwork conclusions

The stone and timber structure excavated in 1879, 1921 and 2003 is clearly a causeway across the narrow floodplain between Street and the old road to Glastonbury over the top of Wearyall hill. The ruts suggest that wheeled transport used the structure.

Initial construction consisted of the insertion of double rows of oak and ash timbers. In the area beside the river they supported a complex timber structure with a stoned surface which was not present a few metres to the south, where the causeway mainly consisted of a few courses of stone. This was also the case in the 1921 excavation at the northern end of the causeway. These differences in the structure suggest that the 1879 excavation encountered the southern bridgehead of the causeway. The less substantial but much wider causeway in the 2003 excavation would have been immediately behind the narrow bridgehead. Wheeled vehicles could not have passed each other on the bridge but could have done on this wider stoned area to the south (Figure 196).

The form of the bridge that carried the causeway over the Brue is unknown. The bed of the river encounters a stony shallow where the causeway would have crossed it, possibly deliberately deposited to prevent scouring of the bed beneath a bridge, or around piles.

The impetus for the creation of the causeway may have been the acquisition of land by Glastonbury Abbey. A charter of AD 680 granted the Abbey land at Leigh in Street, although its authenticity has been questioned (Sawyer 1968, 1249). This may have prompted the building of the causeway to serve as a communication route to the new manor and the early religious centre at Lantoki in Street (Brigers 2003; Rahtz and Watts 2003). By the early 8th century the Abbey had also been granted extensive landholdings on the Polden hills and the northern part of the Parrett valley by the Wessex monarchy (Thorn 2008). This would have provided a more pressing need for a route south from the Abbey to its new properties.

The Polden estate included the parish of Shapwick where a probable early minster church site has been found, associated with a large timber building, the post holes of which produced nine radiocarbon dates from which chronological modelling suggests a start date of cal AD 540–760 (95% probability; Marshall *et al*. 2007, 1190, fig. A45.5; Abrams 1996, 204; Gerrard and Aston 2007, 965–8). The evidence from Shapwick and the causeway, together with the early land grants, suggest the possibility of a significant reorganisation of the local area in the 8th century, a possibility recently suggested for the wider Somerset landscape (Rippon 2008).

The floodplain of the River Brue underwent very significant changes during the Anglo-Saxon period. The open water body which lapped against the downstream side of the causeway appeared immediately after its construction. As the causeway formed one edge of the feature, the bed of the river under the bridge must also have attained a height that prevented the water body spreading upstream. As the causeway defined and helped create the water body, an obvious question was there a similar retaining feature further downstream or was the natural functioning of the floodplain the cause? The latter possibility is supported by the pollen evidence which suggests that the floodplain was still very wet in that area with extensive sedge and reed beds.

The water body could have functioned as a millpond, with the causeway passing along the upstream side. An early 16th century mill was sited nearby at Northover but this was fed by a specially created millstream upstream of the causeway (Dunning 2006, 54–5; Hollinrake and Hollinrake 2007, 236 and fig. 52). Another possibility is that it represents an artificial enhancement of the river to permit navigation upstream as far as the bridge before unloading and turning round. Transhipment to road could have occurred on the broad stone area south of the bridge or the foot of the hill to the north.

The water body may also have linked with an artificial water channel between Northover and the market place in Glastonbury beside the Abbey, which was first recorded in the 19th century (Hollinrake and Hollinrake 2007, 236). Watching briefs and excavations have proved this to be a canal or leat slightly over 1m deep and 5m wide with a flat base and 45° sides. A timber revetment stake was dated to cal AD 690–1030 (HAR-9207 1120±80 BP) with the final silting containing 12th–14th century pottery (Hollinrake and Hollinrake 1989; 1991; 1992). It is therefore possible that the 'canal' and the causeway had similar start and end dates, although the base of the canal was several metres higher than the causeway.

The causeway also possibly helped to prevent flooding reaching upstream of Street, allowing that area to be used as productive meadowland. This has some tentative support from the pollen evidence that suggested the increased potential for summer grazing on damp meadowland at this period.

Other significant changes are known to have occurred in the lower Brue valley in the Anglo-Saxon period. The street names Northload and Madeload (North and Middle Lode, lode being Old English for an artificial watercourse) in Glastonbury suggest the presence of two artificial watercourses in the town and imply the existence of a Southload, which may be the 'canal' below Wearyall Hill (Hollinrake and Hollinrake 2007, 239). The two streets appear to underlie the Norman street pattern and, along with the canal, appear to end at the putative Anglo-Saxon market place in the town. Northload is first recorded in AD 1180 but a watercourse joined Glastonbury to Meare in 1091 as the bones of St Benignus were carried by boat along it at that date (Watkins 1952, ii, no. 399; Rippon 2007, 219; William of Malmesbury, *Saints' Lives*, 360–5 in Winterbottom and Thompson). That watercourse is probably represented by the canalised channel from Northload to Meare Pool (Rippon 2007, 219).

At some point in the medieval period the waters of the river Brue were largely diverted from their natural course and channelled westwards into Meare Pool and eventually to the sea and to the Axe via the Pilrow Cut (*ibid.*). Recent examination of the palaeochannel which carried the Brue into the Axe valley, has shown a dramatic change in sediments and a massive reduction in flow dated to cal AD 691–989 (UtC 6098 1170±60 BP) (Brown 2006). This dates an erosive contact but the subsequent channel profile suggests little erosion took place and can therefore be used to date the diversion of the River into its westward canalised route.

The creation of the causeway and the formation of artificial river courses around Glastonbury are the first steps in the extensive adaptation of the Levels and Moors floodplain by Glastonbury Abbey and other ecclesiastical landowners, which are well documented from later in the medieval period (e.g. Rippon 2006 and 2007). Together they represent the best Anglo-Saxon evidence in the UK for the dramatic alteration of a natural river valley into a reclaimed and canalised landscape designed to maximise its economic potential. Few parallels of this date can be found anywhere else in Europe.

Comparative sites

There are very few known Anglo-Saxon causeways. The author is grateful to Prof. Steve Rippon for suggesting two possibly similar sites. At Mersea Island, Essex, a causeway, a little over 0.5km long, consists of 15–20 rows of oak piles under a 0.2m deep layer of silt and gravel. Dendrochronological analysis of one pile gave a felling range of AD 693±9 (Crummy *et al.* 1982).

The second site represents a causeway at a crossing point on the Thames at St Aldates in Oxford. The earliest phase of the causeway was represented by a 4m wide clay bank with a gully either side and wattle fences beside the gully which produced two radiocarbon dates of AD 699–1153 and 660–1150 (HAR79/85 1120+110 BP and HAR 125 1140+110 BP) (Durham 1977). There remains considerable doubt if the structure actually represents a causeway however, and alternative interpretations, such as a boundary feature are credible.

Street–Glastonbury causeway assessment and monitoring

Assessment of preservation

Visual assessment of wood

The tops of the vertical oak and ash stakes showed much evidence of desiccation, decay and discolouration. The lower ends were well preserved however and the

Table 147. Street Causeway: moisture content values and state of degradation.

Timber no.	% Moisture content	Timber condition
1	420	Heavily degraded
4	514	Heavily degraded
5	708	Heavily degraded
10	571	Heavily degraded
11	420	Heavily degraded
15	582	Heavily degraded
19	464	Heavily degraded
21	690	Heavily degraded
23	1143	Heavily degraded

Table 148. Street Causeway: wood species, moisture content and density values.

Timber no.	Wood species	% MC	Original density	Present density
1	Oak	420	0.67	0.20
4	Oak	514	0.67	0.17
5	No ID	708		0.12
10	Willow	571	0.42	0.15
11	Oak	420	0.67	0.20
15	No ID	582		0.15
19	Oak	464	0.67	0.18
21	Oak	690	0.67	0.13
23	Ash	1143	0.67	0.08

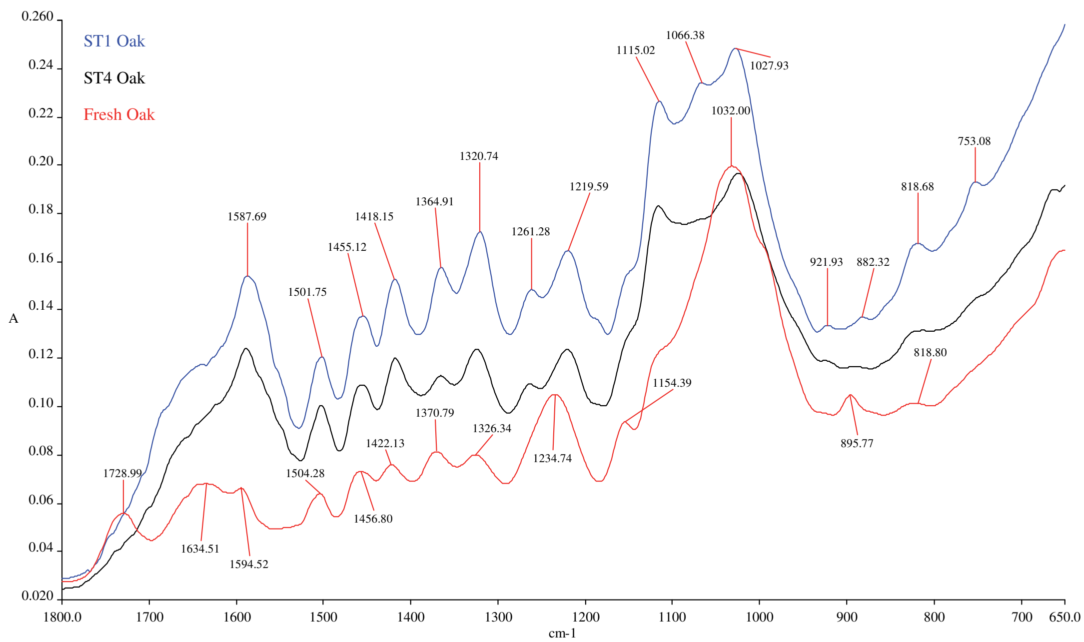


Figure 197. FT-IR spectra of Street–Glastonbury causeway timbers 1, 4 (both oak) and modern oak.

wooden material in the strand deposits at the western end of the structure had a moderately good surface condition.

Detailed examination of wood structure

Mark Jones

Table 147 lists the moisture content values for each timber sample excavated at this site. All samples have moisture content values above 400% and the conditions of the timbers fell into the heavily degraded class. Oak timber samples ranged from 420% to 690%, Timber sample 23 (ash) had an average moisture content of 1143%, which was the second highest value recorded during this study.

The average density values (Table 148) recorded were again much lower than original density values recorded for each species. The lowest recorded density was 0.08, which indicates very little preserved original cell wall material for timber sample 23 (ash). All oak samples had more original cell wall material than the ash sample and density values recorded range from 0.20 to 0.13.

Wood from the Street–Glastonbury site has been identified as oak, willow and ash (two samples not identified). All samples examined under the SEM were highly decayed exhibiting decay patterns, which would suggest ancient bacterial attack. In transverse section, the secondary wall layers of all three wood species examined have been totally degraded leaving intact middle lamella to maintain structural integrity. All three species wood would collapse upon drying.

In terms of chemical degradation to the various

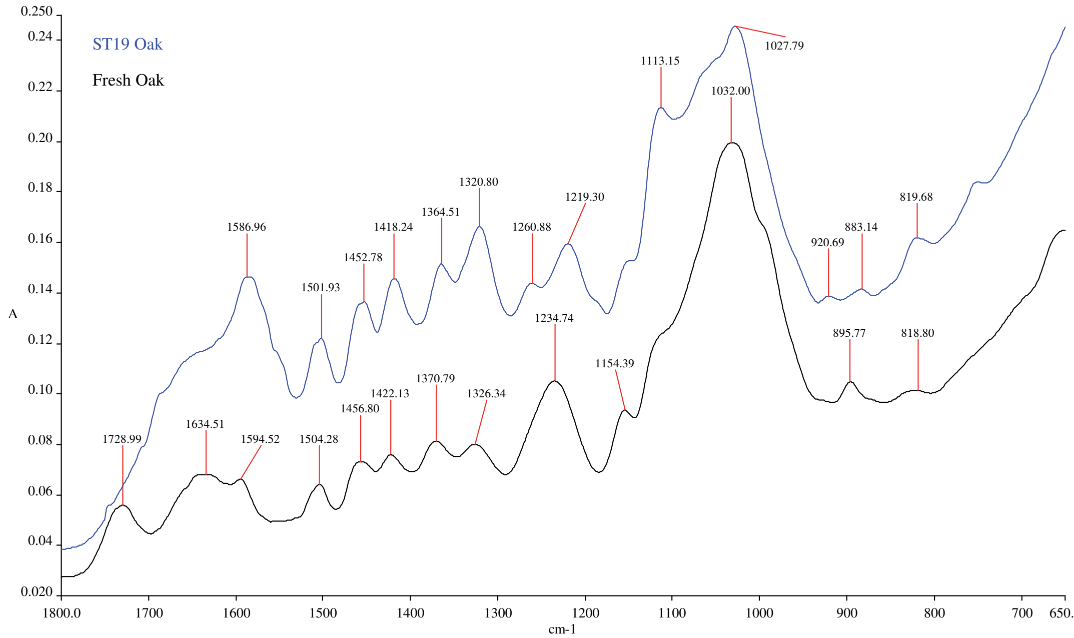


Figure 198. FT-IR spectra of Street–Glastonbury causeway timber 19 (oak) and modern oak.

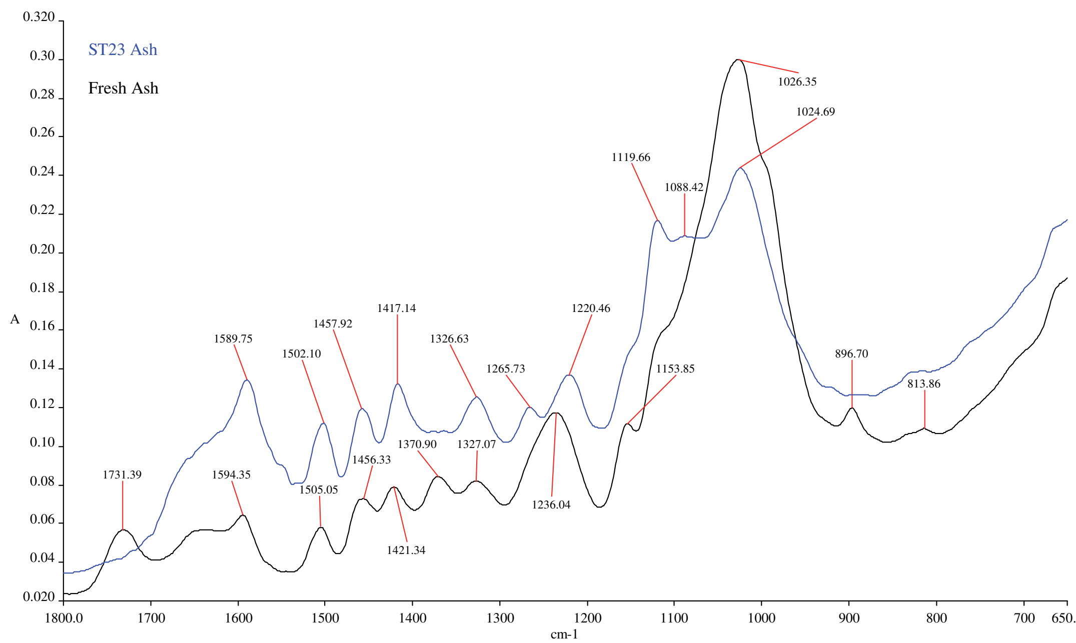


Figure 199. FT-IR spectra of Street–Glastonbury timber 23 (ash) and modern ash.

cell wall components, the most notable changes to Street–Glastonbury woods are the disappearance of hemicellulose and the reduction of cellulose, which is characteristic of microbial attack (Figures 197–9). Once again the lignin peaks are still very prominent. The condition of wood found at Street–Glastonbury site suggests it would irreversibly collapse upon drying.

Pollen evidence

Heather Tinsley

Three of the samples examined from this site come from a 0.5m monolith sequence taken from sediments directly below the broad stone causeway running north–south between Street and Glastonbury. The

Table 149. Street causeway: pollen preservation summary.

	3.55–56m OD	3.77–78m OD	3.99–4.00m OD	Context 5
Total identified pollen grains	100	100	100	100
Pollen concentration	81,800	69,500	463,700	30,600
Number of pollen taxa	13	16	13	23
Total indeterminable grains	4	19	3	18
Total identified extensively corroded grains (a)	2	3	1	4
Total identified extensively degraded grains (b)	1	7	7	11
Total identified extensively crumpled grains (c)	0	0	0	4
Total identified extensively broken grains (d)	4	1	0	1
Total identified grains with poor preservation (a+b+c+d)	7	11	8	20
Total well-preserved grains	43	17	23	22
Total grains of resistant taxa	1	8	2	7
Total ferns	8	211	23	7
Biochemical preservation index	0.49	0.98	0.81	1.06
Mechanical preservation index	0.45	0.47	0.36	0.57

causeway was buried by about a metre of alluvium. An additional sample was assessed from a dark coloured silt containing snails (context 5), which abutted the causeway on its western edge. The lowest sample from the monolith sequence was from 3.55–3.56m OD where fairly wet detrital peat with wood remains had accumulated. Above this, at 3.77–3.78m OD, the peat was similar but rather drier. The uppermost sample was from 3.99–4.00m OD and came from a dry, organic silty-clay which was immediately beneath the causeway.

Pollen preservation

The preservation results are summarised in Table 149. In the basal sample examined, at 3.55–3.56m OD, from the rather wet detrital peat, 43% of pollen grains were well preserved. There were 4 indeterminable grains. 7% of grains identified were poorly preserved, over half of these due to mechanical damage (breakage) mainly to thin-walled Cyperaceae, which were particularly frequent in this sample. Partial breakage and crumpling characterised about one- third of all Cyperaceae grains. Partial degradation and corrosion occurred on a range of taxa, with more than half of all *Corylus*-type showing some corrosion, but only one grain affected extensively. The biochemical preservation index was 0.49 and the mechanical preservation index was 0.45. Fern spores were well preserved.

In the drier peat at 3.77–3.78m OD, preservation was less good, only 17% of grains were well preserved. There were 19 indeterminable grains; in most cases these were amorphous due to extensive degradation. 11% of grains identified had poor preservation, a quarter of these were extensively corroded (*Alnus* and *Corylus*-type), half showed extensive degradation and the remainder exhibited a combination of deterioration types. Partial degradation characterised more than half of all Cyperaceae and *Sparganium emersum*-type grains. 17% of all grains showed some mechanical damage. The biochemical preservation index was 0.98 and the mechanical preservation index was 0.47. The majority of fern spores, which were very frequent in this sample, showed some degradation and some were also extensively etched.

The preservation characteristics of the dry organic silt at 3.99–4.00m OD were somewhat similar to those in the peat below, 23% of grains were well-preserved and 8% had poor preservation the majority of which showed extensive degradation. However, the number of indeterminable grains was only three, very significantly less than at 3.77–3.78m OD. Partial degradation characterised more than 40% of all grains. 15% of all grains showed some mechanical damage. The biochemical preservation index was 0.81 and the mechanical preservation index was 0.36. Fern spores were greatly reduced compared with the sample below, but those present were much better preserved.

In the organic silt of context 5, from beside the causeway, 22% of grains were well-preserved. 18 grains were indeterminable and 20% of identified grains had poor preservation largely due to extensive degradation combined with crumpling. Partial corrosion affected 13% of identified grains and partial degradation affected at least 30% of grains. Around 25% of grains showed some mechanical damage. One grain of *Myriophyllum* and one of *Quercus* exhibited some mineral infilling. The biochemical preservation index was 1.06 and the mechanical preservation index was 0.57. The small numbers of fern spores present were partially corroded.

The poorer preservation associated with the upper

Table 150. Street Causeway: stratigraphy and samples.

Stratigraphy	Plant macrofossil/ beetle samples
3.83–4.03m OD Very dry, organic silty clay. Gradual boundary	3.98–4.03m
3.53–3.83m OD Detrital mud/peat, becoming wetter with depth and with wood remains	3.75–3.80m 3.53–3.58m

two samples from beneath the causeway almost certainly reflects the drier conditions in these sediments, compared to the base of the sequence. Fungal hyphae and fruiting bodies were noted quite frequently in the sample from 3.77–3.78m OD, probably linked to drying out of the surface. The dominant deterioration type seen in all these samples was degradation causing exine thinning, but corrosion was also present affecting particularly *Corylus*-type, *Alnus* and *Betula*, these taxa were however only present at relatively low frequencies at this site. Mechanical damage in the form of crumpling and breakage of grains was quite significant, and this may be related to the increased pressure on the sediments brought about by the building of the overlying stone causeway.

Two samples, 3.77–3.78m OD and context 5 had significant numbers of indeterminable grains, the majority of these appeared amorphous due to degradation, and additionally many were crumpled. Clearly, excessively thinned grains will be most susceptible to mechanical damage by crumpling. It is not clear why numbers of indeterminable grains should be so much higher in these two samples than at 3.99–4.00m OD (the sample immediately beneath the causeway), where the sediment is also very dry. Possibly, the increased clay content at the top of the stratigraphic sequence may have enabled degraded grains to resist crumpling (following increased pressure from the causeway) more successfully than in the softer sediments beneath, resulting in fewer indeterminable grains. The samples from Street Causeway provide a good illustration of the complexity of factors involved in comparisons of pollen preservation even within one site.

There is potential for full pollen analysis of these samples, though with some reservations about the samples from 3.77–3.78m OD and context 5, because of the numbers of indeterminable grains (16% and 15% TP+ indeterminables). The large number of relatively poorly preserved fern spores noted at 3.77–3.78m OD suggest the possibility of differential accumulation of resistant spores as a result of decay of more susceptible pollen types. However, there could be an ecological explanation for the fern peak and full pollen analysis might help elucidate this further.

Plant macrofossils

Julie Jones

Bulk samples were taken from the eastern edge of the causeway, two from a detrital mud/peat with wood remains and one from the overlying drier organic silty clay immediately beneath the causeway (Table 150).

Preservation

The preservation results are summarised in Tables 151–3.

3.53–3.58m OD: The sedges were of variable preservation with almost half being entire fruits, but 28% >50% fragmented with some deterioration to surface cell structure. The few lustrous brown fruits of spike-rush, obovate in outline with rounded edges were also entire although the seed wall with its distinctive square to oblong epidermal cells had suffered slight erosion.

The bi-convex fruits of lesser spearwort are somewhat smaller than other *Ranunculus* types and all three examples here were entire although there was a small degree of erosion to the fine reticulate surface patterning. One further specimen of buttercup (*Ranunculus acris/ repens/bulbosus*) was 25–50% fragmented, with further individuals fragmented to the extent that identification to *Ranunculus* sp only was made.

Fruits of bittersweet are circular to oval in outline with a distinctive network of cells with wavy walls, which allows even fragmented fruits to be identified. Most examples here were whole or only slightly fragmented (<25%) showing some discontinuity in the network surface patterning.

Preservation index 2.17. Nine taxa in 41 counted. Analysis would be possible, larger sample may add more taxa.

3.75–3.80m OD: The range of taxa here was very limited with only 8 fruit/seeds in the whole sample. The single common chickweed was well-preserved, with some fragmentation and deterioration to the surface of the mint (*Mentha*).

Preservation index 1.5. Three taxa in eight counted. Analysis not recommended.

Table 151. Street Causeway: plant macrofossil preservation.

Detrital mud/peat								
		Fragmentation				Erosion		
3.53–3.58m OD (45–50cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Alnus glutinosa	1	1	0	0	0	0	0	0
Berula erecta	1	1	0	0	0	0	0	1
Carex spp	21	9	5	1	6	2	4	4
Eleocharis palustris/uniglumis	2	2	0	0	0	0	2	0
Ranunculus acris/repens/bulbosus	1	0	0	1	0	0	1	0
Ranunculus flammula	3	3	0	0	0	0	1	1
Ranunculus spp	4	0	0	3	1	0	4	0
Solanum dulcamara	7	4	3	0	0	0	1	0
Typha spp	1	0	1	0	0	0	1	0
Other macrofossils: frequent wood frags/roots/nodules, rare *Salix* bud								
Detrital mud/peat								
3.75–3.80m OD (23–28cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Mentha spp	5	1	4	0	0	5	0	0
Potamogeton spp	2	1	0	1	0	1	0	0
Stellaria media	1	1	0	0	0	0	0	0
Other macrofossils: frequent wood frags								
Dry organic silty clay immediately below causeway								
3.98–4.03m OD (0–5cm)	Total counted	whole	<25%	25–50%	>50%	<25%	25–50%	>50%
Carex spp	4	4	0	0	0	0	0	0
Mentha spp	4	2	1	1	0	2	2	0
Potamogeton spp	1	0	1	0	0	0	0	0
Typha sp	1	0	1	0	0	1	0	0
Other macrofossils: occasional wood frags								

Table 152. Street Causeway: pollen preservation summary.

	3.53–3.58m OD	**3.75–3.80m OD**	**3.98–4.03m OD**
Total macrofossils counted	41	8	10
Estimated total in sample	41	8	10
Total taxa	9	3	4
Total well preserved	20	3	6
Total <25% fragmented	9	4	3
Total 25%–50% fragmented	5	1	1
Total >50% fragmented	7	0	0
Total <25% erosion	2	6	3
Total 25%–50% erosion	14	0	2
Total >50% erosion	6	0	0
Preservation index	**2.17**	**1.5**	**1.2**

Table 153. Street Causeway: properties of 250g unprocessed samples.

	Dry weight	**0.25mm**	**0.5mm**	**1mm**	**2mm**	**4mm**	**Organic matter %**
3.53–3.58m	58.2g	4.6g	5.4g	4.7g	4.8g	6.5g	44%
3.75–3.80m	68.02g	4.4g	4.8g	5g	4.7g	5.1g	34%
3.98–4.03m	106.95g	3.3g	3.3g	3.9g			10%

Table 154. Street Causeway: assessment of insect and other invertebrate remains.

m OD	Description of flot and its fauna	Interpretative potential and priority
3.98–4.03	Trace flot with rootlets; no more than traces of very decayed invertebrates other than earthworm (Oligochaeta) egg capsules.	No further action. P0
.75–3.80	Minute flot with crumbs of undisaggregated organic sediment and traces of plant detritus. A few beetles and traces of very decayed cuticle; probably many remains lost.	No interpretative value beyond aquatic deposition. P3
3.53–3.58	Small flot of plant detritus and abundant invertebrate fragments. Aquatics dominant (e.g. *Ochthebius* and *Hydraena* sp.; *Tanysphyrus lemnae* (Paykull)) but also an appreciable terrestrial or damp ground component. No heathland/bog taxa noted. Some unfamiliar beetle remains.	Larger sub-sample (3kg or more) would give a useful representation of the non-aquatics; overall would give useful ecological recon-struction; difficult identifications. P1A

Table 155. Street Causeway: preservational condition of invertebrate (principally insect) remains.

m OD	Chemical erosion				Fragmentation				Colour change					Other properties
	range		mode	str	range		mode	str	To	range		mode	str	
3.98–4.03	5.5	–	–	V	–	–	–	–	–	–	–	–	–	most remains completely decayed
3.75–3.80	2.0	5.0	4.5	W	3.0	5.5	5.0	W	Pale	2	3	3	D	
3.53–3.58	2.5	4.5	3.5	S	1.5	2.5	2.0	W	Pale	2	3	3	S	

3.98–4.03m OD: Much of the sample float comprised unbroken down sediment and although few taxa were recovered from this drier peat below the causeway preservation of the 10 seeds recorded was good. The sedges show no sign of deterioration and there was only slight fragmentation to the mint, pondweed and bulrush. Interpretation of such limited assemblages is however difficult.

Preservation index 1.2. four taxa in 10 counted. Analysis not recommended.

Recommendations

Only one of the samples from the peat below the causeway at Street provided an assemblage suitable for environmental reconstruction. However, this lowest sample in the detrital mud/peat at the base of the sequence only produced 41 macrofossils from the entire sample, mostly sedges, half of which may not be identifiable to species due to fragmentation and loss of surface detail. Further analysis would be possible with larger samples to hopefully increase species diversity.

In the upper two samples very few macrofossils were recovered although a lower preservation index does suggest that the condition of those individuals counted was better than in the basal sample. However in the top sample from the dry, organic silty clay it was estimated that 80% of the float consisted of unbroken down sediment with an organic content of only 10% and therefore very large samples would be required to allow satisfactory environmental interpretation. Further analysis of the top two samples is therefore not recommended.

Coleoptera

Harry Kenward

Three samples were assessed, one from the organic silty clay (3.98–4.03m OD) and two from the lower detrital mud/peat (3.75–3.80m OD and 3.53–3.58m OD). The two upper samples deposits showed very great decay (Tables 154 and 155), most remains having rotted completely in the upper sample, and the modes for E and F laying at 4.5 and 5.0 respectively (with more degraded material present in each case). Insect remains in the lowest deposit (3.53–3.58m OD) were in better condition, with limited fragmentation but still sometimes substantial chemical change (to E 5.0).

Table 156. Street Causeway: Station 1.

Horizon depth (cm)	Description
0–15	Dark grey (10YR 4/1) moist silty clay loam with common fine rusty mottles
15–55	Light yellowish brown (10YR 6/4) moist clay with common fine mottles of greyish brown (10YR 5/2)
55–95	Grey to light grey (N6/-) moist clay with common medium mottles of yellowish red (5YR 4/8), mottling increasing with depth
95–110	Light grey (N7/-) very moist clay (water encountered at 108cm depth) with many fine mottles of yellowish red (5YR 5/6)
110–140	Dark reddish brown (5YR 2/2) greasy woody amorphous peat (H8) with areas of 5YR 3/3, but no free water
140–150+	Dark reddish brown (5YR 3/3) greasy woody amorphous peat (H7)

Table 157. Street Causeway: Station 2.

Horizon depth	Description
0–15	Dark greyish brown (10YR 4/2) moist silty clay loam with common fine rusty mottles
15–35	Light brownish grey (10YR 6/2) moist clay with many fine faint mottles of strong brown (7.5YR 5/6)
35–65	Light brownish grey (10YR 6/2) moist clay with very many medium mottles of strong brown (7.5YR 5/6)
65–95	Light grey (N7/-) moist clay with many medium mottles of yellowish red (5YR 4/8), horizon becoming darker below 95cm
95–135	Dark reddish brown (5YR 2/2) firm amorphous peat (H8) with small pieces of wood; no free water
135–155	Dark reddish brown (5YR 3/3) amorphous grass-sedge peat (H7) with remains of roots and occasional leaves; no free water

Table 158. Street Causeway: Station 3.

Horizon depth	Description
0–10	Brown to dark brown (7.5YR 4/2) moist silty clay loam with common fine rusty mottles
10–25	Greyish brown (10YR 5/2) moist clay with common fine faint mottles of strong brown (7.5YR 5/6)
25–45	Pale brown (10YR 6/3) moist clay with many fine faint mottles of strong brown (7.5YR 5/6)
45–65	Very pale brown (10YR 7/3) moist clay with many medium prominent mottles of strong brown (7.5YR 5/6)
65–90	Light grey (N 7/-) moist clay with many medium mottles of yellowish red (5YR 5/6)
90–130	Dark reddish brown (5YR 2/2) greasy firm amorphous peat (H9)
130–150	Dark reddish brown (5YR 3/4) wet amorphous grass-sedge peat (H7) with remains of roots and occasional leaves

Table 159. Street Causeway: Station 4.

Horizon depth	Description
0–15	Brown to dark brown (7.5YR 4/2) moist silty clay loam with common fine rusty mottles
15–45	Light yellowish brown (10YR 6/4) moist clay with common fine faint mottles of strong brown (7.5YR 5/6)
45–65	Pale brown (10YR 6/3) moist clay with many fine and medium mottles of yellowish red (5YR 5/6)
65–85	Light grey (N 7/-) moist clay with many medium mottles of yellowish red (5YR 4/8)
85–105	Dark reddish brown (5YR 2/2) loamy (clayey) peat becoming greasy and with wood (H9) with depth; no free water
105–150	Dark reddish brown (5YR 3/4) amorphous woody peat (H7); no free water

Monitoring of burial environment

David Hogan

Site description

Transect: Commencing from the base of the embankment of River Brue, at right-angles to the river at 5m (Station 1), 10m (Station 2, by excavation) and 20m (Station 3). Station 4 is 5m out from base of slope to roadway (20m from causeway wall), between second and third tree from the river.

Land-use: Permanent mesotrophic grassland, grazed by cattle. Water ponded in elongated depressions in field.

Station 1 (Table 156): Instrumentation: piezometers at 50cm, 100cm and 150cm depth.

Station 2 (Table 157): Instrumentation: piezometers at 50cm, 100cm and 150cm and redox probes at 40cm, 60cm and 80cm depth.

Station 3 (Table 158): Instrumentation: piezometers at 50cm, 100cm and 150cm.

Station 4 (Table 159): Instrumentation: piezometers at 50cm, 100cm and 150cm.

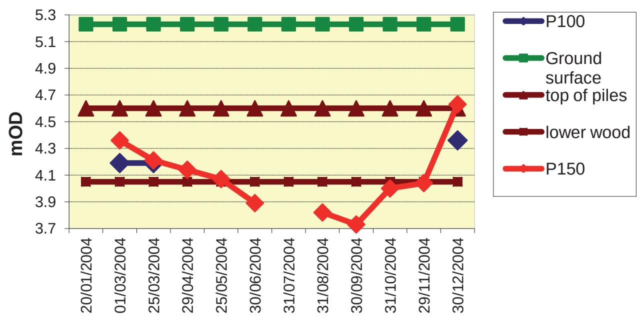


Figure 200. Water table at Station 2.

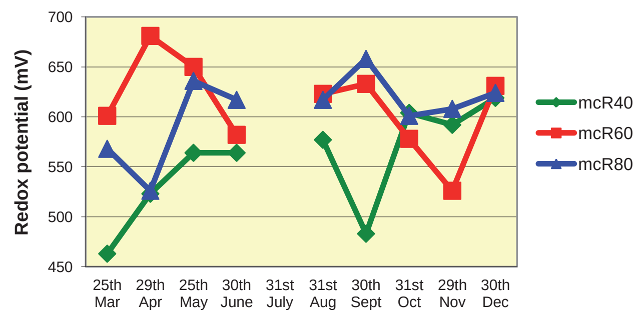


Figure 201. Redox potential at Station 2.

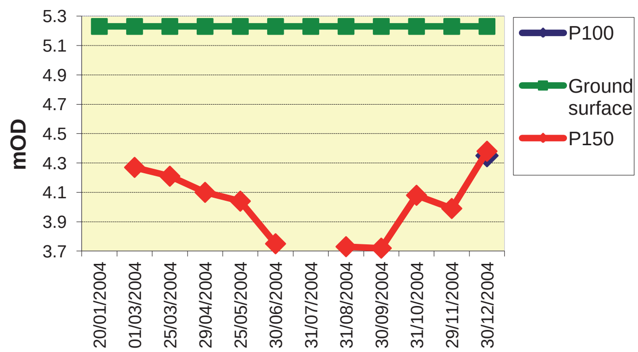


Figure 202. Water table at Station 1.

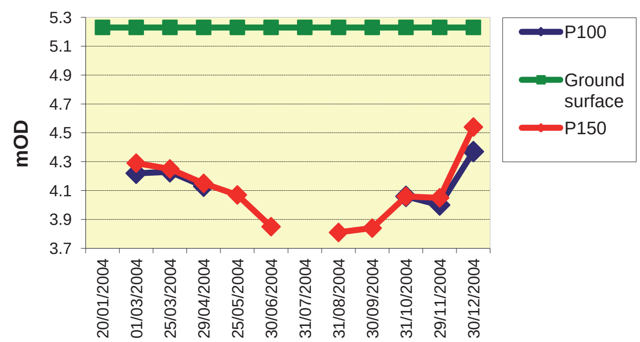


Figure 203. Water table at Station 3.

Results

The profile comprises about 1m thickness of clay (95cm at the excavation) over peat, the archaeology occurring in a narrow horizontal band at the top of the peat (at about 104cm depth), and as piles set vertically through the clay up to 63cm below the surface. Figure 200 indicates that the water table lies completely below the remains for all but the winter and early spring, and that overlying layers of clay remained *oxidised* throughout the year (Figures 201 and 202). Though no redox data are available for the underlying peat, reference can be made to the piezometer data at all stations (Figures 200, 202–4), which indicate that water levels were often below the recording depths of the P50 and P100 tubes. However records from the 150cm deep piezometers are more complete and indicate a fall in the water table below the top of the peat between late May and late November.

At wetter times, though upward pressure of water in the peat suggests some rewetting of the clay is possible, this is not evident in redox response, conditions remaining *oxidised* throughout the year. Groundwater taken from piezometers beside the structure had a pH of 7.3, while a pH of 7.9 was recorded from water from the River Brue on the northern side of the field.

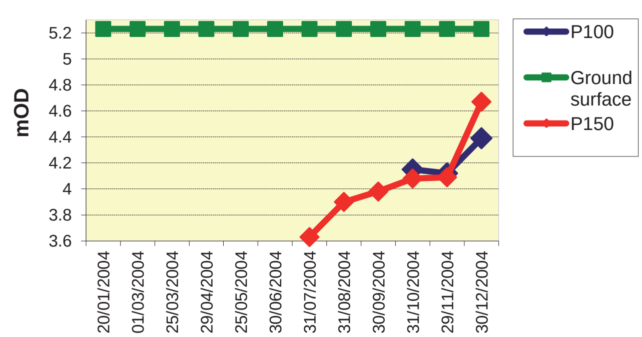


Figure 204. Water table at Station 4.

Conclusions

The permanently oxidised conditions throughout the superficial clay deposit indicate little likelihood of preservation of the piles found there. Wood preserved at the top of the peat experiences only seasonally waterlogged conditions, though the effect of a wetting front will offset the effects of desiccation. However since permanently waterlogged conditions do not exist at this depth, some on-going degradation of organic materials is probably taking place.

7. Preservation and Environmental Change

General preservation results

Water quality monitoring

David Hogan

Due to a general lack of water available for sampling, laboratory analyses have been limited to a single sampling occasion at each location, split between October 2004 and February 2005 as shown in Tables 160 and 161. While it is not possible to determine any trends or long-term effects, these snap-shots give a useful indication of general water quality during the period of the investigation. Groundwater (soil water) is represented by piezometer samples, while surface water is taken from ditches and channelised rivers (South Drain and River Brue). Some comparison is also possible with water quality data collected in a previous study of the Sweet Track at Shapwick Heath (Brunning *et al.* 2000), where the land is managed for nature conservation and water quality is expected to be good. The following general points emerge.

Conductivity

There is no obvious pattern in relation to either surface or groundwater samples. The highest values (around 1900µScm) are found at Harter's Hill (piezometer and ditch waters), with other values of 1000µScm or more occurring at Saul Platform (piezometer and ditch waters) and Chilton Track (ditch) and Street causeway (piezometer). The lowest value (444µScm) was from a piezometer sample at Abbot's Way. Values were generally higher than those found at the Sweet Track, where the range was 142–636µScm.

pH

Due to the alkaline character of the Brue catchment geology, water samples were generally circum-neutral, in the range 6.5–7.5. the highest value of 7.7 being found in a piezometer at Chilton Tracks and in water from the South Drain at Tinneys.

Ammonia

High values (5–7mgl^{-1}) were reported in samples from piezometers at Glastonbury, Chilton and Bell Tracks, where contamination of soil water from organic matter is indicated as a likely cause. Values at the Sweet Track site were generally <1, with comparable high values in the range 6.5–8.5 limited to ditches in winter, together with a single exceptional reading of 16µScm from a 1m deep piezometer in November.

Orthophosphate

Most samples give low values (<480µgl^{-1}), the highest being 1450 µgl^{-1} from a piezometer at Glastonbury. Some larger values up to 3530µgl^{-1} were found at the Sweet Track.

Nitrate

Most samples were low (<3mgl^{-1}) in nitrate–N concentration, with higher values restricted to surface waters, notably ditches at Saul Platform (14mgl^{-1}) and Harter's Hill (12mgl^{-1}), the River Brue (35 mgl^{-1}) and the South Drain at Tinneys (17 mgl^{-1}). All water samples measured at the Sweet Track were found to be <5 mgl^{-1}.

Chloride

Most samples are between 20mgl^{-1} and 60mgl^{-1}, with a highest value of 80mgl^{-1}. The range is similar to that found at the Sweet Track. There is no evident pattern in the variation found.

Table 160. Analyses of water samples collected 26/10/04.

Analysis Location	EC μScm^{-1}	pH	NH_4_N mgl^{-1}	Ortho-P (P_2O_5) μgl^{-1}	NO_3_N mgl^{-1}	Cl^- mgl^{-1}	SO_4^{2-} mgl^{-1}	PO_4^{2-}P μgl^{-1}	Alkalinity as HCO_3 mgl^{-1}	Ca^{2+}	K^+	Mg^{2+}	Na^{2+}
Bell Track (P)	805	7.1	5.4	<480	1.4	80	27	<150	–	–	5.2	15	45
Bell Track (D)	612	7.1	<0.5	<480	<0.2	58	11	<150	250	75	16.0	11	41
Chilton Track (P)	749	7.7	5.6	<480	0.8	40	2	<150	–	–	6.9	21	41
Chilton Track (D)	1110	7.5	2.6	<480	0.79	60	96	<150	450	210	31.0	13	44
Glastonbury (P)	987	6.7	6.8	1450	<0.2	48	54	600	570	140	3.7	21	66
Glastonbury (D)	969	7.1	<0.5	<480	0.44	43	150	<150	380	170	6.1	11	42
Harter's Hill (P)	1900	6.5	2.7	<480	3.6	21	970	<150	–	–	3.9	94	46
Harter's Hill (D)	1920	6.6	<0.5	<480	12.0	42	480	<150	240	260	48.0	36	37
Saul Platform (P)	1370	6.8	<0.5	<480	1.4	67	220	<150	–	–	14.0	32	62
Saul Platform (D)	1060	7.4	<0.5	537	14	59	120	220	390	200	22.0	21	41
Tinney's Tracks (P)	556	7.0	2.6	<480	3.3	22	56	<150	–	–	1.9	12	17
Tinney's Tracks (D)	690	7.7	<0.5	<480	17	32	51	<150	290	120	7.5	7.4	26

Water sample source: P = piezometer, D = ditch

Table 161. Analyses of water samples collected 07/02/05.

Analysis Location	EC μScm^{-1}	pH	NH_4_N mgl^{-1}	Ortho-P (P_2O_5) μgl^{-1}	NO_3_N mgl^{-1}	Cl^- mgl^{-1}	SO_4^{2-} mgl^{-1}	PO_4^{2-}P μgl^{-1}	Alkalinity as HCO_3 mgl^{-1}	Ca^{2+}	K^+	Mg^{2+}	Na^{2+}
Street Causeway (P)	1000	7.3	6.5	<480	1.1	35	130	<150	–	–	2.3	7.5	31
Street Causeway (Brue)	648	7.9	<0.5	<480	35	30	39	180	260		5.7	7	23
Meare (P)	–	6.4	0.5	<480	5.9	26	630	<150	–	–	4.5	39	23
Meare (D)	882	7.0	<0.5	<480	2.1	26	140	<150	350		1.5	11	21
Abbot's Way (P)	444	6.7	2.4	<480	2.8	25	25	<150	–	–	3.0	11	26
Abbot's Way (D)	881	6.6	<0.5	<480	26	29	110	<150	340		3.1	15	31

Water sample source: P = piezometer, D = ditch, Brue = River Brue along site boundary

Sulphate

There is a very large range with the highest values found at Harter's Hill with 970mgl^{-1} in a piezometer sample and 480mgl^{-1} in ditch water. At Saul Platform, 220mgl^{-1} was recorded in a piezometer and 120mgl^{-1}in a ditch. At Meare, 630$mgl^{-1}$was recorded in a piezometer and 140mgl^{-1}in a ditch. Elsewhere values were generally <100mgl^{-1}, while at the Sweet Track most values were <10mgl^{-1}. High values could result from the presence of acid-sulphate peat soils. Burton and Hodgson (1983) describe acid-sulphate peat soils occurring in a number of places on the Somerset Moors.

Phosphate as P Phosphorus

A high value of 600µgl^{-1} was found only in a piezometer sample at Glastonbury, most water samples having <150µgl^{-1}. Similarly at the Sweet Track many values were <200µgl^{-1}, though a number of values in excess of 1000µgl^{-1} were found, though no obvious pattern in P concentration was determined.

Alkalinity

Values were in the range 240–570mgl^{-1} HCO_3, the highest being in a piezometer at Glastonbury. Most alkalinity values along the Sweet Track were lower, in the range 100–300mgl^{-1} HCO_3.

Calcium (total hardness)

Values are high, due to the calcareous geology and consequent hydrogeology of the Brue catchment. Highest concentrations were found in ditches at Harter's Hill (260mgl^{-1}), Chilton Tracks (210mgl^{-1}) and Saul Platform (200mgl^{-1}). However, due to the shortage of water for a sample from most piezometers, most samples analysed were from ditches. Figures from the Shapwick Heath Sweet Track were almost all <100mgl^{-1}.

Potassium

Concentrations were found to be generally higher in ditches (range 6.1–48mgl^{-1}) than in piezometers (1.9–14mgl^{-1}), a similar pattern to that occurring along the Sweet Track, where soil water values were generally <10mgl^{-1}, while ditch concentrations were a little higher (maximum 15mgl^{-1}). The highest concentrations in both soil and surface water was found at Harter's Hill, probably resulting from fertilizer additions.

Magnesium

In contrast to the values for potassium, magnesium concentrations were found to be higher in piezometers (12–94mgl^{-1}) than ditches (7.4–36mgl^{-1}). As in the case of potassium, the highest values in both piezometers and ditches were found at Harter's Hill, again likely to result from fertilizer use. Figures from the Sweet Track were consistently low (<15mgl^{-1}).

Sodium

There was no consistent difference between values from piezometers and ditches. The overall range was 17–66mgl^{-1}, the highest values occurring in piezometers at Glastonbury (66mgl^{-1}) and Saul Platform (62mgl^{-1}), while the lowest value (17mgl^{-1}) was from a piezometer at Tinneys. Comparable values were found at the Sweet Track.

Water quality summary

In general no serious water quality problems were highlighted. Some poor water quality was identified from elevated ammonia concentrations at Glastonbury, Chilton and Bell Tracks, presumably resulting from the effluent of grazing animals. Nitrate concentrations were highest in a number of ditch systems, while the only indication of high phosphorus was in a piezometer at Glastonbury. Indications are that Harter's Hill has been more intensively managed than other sites, resulting in highest conductivity values in both piezometer and ditch waters, with high concentrations found in both magnesium and potassium, probably deriving from fertilizer usage.

Summary of risk to preservation of organic archaeological remains

Findings from studies give little indication of sites where stable anoxic conditions exist, suited to preservation of organic archaeological remains under present site management conditions. Only three sites showed any indication of sufficiently persistent anoxic conditions to render them suitable as preservation environments. At Glastonbury Lake Village the lower timbers appear to remain waterlogged and anoxic, though upper timbers experience periods of oxidation. At Saul Platform the conditions around the lower remains are largely anoxic, though very short periods of oxidation may enable slow degradation to proceed. Conditions for preservation at Chilton tracks are moderate. No substantial fall in the water table was recorded, precluding the development of oxidised conditions, though maintenance of a suitable environment may be dependent on an adequate amount of summer rainfall.

In all other cases a considerable fluctuation of the water table was found within the zone of the archaeology, accompanied by substantial periods of oxidised or only slightly reduced conditions, according to measured redox potentials. Some degree of continued degradation of organic remains is likely to be taking place under the current hydrological regime, even where peat is overlain by a thick superficial clay deposit as at Street Causeway, where around 1m thickness of clay overlies peat.

No serious water quality problems were highlighted in this study. In some places poor water quality was thought to result from the on-site impact of effluent from grazing animals, while fertilizer additions were also considered to be responsible for some elevated parameters in the water chemistry. In general, the water in ditches tended to be of lower quality than that found in piezometers, the latter representing soil/ground water, since ditches and surface drains are more vulnerable to direct pollution impacts and are unprotected by any

Table 162. Condition assessment of MARISP wood.

Timber no.	Wood species	% Moisture content	% Longitudinal shrinkage	% Radial shrinkage	% Tangential shrinkage
Chilton 1	Hazel	354	4.2	45	49
Meare 3	Oak	452	4.4	26	41
Glastonbury 12	No ID	908	6.8	39	65
Street –G. 10	Willow	1041	16	32	64
Harter's 129	Alder	955	6.7	30	54
Saul 32	Alder	832	6.5	29	51
Tinney's 1	Alder	1036	7.0	36	54
Abbot's 6	No ID	613	7.6	33	54
Bell 1	Ash	175	3.1	21	35

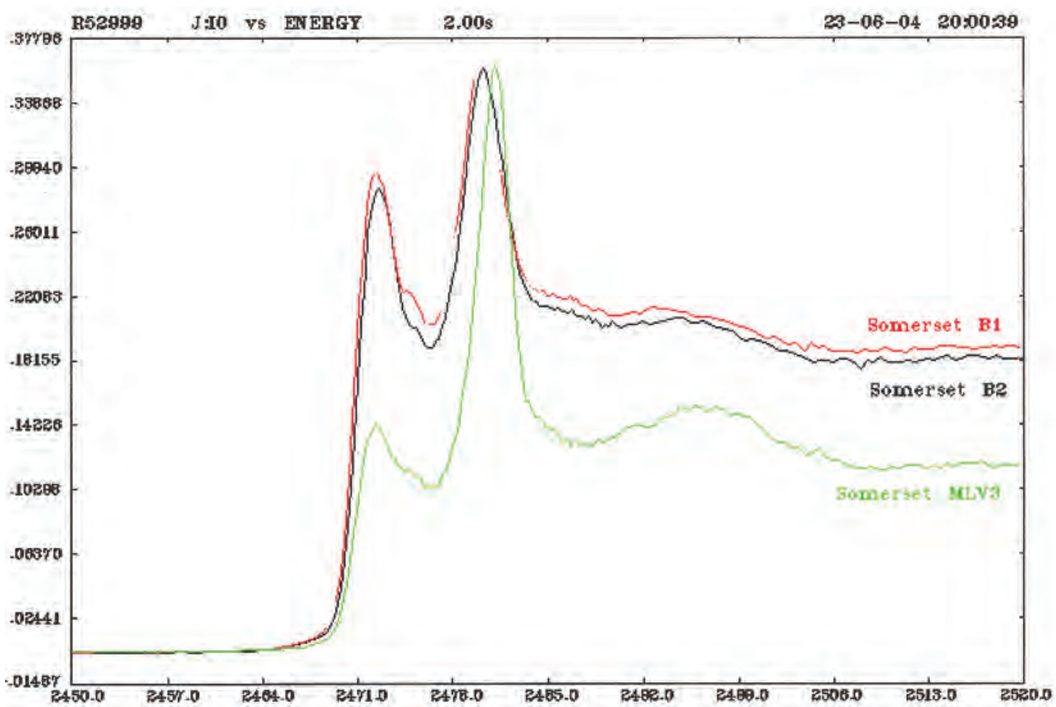


Figure 205. Sulphur XANES spectra from timber samples excavated from the Bell Track and Meare Lake Village.

soil or vegetation which might otherwise intercept or transform inputs. Additionally, pollution in ditch water may derive from off-site impacts, depending on surface water drainage patterns and pathways.

Wood

Mark Jones

Wood texture

All timber samples examined did not have a solid feel and were spongy to friable. Some of the timbers were so friable that the samples could easily disintegrate upon sectioning. Upon drying the colour of timber samples ranged from light brown to dark brown. A feature most frequently encountered with timbers from many archaeological sites is the presence of surface slime and iron corrosion products. Slime on the surface of wood is due to the presence of active microbial growth (bacterial) and this was not observed on any timber surface examined. There does not appear to be any iron deposits on the wood surface. If present they appear as orange to red-brown deposits on the surface. Although not part of the current study, an investigation involving X-ray diffraction is currently underway to determine to presence of iron compounds within a number of timber samples excavated from the various Somerset sites.

Wood shrinkage

On drying the deteriorated ancient timber samples from the various archaeological sites in Somerset are subject to changes in size and shape as moisture is removed. This can result in the virtual destruction of the timber because the wood cell structure is not strong enough to resist drying stresses adequately. Data obtained for a number of ancient Somerset timbers are shown in Table 162 and the results indicate that all timbers will shrink significantly more than modern wood. Unless the burial sites are maintained in a waterlogged condition, irreversible damage will occur to the buried timbers at the various archaeological sites in Somerset.

X-Ray absorption near edge spectrometry

The sulphur XANES spectra from timber samples excavated from two archaeological sites in Somerset display two major peaks at 2472eV and 2482Ev (Figure 205). Comparisons with spectra of known standard sulphur compounds indicate the peak at 2471eV corresponds to reduced sulphur forms such as disulphides, thiols and elemental sulphur. The peaks at 2482eV originate from sulphate ions. If there are plans to excavate these timbers in the near future, sulphur scavengers must be used to remove these compounds before conservation commences. Otherwise, the reduced sulphur compounds will oxidise slowly over time to form sulphuric acid.

Conclusions

- Forty-five timbers examined were Heavily degraded, 10 were of Medium degrade, one was Slightly degraded.
- All timbers examined showed evidence of ancient microbial decay (bacterial and in some cases fungal attack).
- No evidence of active cellulolytic bacteria within ancient timber samples.
- Reduced sulphur and sulphates are present in timbers at Bell Track and Meare lake village. Future analysis will determine their presence in timber samples excavated from the remaining archaeological site in Somerset.
- Sulphur reducing and sulphur oxidising bacteria have been involved in the sulphur cycle in buried Bell and Meare archaeological timbers.
- Best preserved timbers were excavated from the Bell Track (wood species – ash).
- Lowest recorded moisture content: Bell Track (timber no. 2,) 175%, highest recorded moisture content: Street–Glastonbury (timber no. 23) 1143%. Both samples were ash.
- Heavily degraded woods had lost all of their hemicellulose and significant amounts of cellulose component. Lignin component was generally unaffected.
- Outer surface of all timbers was found to be very spongy.

Issues in the method for recording pollen deterioration

Heather Tinsley

It is standard practice for pollen analysts to record and classify the indeterminable grains seen during routine analysis into deterioration types (and unknowns) (Berglund and Ralska-Jasiewiczowa 1986), and to use this as a basis for statements regarding the quality of preservation in the whole pollen assemblage. However, pollen taxa can be routinely identified even when they have begun to deteriorate, in many cases even when deterioration is quite far advanced, because of the combination of diagnostic taxonomic features such as shape, sculpturing, apertures etc. Despite this, it is less usual for pollen analysts to record the individual preservation characteristics of all identifiable grains, as has been done for the MARISP assessments, probably because it is a time-consuming process. Exceptions include studies in Britain by Lowe (1982) Smith (1984) and Tipping (1987). Tipping (2000) discussed the value of pollen preservation analysis in Holocene palynology generally and concluded: 'Despite a history of work extending back over 30 years and more, and the often expressed recognition of the importance of such work, quantitative data on pollen preservation are still rare ...'.

The MARISP pollen assessments were carried out, not primarily for purposes of environmental reconstruction, but to provide information relating to the susceptibility of the pollen to further possible deterioration associated with changes in local water regimes. There is no doubt the data collected also have potential value in any future palaeoecological work which might be carried out at these sites, but the current sample sizes are at assessment level only and full analysis would be needed before this could be pursued. This aspect of the data will not therefore be discussed further. Instead discussion will concentrate on the reliability and value of the preservation data obtained, and its usefulness in determining whether there is currently risk of loss of ecological information from sites due to pollen deterioration.

The deterioration classification

The classification of pollen deterioration types is well established, originating in work by Cushing (1964), which has been adapted and developed by many authors. The system adopted here, based on the definitions of Delcourt and Delcourt (1980), has been found to be relatively straightforward to use, though not without difficulties, particularly when grains fell into more than one deterioration class. For example, where mechanical damage was extensive it could be difficult to distinguish between corrosion and degradation.

Subjective judgments could not be avoided, particularly in recording degradation and assessing the state of 'thinness' of a particular grain compared with its well-preserved condition. It was also difficult to standardise judgements regarding the degree of degradation exhibited by grains of taxa with markedly varying exine thickness and sculpturing patterns.

The significance of differences in the incidence of the two main biochemical deterioration types identified, corrosion and degradation, is not entirely clear, either from the literature or from this study. According to Havinga (1984), corrosion is associated with biochemical activity in aerated sediments, with bacterial action particularly implicated. Delcourt and Delcourt (1980) suggested that degraded grains are associated with chemical oxidation within aerial or sub-aerial environments. However, not all authors agree on these distinctions, and Tipping (2000) pointed to some confusion in the literature regarding corrosion and degradation, which may in part relate to definitions of terminology. Tipping (2000), commenting on his own observations, noted that there was no clear correlation between corroded and amorphous (very extensively degraded) grains, which certainly suggests that two different processes are at work. The lack of correlation between corroded and extensively degraded grains is to some extent borne out by the data collected for this report, but it still cannot be assumed that different chemical/ biochemical processes are implicated in samples showing more corrosion, compared with ones that are more degraded. This is because the taxonomic make up of the pollen assemblage has a bearing on the incidence and intensity of the deterioration processes.

The MARISP data demonstrate that corrosion registers as a major deterioration type in those samples where the smooth-exined taxa *Corylus*-type, *Alnus* and *Betula* predominate (for example at the Chilton Track and the Bell Track), with *Betula* apparently the most susceptible taxon of these three (sample 1.68–1.69m OD at the Bell Track). This is not to say that corrosion is confined to these taxa; the data demonstrates that it occurs widely, but that corrosion is most frequently observed where these particular tree taxa predominate.

Features of the pollen assemblages

A number of features of the whole pollen assemblage, which potentially might be useful guides to overall preservation, have been recorded in the summary tables. Probably the most valuable of these proved to be the number of indeterminable grains. Birks (1973) discussed the importance of recording and publishing numbers of indeterminable grains associated with every pollen sample analysed, in order to indicate the reliability of the counts. The larger the number of indeterminable grains counted, the greater the information that has been lost from that sample. As pollen grains vary in their susceptibility to deterioration, these losses will be differential, the least robust taxa being affected to the greatest degree, thus the pollen assemblage will become increasingly biased towards more resistant taxa as numbers of indeterminable grains increase.

In the MARISP samples the numbers of indeterminable grains were very variable, high numbers do not characterise any particular site, but were found in some individual samples where preservation of identified grains was also poor (e.g. samples from 1.68–1.69m OD at the Bell Track, 5.12–5.13m at Glastonbury Lake Village, 4.18–4.19m OD at Harter's Hill, 5.04–5.03m OD at Sharpham Park and context 5 at Street Causeway all had 20 or more indeterminable grains in counts of 100). In the full data set from all the 35 MARISP samples examined there was a positive correlation (significant at the 0.5% level) between numbers of indeterminable grains and total numbers of poorly preserved pollen grains, suggesting that this feature may be a reasonable proxy for the pollen preservation state of the whole sample. However, indeterminables were not always directly linked with other indicators of poor preservation (e.g. at 5.12–5.13m OD at Glastonbury Lake Village), a feature also noted by Tipping *et al.* (1994).

At what level does the number of indeterminable pollen grains become so large that the sample should be rejected for pollen analysis? There is no generally agreed figure for this in the literature, Bunting and Tipping (2000), in their discussion of post-depositional assemblage biasing in archaeological palynology, suggested samples should be rejected for full analysis if indeterminable grains formed >30% of total land pollen + indeterminables. This figure seems rather high; in my experience, a sample in which more than 20% of grains are indeterminable cannot usually be recommended for full analysis.

Bunting and Tipping (2000) used a range of other assemblage properties (considered together, not used individually) to assess the possibility of post-depositional biasing in archaeological pollen samples, and some of these (total pollen concentration, number of pollen taxa in the assemblage, percentages of resistant taxa, abundance of fern spores) have been recorded in the summary tables for the MARISP samples. If these properties correlated well with numbers of poorly preserved grains, they too would have the potential to be used as proxies for assessing pollen preservation in any future assessments of this type, without the need to record the condition of every identified grain. Total pollen concentration is a property of a range of factors, including pollen production of the major source communities, rate of sediment accumulation, and preservation (or lack of preservation) of pollen deposited within the sediment.

The pollen concentrations in the MARISP samples were generally high, though rather variable. In only one sample, 5.03–5.04m OD at Sharpham Park, was the concentration so low that the counting of 100 grains became a very protracted exercise, though the total was eventually reached. At this site, overall preservation was amongst the worst found and therefore it is likely that pollen had been lost from the whole assemblage, differentially removing the most susceptible taxa. However, when the data set as a whole was examined there was no significant correlation between pollen concentration and numbers of poorly preserved pollen grains.

The total number of pollen taxa in an assemblage is likely to decline if taxa susceptible to deterioration are eliminated from it; in the extreme situation found in some soils, only a very few particularly resistant taxa may be left (Dimbleby, 1985). Numbers of pollen taxa in the MARISP samples varied from six at 2.59–2.60m OD at Tinney's Track, a reasonably well-preserved sample, to 23 at context 5 from Street Causeway, which was somewhat less well preserved. There was no correlation between number of taxa and the numbers of poorly preserved pollen grains. It must be concluded that none of the MARISP samples have been affected by differential losses to the extent that taxa have been eliminated. This is supported by the data on percentages of resistant taxa. The thick-walled pollen taxa such as *Tilia*, Caryophyllaceae, Chenopodiaceae, Lactuceae, *Artemisia*-type, and Brassicaceae are relatively resistant to decay and also easy to identify in an extensively deteriorated state. High numbers of such grains could potentially indicate differential accumulation of these resistant types (Bunting and Tipping 2000), although, of course, the herb taxa in this group characterise disturbed environments and their concentration in a pollen assemblage may reflect communities dominated by ruderals.

There is only one sample in the MARISP data set where resistant taxa were present in large numbers. This was at 4.95–4.96m OD at Sharpham Park where they formed 17% of the assemblage, principally due to the Lactuceae. However, the pollen preservation in this sample was moderately good, and it seems likely that there is an ecological explanation for this feature, something which could be pursued further by full pollen analysis.

Fern spores, particularly the undifferentiated monolete type, are highly resistant to deterioration; they tend to accumulate differentially in mineral soils in particular, when many pollen taxa have been lost (Dimbleby 1985). In the MARISP samples, which are largely organic, the number of fern spores was variable. Fewer than 20 spores were counted in the majority of samples, but in two samples from the Chilton Track and one from the Bell Track, numbers greatly in excess of this occurred, with a maximum of 1426 undifferentiated ferns at 1.29–1.30m OD from the Chilton Track. Pollen preservation was not good in any of these three samples, which might suggest that there had been differential accumulation of spores. However, fern sporangia were also found in all three pollen preparations, clearly indicating that ferns were growing close to these sites; it seems that sporulating fern fronds must have been incorporated directly into the accumulating peats at these two sites. When the data set as a whole was examined, there was found to be a positive correlation (significant at the 1% level) between the total numbers of ferns spores in the MARISP samples and numbers of poorly preserved pollen grains.

Thus, of the whole assemblage features that might have potential for use as proxies for the preservation state of the individual pollen grains in the MARISP samples, the most valuable guide appears to be the numbers of indeterminable grains. The number of fern spores was a less useful indicator of preservation state in these samples. Other assemblage features, such as the pollen concentration, the total number of taxa and the numbers of resistant taxa, were not found to be valuable. This is because the pollen in these predominantly peaty sediments had not deteriorated to the state found in many of the more mineral rich sediments which are often submitted for archaeological palynology and which formed the basis for Bunting and Tipping's (2000) suggested measures of post-depositional biasing.

The preservation indices

The pollen preservation indices used in this report were designed to take into account the preservation status of all the grains that were identified (they did not include the indeterminable grains). The classification system allowed grains to be recorded in one or more categories of deterioration, and the scores that were applied to the different categories reflected the observed intensity of decay. The problems associated with the subjective judgements necessary to score grains have been discussed above. When the whole data set was examined, there was found to be significant positive correlations between the biochemical and mechanical pollen preservation indices and the total numbers of indeterminable grains (significant at the 1% level). The indices include both poorly partially and extensively deteriorated grains, and overall they seem to have been reliable indicators of the overall preservation characteristics of the pollen assemblage. In the vast majority of cases the biochemical preservation indices were markedly higher than the mechanical preservation indices, indicating that the major processes of pollen deterioration at the MARISP sites were biochemical.

The question of the reproducibility of the indices

Table 163. Check assessment of preservation indices for 3 randomly selected MARISP samples.

Site	Metres OD	Initial assessment of preservation indices		Check assessment of preservation index	
		Biochem	Mechan	Biochem	Mechan
Meare Village East	3.17–3.18	1.01	0.48	1.03	0.32
Tinney's Track	2.90–2.91	0.28	0.42	0.61	0.29
Abbot's Way	1.85–1.86	0.54	0.21	0.92	0.15

Table 164. Biochemical pollen preservation indices and numbers of indeterminable grains from all MARISP samples.

Site and sample height in m OD	Total indeterminable grains	Biochemical pollen preservation index
Abbot's Way 1.75–1.76	5	0.17
1.85–1.86	2	0.54
Bell Track 1.68–1.69	24	1.60
1.93–1.94	7	1.52
Chilton Track 1.03–1.04	4	1.16
1.29–1.30	5	1.99
1.32–1.33	17	1.75
Glastonbury Lake Village 4.51–4.52	4	0.69
4.71–4.72	3	0.26
4.81–4.82	1	0.45
4.90–4.91	5	0.37
5.12–5.13	21	1.23
Harter's Hill 4.18–4.19	24	2.01
4.21–4.22	14	1.52
4.37–4.38	1	0.92
4.46–4.47	6	1.11
Meare Village East 2.86–2.87	1	0.14
3.01–3.02	4	0.62
3.175–3.185	7	1.01
Sharpham Park 4.95–4.96	14	0.93
5.03–5.04	20	1.94
5.11–5.12	5	0.98
5.34–5.35	4	0.63
5.41–5.42	13	0.61
5.52–5.53	10	1.23
Street Causeway 3.55–3.56	4	0.49
3.77–3.78	19	0.98
3.99–4.00	3	0.81
Context 5	18	1.06
Tinney's Tracks 2.59–2.60	4	0.83
2.69–2.70	0	0.25
2.80–2.81	4	0.28
2.90–2.91	4	0.28
3.12–3.13	4	0.57
3.23–3.24	0	0.90

was addressed by reassessing three samples at random, after the initial recording was completed. The results are shown in Table 164.

There are obvious reasons why complete agreement would not be expected. It has already been made clear from discussion above that different taxa have varying susceptibilities to the different types of pollen deterioration, and that some taxa are very much more resistant to all types of deterioration than others. With a sample size of only 100 grains, there were small differences in the proportions of individual taxa recorded, when the initial sample assessments and the check assessments were compared. This is to expected, the pollen sample size would need to be increased to at least 500 grains before differences between the main taxa are minimised (Berglund and Ralska-Jasiewiczowa 1986). Variation in numbers recorded for individual taxa therefore accounts for some of the small difference between the calculated preservation indices for the initial assessment and for the check assessment.

Bearing this in mind, agreement between the initial and the check indices appears quite good, suggesting consistency of recording. The reproducibility of the indices within this project, with all samples assessed by the same operator, therefore seems acceptable. However, within the work carried out for MARISP, there was no means to test the reproducibility of the index if used by different operators, a key point for future comparisons. It seems probable that the numbers of severely deteriorated grains would be fairly consistently assessed, but that there would be a wider range of variation between judgements of the partially deteriorated grains in any sample.

The discussion above suggests that for these MARISP samples, the magnitude of the biochemical and mechanical pollen preservation indices can be used as a guide to both the acceptability of a sample for full pollen analysis, and to the potential risk of further loss of pollen from a sample due to deterioration under the present environmental conditions. Biochemical and mechanical preservation indices of below 0.5 indicate excellent preservation and suggest that currently there is little risk of loss of pollen. Biochemical preservation indices of between 0.5 and 0.8, with mechanical preservation indices below 0.5 indicate good pollen preservation, with low risk of loss of pollen under current environmental conditions. Biochemical preservation indices of between 0.8 and 1.5, with mechanical preservation indices below 0.8, indicate moderate preservation and suggest there will be increasing risk of loss of pollen if biochemical decay processes proceed further. Samples with biochemical preservation indices higher than 1.5 show increasingly poor preservation; above a value of 2.0, samples are unsuitable for full analysis and differential decay of pollen is likely to have begun. Mechanical preservation indices greater than 0.8 were not found in these samples.

The MARISP data: intra- and inter-site comparisons of pollen preservation

Table 164 shows the biochemical pollen preservation indices and numbers of indeterminable grains for all samples from the nine MARISP sites assessed for this project. It is immediately apparent that there is great variation both within and between sites. The biochemical preservation indices are highlighted here as biochemical deterioration was far more marked than mechanical deterioration in these samples.

The sites where preservation was best and where risk of loss of palynological information at present seems lowest are the Abbot's Way and Tinney's Tracks. At these two sites biochemical preservation indices do not rise above 0.90 (upper sample at Tinney's) and the maximum number of indeterminable grains is five. Preservation is also good in the lower samples at Meare Village East, though only moderate at the top of the sequence.

Preservation was worst at the Bell Track and the Chilton Track. At the Bell Track both samples had biochemical preservation indices >1.5 and the sample at the level of the track had 24 indeterminable grains. At the Chilton Track, the basal sample below the track showed moderate preservation but at the level of the track, and above, pollen was poorly preserved, biochemical preservation indices were >1.75 and the upper sample also had 17 indeterminable grains. It seems likely that some differential losses of less robust pollen taxa may have already taken place in the upper horizons of these two sites resulting in loss of palynological information.

However, for the other sites examined, between-sample preservation characteristics were very variable, though the sites as a whole do not appear to be at risk of loss of pollen, some samples within them certainly are. At Glastonbury Lake Village, biochemical preservation indices ranged from 0.26–1.23, preservation was least good in the uppermost sample, which also had 21 indeterminable grains. At Sharpham Park, the sample from 5.03–5.04m OD, towards the bottom of the stratigraphy examined, had a biochemical preservation index of 1.94, but preservation in other samples ranged from good to moderate. At Street Causeway, biochemical preservation indices ranged from 0.49–1.06, indicating good to moderate preservation, but the sample from context 5 at this site (preservation index 1.06) had 20 indeterminable grains. At Harter's Hill, the two samples from the base of the stratigraphic sequence had preservation indices of 1.52 and 2.01 and relatively large numbers of indeterminable grains, but preservation improved somewhat higher up the stratigraphy.

It is clear from this résumé of results that the variability in pollen preservation characteristics observed in the MARISP assessments cannot be explained solely by factors associated with recent changes in water regimes. If this were the case, then pollen preservation would be expected to deteriorate in samples closest to the ground surface, which are exposed to the greatest fluctuation in water regime, and to become better in sediments which are constantly saturated. In this simple model the position at which deterioration became marked at each site would depend on local hydrology. This situation is seen in the data from Meare Village East, pollen preservation is excellent at 2.86–2.87m OD in wet moderately humified *Phragmites* peat but deteriorates above this; preservation is good at 3.01–3.02m OD where the peat is drier, and only moderate at 3.175–3.185m OD in the dry, very well-humified peat just below the clay of the settlement mound. The same pattern is seen in the data from the Chilton Track, though the overall state of preservation is much poorer. At this site, pollen preservation is moderate at 1.03–1.04m OD in wet, well-humified peat, but poor in the upper two samples (1.32–1.33m OD and 1.29–1.30m OD) where the peat is dry and well-humified.

In other sites this simple pattern of better-preserved pollen with increased depth is obscured by other factors. Variations in sediment type appear to influence pollen preservation. In particular, increases in the silt content of the sediment appear to be associated with increased degradation of pollen; this is the case at 5.03–5.04m OD, from the middle of the stratigraphic sequence at Sharpham Park and from context 5 at Street Causeway. Another set of complicating factors relates to the pre-depositional history of the pollen in an assemblage, including the length of time between dispersal and deposition and the method of transport of pollen to the site.

This is demonstrated at Harter's Hill where pollen preservation is poor in the basal sample of organic clay, which was completely waterlogged, and improves to become moderate higher up the section in peat sediments. The likely origin of the clay is colluvial wash from higher ground bringing particles of eroded topsoil and associated pollen (already possibly somewhat deteriorated) down into the developing mire at the foot of Harter's Hill. Transportation of these grains would have resulted in further damage, accounting for the relatively large number (28%) of pollen grains showing breakage or crumpling in the basal sample at this site.

In some of the MARISP samples there appears to be significant variation in the state of pollen preservation between the dominant taxa within an assemblage. This is particularly marked at 1.68–1.69m OD from the Bell Track, where overall the pollen is rather poorly-preserved with *Betula, Alnus* and *Corylus*-type exhibiting extensive corrosion, however, the majority of the Cyperaceae, which are thin-walled grains and not very robust, show only partial degradation. This could be a consequence of the differing dispersal histories of these two taxa, the sedges growing directly on the peat having dropped their pollen directly onto damp accumulating sediment, whereas the pollen from trees is likely to have had a more distant source, with possibly some deterioration of grains initiated prior to deposition. Another possible explanation is that there has been some contamination in this sample, with more recent Cyperaceae pollen having been transported from higher levels in the profile, or from the ground surface.

The pH of the depositional environment is another important variable influencing pollen preservation. At Sharpham Park the lower, more waterlogged samples have poorer preservation than those higher up the stratigraphic sequence, and this seems likely to be linked to high pH, as calcareous marl underlies the lower peat and will undoubtedly have influenced the local ground water. The sample from 2.59–2.60m OD from the base of the sequence at Tinney's Track also had poorer preservation than the samples higher in the stratigraphy, but in this case this appeared to be linked to active fungal activity at the time of peat formation.

Post-depositional history will also have influenced pollen preservation at these sites. Factors include past fluctuations in the water table, peat cutting and burial of organic sediments. At Glastonbury Lake Village the basal sample from 4.51–4.52m OD was completely water-logged, but the pollen exhibited high levels of corrosion, suggesting that at some time in the past the water table may have lowered temporarily.

Peat cutting has probably affected many of the MARISP sites, and this may well have influenced pollen preservation in the uncut horizons, through exposing them to increased risk of oxidation. The burial of sediments may be due to either natural processes, (e.g. the alluvium which covers the sites at Street Causeway and Glastonbury Lake Village) or human activity (e.g. the clay settlement mound at Meare Village East [though this itself is buried by later alluvium] or the clay bank at Tinney's Tracks). Flooding will have raised water tables temporarily, reducing biochemical oxidation and leaving behind alluvial sediments sealing the peat beneath. The artificial burial of sites will also have sealed the underlying peat and may well have altered local hydrology. The MARISP data suggest that pollen deterioration in the upper peat samples is less marked under a sealing mineral layer, than in situations where the peat is exposed at the surface (compare, for example, the data from the Bell Track, where pollen is poorly preserved and the peat is exposed at the ground surface, with the data from the Abbot's Way, where pollen is well preserved and the peat is buried by just 0.24m of clay.

Recent water table change due to modern management practices on the Levels is, of course, also likely to have influenced the current state of pollen preservation. This was one of the initial premises of the MARISP investigations. However, in the light of the range of factors discussed above, it is not possible to attribute the pollen preservation characteristics at any of the sites examined solely to this factor. It seems probable that the Bell Track and the Chilton Track locations have been most affected by recent change, the archaeology is close to the surface at both sites (0.25m below ground for the Bell Track, 0.40m for the Chilton) and at both locations the peat in which the wood remains occur is exposed at the surface without any overlying inorganic sedimentary cover. As a result, the peat at both these sites is excessively dry. The pollen has deteriorated to the state where full analysis could not be recommended, as the results are likely to be biased towards resistant types.

In surprising contrast, at the Abbot's Way site, where the archaeology is also close to the surface and the enclosing peat appeared dry and compacted when viewed in the field, the pollen preservation was very good; but, as discussed above, the peat at this location is sealed with clay. The Abbot's Way site demonstrates that it is inappropriate to make assumptions regarding the likely state of preservation of pollen based on observations of field stratigraphy alone, a proper programme of assessment should always be undertaken.

Recording pollen preservation in assessments

The recording of the preservation characteristics of individual pollen grains within an assessment count, as has been done for the assessments discussed in this project, is considerably more time consuming than the more usual archaeological pollen assessment. In routine assessment work the first 100 or so grains are identified and notes are made on the overall state of pollen preservation, along with the recording of indeterminable grains and spores. The methodology adopted for MARISP is a more costly process; whether or not this extra cost would be justified for other projects depends on the use intended to be made of the data.

In terms of assessing the potential of a sample for full pollen analysis, the MARISP data show that numbers of indeterminable grains are quite a good proxy for the overall state of pollen preservation in these samples and are also probably a fairly good guide to the reliability (or lack of reliability) of full pollen counts from the sample. Therefore, if a statement of potential for full analysis is all that is required of an assessment, it might be difficult to justify the extra cost involved in recording preservation characteristics in detail. However, if, as in the case of these MARISP assessments, the data are to be used as a 'marker' for the state of pollen preservation at a particular time, then this type of recording is potentially valuable, particularly for sites sensitive to environmental change. In an ideal world, as Tipping (2000) suggested, preservation data should be viewed as a 'necessity' in archaeological palynological analysis; in practice, in assessment work, budget constraints are likely to govern the methodology adopted.

Pollen

Heather Tinsley

These assessments have demonstrated that the present state of pollen preservation at the MARISP sites examined was very variable, both between and within sites, and that this variation resulted from a range of factors, both natural and anthropogenic. At the majority of sites, pollen was surprisingly well preserved, considering the position of the samples examined in relation to the ground surface, and the history of recent water management. A general tendency could be identified for pollen preservation to improve as depth below the ground surface increased, but there were some marked exceptions. For example, the poor preservation in the lower two samples assessed from Harter's Hill and for the sample from 5.03–5.04m OD at Sharpham Park cannot be attributable to recent water table change. However, where a deterioration in pollen preservation occurs right at the top of a stratigraphic sequence, falling water tables resulting in increased rates of oxidation are likely to be implicated.

The most extreme demonstration of this was at the Bell Track and the Chilton Track where pollen preservation at the level of the archaeological remains and above was so poor that it is possible that some ecological information is already lost. It is impossible to say whether recent changes in water regime, past peat cutting, or indeed other factors in combination with these, were primarily responsible for this situation, but the pollen deterioration is irreversible and could not be ameliorated by any future management. However, it is certainly possible that other locations on the same tracks may retain better preservation, depending on local conditions.

The Sharpham Park, Glastonbury Lake Village, Meare Village East, and Street Causeway sites all showed some deterioration in pollen preservation in the upper samples assessed, and this may be attributable to water table change. Pollen preservation indices are similar in these samples. All the sites are sealed with an inorganic sedimentary layer, which may have helped reduce the effects of oxidation in the top of the peat. Overall, it seems likely that any substantial lowering of the water table at these sites would have an adverse affect on pollen preservation and this would be most marked at the higher levels in the stratigraphy. Experimental data produced by Havinga (1984) on rates of pollen decay in different soil types demonstrated that in two soils with high biological activity (leaf mould and river clay) substantial losses of pollen occurred within 2.5 years. No direct comparison can be made between these results and pollen in drying peat, but they do serve to indicate that pollen deterioration can be rapid.

Pollen preservation at Tinney's Track and at the

Table 165. Summary of plant macrofossil abundance, diversity and preservation from the MARISP sites.

Height (m OD)	Total macrofossils counted	Estimated total in whole sample	No. taxa	Preservation index	Organic matter
Abbots Way					
1.73–1.78	100	500	1	2.42	24%
1.83–1.88	100	400	2	2.77	37%
Bell Track					
1.66–1.71	100	120	7	1.93	42%
1.91–1.96	29	29	3	3.24	37%
Chilton Trackway					
1.00–1.05	100	500	7	1.25	59%
1.26–1.31	33	33	3	4.06	44%
1.31–1.36	22	22	4	2.18	45%
Glastonbury Lake Village					
4.49–4.54	100	1000	21	1.21	60%
4.69–4.74	100	1000	20	0.88	43%
4.79–4.84	100	1000	21	0.58	28%
4.88–4.93	100	500	18	0.98	23%
Harter's Hill					
4.16–4.21	100	200	6	2.36	35%
4.21–4.26	41	41	8	2.73	23%
4.35–4.40	100	500	18	2.17	21%
4.44–4.49	100	200	13	2.11	12%
eare Village East					
2.84–2.89	100	300	8	1.76	52%
2.99–3.04	67	67	5	2.53	35%
3.15–3.2	100	200	1	2.36	41%
Sharpha Park					
5.09–5.14	100	200	8	1.33	49%
5.30–5.35	78	78	10	1.74	26%
5.41–5.46	2	2	2	3.5	19%
Street Causeway					
3.53–3.58	41	41	9	2.17	44%
3.75–3.80	8	8	3	1.5	34%
3.98–4.03	10	10	4	1.2	10%
Tinneys Track					
2.57–2.62	100	300	4	2.16	54%
2.66–2.71	94	94	13	1.98	39%
2.78–2.83	93	93	20	1.90	27%
3.10–3.15	0	0	0	0	92%
3.21–3.26	69	69	11	1.53	15%

Abbot's Way was excellent-good, with the exception of the basal sample from Tinney's where fungal activity appeared to have been very active in the immediate post-deposition phase. At these two sites the effects on pollen preservation of any recent changes in water regime appear to have been very limited. Inorganic sediments seal both sites, but these are relatively shallow and it is not obvious why preservation is so much better than at some of the other MARISP sites. It would be unwise to view the current state of pollen preservation at these two sites as a guide to future change, should water tables lower substantially.

Plant macrofossils

Julie Jones

The assessment of the nine wetland sites has produced a body of data recording the abundance, species diversity and state of preservation of plant remains contained in the 29 samples examined. This data is summarised in Table 165 and suggests where there is potential for further analysis.

The methodology used concentrates mainly on the assessment of fruits/seeds as it was felt that including other remains such as buds, moss or leaves would provide additional complications due to the widely varying nature of these items. Even with fruits/seeds there is such a variety of forms, textures and materials that each species was considered individually to standardise recording throughout. Some examples of the most commonly occurring species are shown photographically including species descriptions in Figures 1–19, Appendix 4. Photographic reproduction proved fairly difficult as some detail, particularly relating to epidermal erosion, which could be clearly viewed through the microscope, was much less obvious when seen photographically.

Recording the level of deterioration concentrated on two categories, fragmentation and erosion of the fruit/seed wall with the use of three sub-divisions based on the percentage of damage caused. Each sub-division was given a score that was totalled for each individual, a low score (0) suggesting the fruit/seed was well preserved, the highest score (6) meant the fruit/seed was badly preserved, (>50% fragmented and >50% eroded). A sum of all these scores divided by the total number of seeds counted gave a preservation index for each sample. This methodology appears to have worked fairly well for most sites. Sites with the lowest preservation index such as Glastonbury Lake Village showed ranges from 0.58–1.21 and are those where there is good potential for further analysis. High preservation indexes such as the top sample at Sharpham Park (3.5 index) and the top sample at Bell Track (3.24 index) are those where full analysis is not recommended.

However the system fails somewhat where only a few macrofossils were present in a sample but these were in fairly good condition. The upper two samples from Street Causeway are good examples of this where the preservation indexes are low (1.5 and 1.2) but only 8 and 10 macrofossils occurred in the whole sample. In the upper sample in particular the amount of organic material in the float was very low (10%) so very large samples would be required to allow environmental reconstruction to be made. The upper raised bog peat at Meare Village East illustrates a further complication where although there were an estimated 200 individual seeds in the sample these were all the same species, *Calluna vulgaris*. Full analysis is therefore not recommended as processing of larger samples is thought unlikely to increase the number of taxa as this community would appear to have been dominated by heather.

Although some sites have suffered from root penetration from the contemporary ground surface no evidence was found at the levels examined for the downward movement of modern plant remains. Even where cracking due to desiccation occurred such as at Tinneys Track there was no evidence for modern intrusions. This contrasts to earlier studies at the Abbots Way (Cox *et al.* 2000) where penetration particularly by modern birch seeds occurred through desiccation cracks.

The best preserved site was clearly Glastonbury Lake Village where all the samples showed an abundance of mostly well-preserved macrofossils with good species diversity. At Harter's Hill preservation was more variable with higher preservation indexes and low species diversity in the two lower samples, compared to the two upper ones where less deterioration of macrofossils occurred and species diversity increases. At Sharpham Park the two lower samples show good preservation although species diversity is fairly low with low levels of abundance in one. Similarly at Tinney's Track the potential for further analysis is suggested as 'possible'. Although preservation is fairly good (indexes of 1.98, 1.90 and 1.53) overall abundances were low, although species diversity was reasonable. With each of these three sites, Sharpham Park, Harter's Hill and Tinneys Track processing of larger samples should allow sufficient numbers of macrofossils to be recovered for environmental reconstruction to be made.

The lack of potential for further analysis from several sites, Abbot's Way and Bell Track and some samples from Chilton Trackway and Street Causeway is due more to low concentration of macrofossils and low species diversity which makes interpretation unsatisfactory, rather than poor preservation. In some cases a high percentage of the sample floats consisted of unbroken down sediment from the sieving process, which suggests the level of organic matter remaining is in fact much lower than suggested by the figures in Table 165, implying a high level of humification for these samples. Whether this process has also lost macrofossil remains or whether they were simply not there in the first place is uncertain. In the case of the raised bog peat at Abbot's Way, the abundance of *Calluna* seeds, suggests an environment dominated by heather, so further taxa may be unlikely to occur.

Concluding comments

On those sites with the best preservation and where full analysis has been recommended this could be achieved by the processing of the samples already obtained for the MARISP Project, but it seems likely that further deterioration will continue to occur in the future particularly from those sites which lie close to the contemporary ground surface and are more affected by desiccation. However, although preservation was poor at some sites in many instances the peat retains sufficient potential to place them in their environmental context and provide information on the local vegetation.

While the methodology used for this project appears to have worked fairly successfully it is felt worthwhile

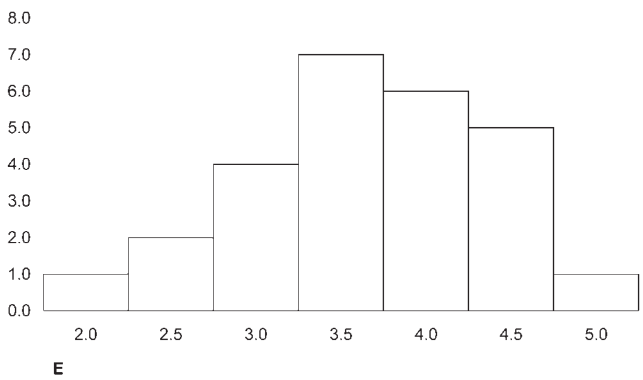


Figure 206. Distribution of modes for erosion for insect assemblages from samples from nine sites.

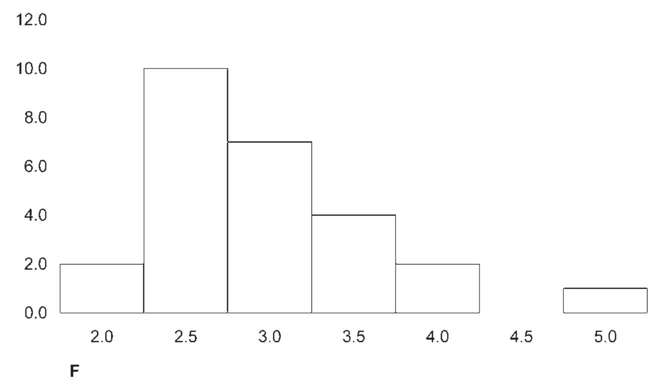


Figure 207. Distribution of modes for fragmentation for insect assemblages from samples from nine sites.

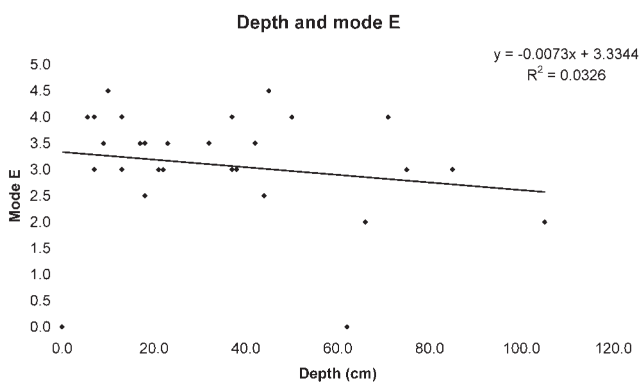


Figure 208. Scattergram of depth and mode for erosion for insect assemblages from samples from nine sites.

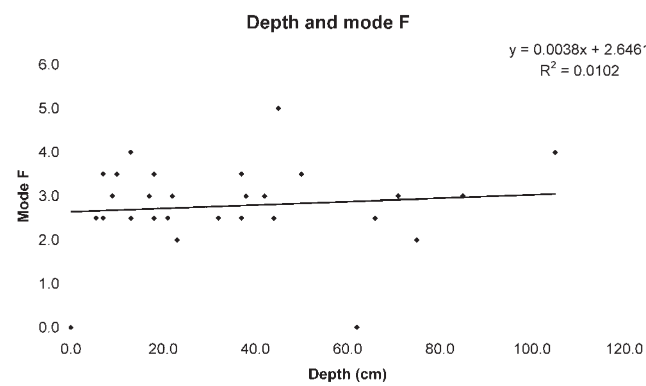


Figure 209. Scattergram of depth and mode for fragmentation for insect assemblages from samples from nine sites.

making a few general comments on the problems of assessing material in this way. It is difficult to judge the preservation of individual seeds objectively due to the variation in the nature of each individual. In terms of repeating this process on other projects, judging the quality of material would depend on the experience of the person carrying out the work. A specialist with wider experience may identify small fragments of some seeds/fruits that may be passed over or classified as unidentifiable by a less experienced worker.

There is also the practical side of such a scheme to consider and the difficulty of evaluating other categories of macrofossil than fruits/seeds such as buds, leaves, wood, moss, flowers and to assess all these would be very time consuming. The methodology used for this project was definitely more time consuming than the normal type of assessment used as part of MoRPHE evaluations and in general the aim of an assessment is to be rapid and easy to use.

Coleoptera

Harry Kenward

Pattern in the results?

The results of the preservation recording are summarised in various ways in Table 166 and Figures 206–15. Figures 206 and 207 give the distribution of modal values for erosion and fragmentation, with a peak at 3.0 for E and at 2.5 for F. Both of these values indicate moderately good preservation, suggesting that the fossils are suitable for routine analysis, but this belies the very degraded condition of a proportion of fossils in many of the layers. It is thus essential to take cognisance of the range as well as the mode for these properties.

Figures 208 and 209 show the relationship of depth to erosion and fragmentation respectively. In neither case is there a significant correlation. Visually there is a slight improvement in preservation with depth (this might be stronger if position in each sequence rather than absolute

Table 166. Somerset Levels: records of preservational condition of invertebrate (principally insect) remains in deposits at nine sites.

Site	CN, SN	mOD	Chemical Erosion				Fragmentation				Colour change					Other properties
			range		mode	str	range		mode	str	To	range		mode	str	
Mere Village East	55105 1/T	3.15–3.20	3.0	4.0	4.0	W	2.5	5.0	2.5	W	Pale, hint brown	1	2	2	W	
	2227 3/T	2.99–3.04	2.0	4.5	3.0	W	2.0	3.5	2.5	W	Pale	0	3	–	–	
	3742 2/T	2.84–2.89	2.5	4.0	3.0	W	2.5	4.0	3	W	Pale	1	3	2	D	
Chilton Trackway	1318 3/T	1.31–1.36	2.0	3.5	2.5	W	2.0	3.5	2.5	W	–	–	–	–	–	
	1823 1/T	1.26–1.31	3.0	3.5	3.0	W	2.0	3.0	2.5	W	Orange, pale	2	3	3	D	
	4449 2/T	1.00–1.05	2.5	3.5	2.5	D	2.0	3.5	2.5	W	Pale	1	1	1	S	
Street Causeway	05 1/T	3.98–4.03	5.5	–	–	V	–	–	–	–	–	–	–	–	–	most remains completely decayed
	2328 3/T	3.75–3.80	2.0	5.0	4.5	W	3.0	5.5	5.0	W	Pale	2	3	3	D	
	4550 2/T	3.53–3.58	2.5	4.5	3.5	S	1.5	2.5	2.0	W	Pale	2	3	3	S	
Saul Platform, Sharpham Park	1015 1/T	5.41–5.46	4.0	5.5	4.5	D	3.5	5.5	3.5	W	–	–	–	–	–	some remains probably completely decayed
	2126 3/T	5.30–5.35	2.5	4.0	3.5	D	2.5	5.0	3.0	W	Pale, brownish	1	3	2	W	
	4247 2/T	5.09–5.14	2.0	4.0	3.0	W	2.5	4.0	2.5	W	–	–	–	–	–	
Glastonbury Lake Village	6671 4/T	4.88–4.93	1.5	2.5	2.0	W	2.0	5.5	4.0	W	–	–	–	–	–	
	7580 3/T	4.79–4.84	1.5	4.0	3.0	W	2.5	5.0	3.0	W	Pale	1	3	2	W	
	8590 1/T	4.69–4.74	1.5	2.5	2.0	W	2.5	3.5	2.5	W	–	–	–	–	–	
	105110 2/T	4.49–4.54	1.5	3.5	1.5 3.0	D D	1.5	3.0	2.0	W	Pale	0	3	0 3	D D	
Harding Alignment	914 4/T	4.44–4.49	2.0	4.5	2.5 4.0	W W	2.5	5.0	3.5	W	Orange	0	1	1	W	
	1823 3/T	4.35–4.40	2.5	4.5	3.5	W	2.0	3.5	2.5	W	Yellowish	0	3	2	W	
	3237 2/T	4.21–4.26	3.0	4.0	3.5	W	2.5	5.0	3.5	W	Pale via brownish	1	3	2	W	
	3742 1/T	4.16–4.21	2.5	5.0	3.5	W	2.5	5.0	3.0	W	Pale via yellowish brown	2	3	3	W	
Tinney's Track	712 5/T	3.21–3.26	4.0	5.0	4.0	W	2.5	4.0	3.0	W	–	–	–	–	–	Local decay spots on some fossils
	1823 4/T	3.10–3.15	–	–	–	–	–	–	–	–	–	–	–	–	–	Too few fossils; E ?2.0
	5055 3/T	2.78–2.83	2.5	5.0	4.0	W	2.5	5.0	3.5	W	Pale via brownish	2	4	3	D	Some shrivelled fossils
	6267 1/T	2.66–2.71	2.0	5.0	4.0	D	2.0	5.0	3.5	D	Pale via brown	1	4	3	W	
	7176 2/T	2.57–2.62	1.5	3.5	2.5	W	1.5	3.0	2.5	W	–	–	–	–	–	
Abbot's Way Track	712 2/T	1.83–1.88	2.0	4.5	3.5	D	2.5	4.5	3.0	W	Pale	0	3	2	W	Some fossils with patchy decay
	1722 1/T	1.73–1.78	2.5	4.0	3.0	W	2.0	3.5	2.5	W	–	–	–	–	–	
The Bell Track	1318 1/T	1.91–1.96	3.5	5.5	4.0	W	2.5	5.0	4.0	W	Pale	1	3	2	W	Some rather shrivelled fossils; ?dried in ground at some stage
	3843 2/T	1.66–1.71	2.0	4.0	3.0	W	2.5	4.0	3.0	W	–	–	–	–	–	

Preservation CN – PRS context number; SN – PRS sample number. Within each site, samples arranged in stratigraphic order, older down the page. The scales are introduced and defined in Chapter 2

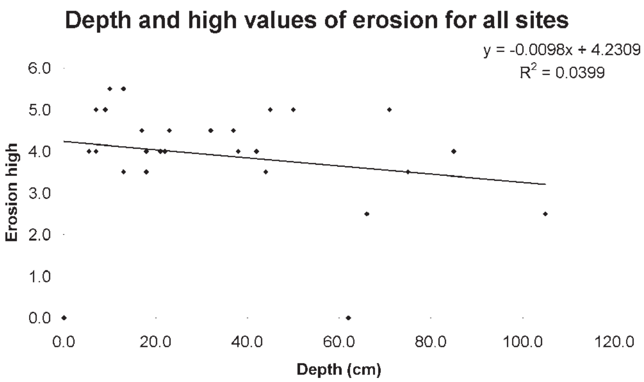


Figure 210. Scattergram of depth and high (worst) value for erosion for insect assemblages from samples from nine sites.

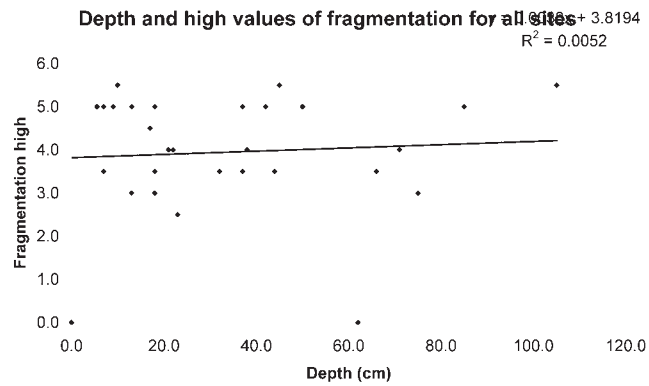


Figure 211. Scattergram of depth and high (worst) value for fragmentation for insect assemblages from samples from nine sites.

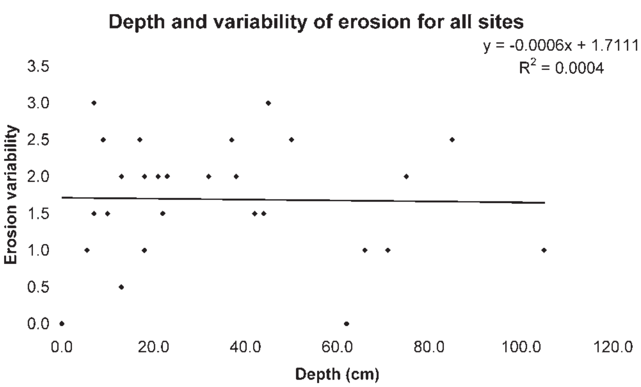


Figure 212. Scattergram of depth and within-assemblage variability of erosion for insect assemblages from nine sites. Variability calculated by subtracting low from high value of E for each assemblage.

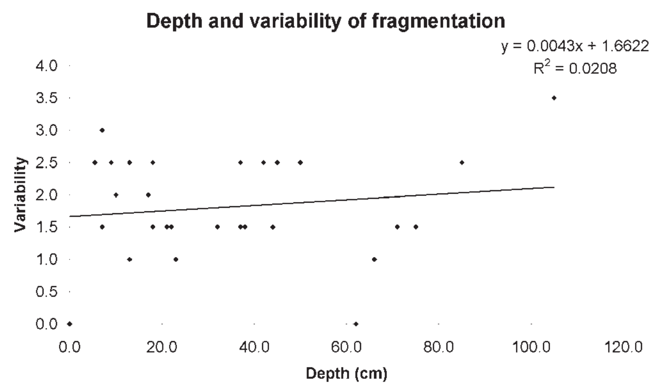


Figure 213. Scattergram of depth and within-assemblage variability of fragmentation for insect assemblages from nine sites. Variability calculated by subtracting low from high value of F for each assemblage.

depth were used), but the trend line for fragmentation is effectively horizontal. The worst values for each assemblage are plotted against depth in Figures 210 and 211. There is no significant relationship. The trend line for variation in fragmentation is near horizontal. The data for fragmentation thus suggest that there was no systematic tendency for near-surface deposits to be more mechanically damaged, or that any damage was uniform across any each assemblage. Figures 212 and 213 show the intra-assemblage variation in E and F by depth. Again, there is no significant relationship.

There is a clearer relationship between the two parameters of preservation (Figure 214), significant at the $P<0.05$ level. Notably, there is a strong ($P<0.01$) relationship between intra-assemblage variation in erosion and fragmentation (Figure 215). Whether this relationship is the result of parallel effects in the buried sediment, or of increasing chemical change rendering fossils more fragile, is not known, and this is one of many aspects of the preservation of archaeological organics that requires research. It would be useful to analyse the numerous records of insect preservation for assemblages from many (though mainly urban) sites made using the Kenward and Large (1998) scheme to determine whether there are patterns which might cast light on the decay process.

Assessment of archaeological potential: general comments

Most layers had a sufficiently high concentration of insect fragments for larger subsamples to give enough remains for useful ecological reconstruction (Table 167). However, many showed poor preservation, and there were numerous remains representing taxa that are

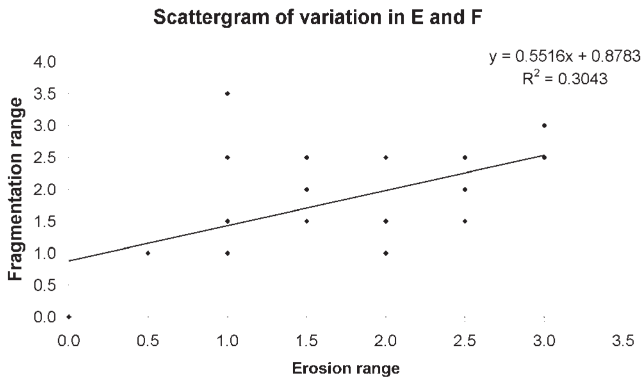


Figure 214. Scattergram of variation in erosion and fragmentation values within insect assemblages from nine sites. Correlation is significant at the 0.01 level (Spearman's rho, SPSS).

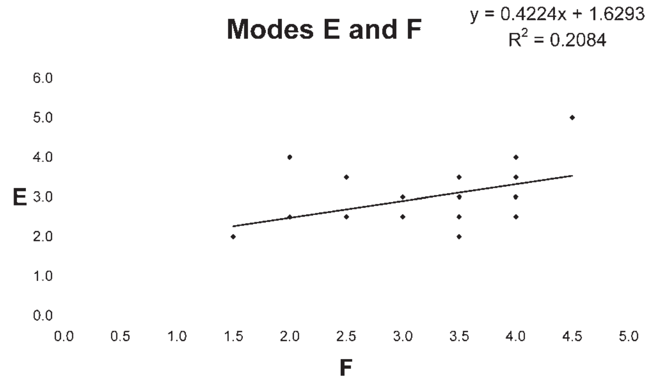


Figure 215. Scattergram of modes of E and F for insect assemblages from nine sites. Correlation is significant at the 0.05 level (Spearman's rho, SPSS).

challenging to identify even from very well preserved fossils. It would be enormously time consuming to analyse large numbers of these samples in meticulous detail, though a more streamlined approach (not naming all the difficult taxa) would recover ecological/archaeological data at the expense of discovering significant rarities. Thus, large-scale detailed analysis was not recommended unless to address particular archaeological questions (e.g. ecological changes associated with human activity indicated by other evidence), or if the deposits are threatened by destruction, or within a training programme.

Environmental change in the central Brue valley

Heather Tinsley and Julie Jones

Previous palaeoecological work in the central Brue valley

Palaeoecological studies in the Brue valley have a long history, centred on the former raised bog area, where commercial peat cutting in the 20th century resulted in the exposure of extensive preserved wood archaeology. The pioneering work on vegetation history was carried out by Sir Harry Godwin, who studied peat stratigraphy particularly in relation to the wooden trackways (Godwin 1960) and produced the first pollen diagrams from the area. Godwin's Shapwick Heath diagram was drawn up in 1938, though not published until later (Clapham and Godwin 1948). This paper also included pollen profiles from the Meare Heath and Westhay trackways. Pollen diagrams and stratigraphical studies from a wide range of other archaeological sites soon added to the emerging picture of the vegetation history of the Levels.

It was established that, following the retreat of the sea in late Mesolithic times, reed swamp peat developed on the exposed estuarine alluvium (the Lower Wentlooge formation) and was later replaced by raised bog. However, it was not until the detailed palynological work of Beckett and Hibbert (1979), on scientifically dated long profiles from the Abbot's Way, Meare Heath and the Sweet Track Factory site (all sites within the raised bog area), that it was possible to place the many pollen diagrams into a regional framework which highlighted changing human influence in the surrounding dry land woodlands. Beckett and Hibbert (1979) established that there was a basic similarity in the pattern of vegetation change at their three sites and that comparable patterns could be detected at other sites in the central Brue valley. They expressed this pattern in a series of regionally recognized pollen assemblage zones designated A–G. At the Abbot's Way site these zones extended from 3584–3520 cal BC (Zone A) to sometime after cal AD 3–85 (Zone G).

Raised bog never formed in the upper Brue valley and its tributaries and this area has been less studied. However, Housley's work (1988) has provided a firm basis for an understanding of the stratigraphy and vegetation history of the area. He established that following deposition of the Lower Wentlooge clay, a mix of reedswamp, sedge fen, and fen carr communities occupied this part of the valley, along with open areas of shallow water. More recently Housley *et al*. (2000) mapped the geographical distribution of the three main lithological units of the Wentlooge formation, and produced a detailed account of sedimentary variation in the organic Middle Wentlooge, based on extensive borehole data. Work by Aalbersberg (1997), Aalbersberg, *et al*. (in press) and Aalbersberg and Brown (in prep.) have added

Table 167. Somerset Levels: assessment of insect and other invertebrate remains from samples from nine sites.

Site	CN, SN, Box	Description of flot and its fauna	Interpretative potential and priority
Mere Village East	2227 3/T Box 2	Flot quite large, plant fibres, fragments of stem. Useful numbers of insects, with some aquatics but mostly suggesting damp acid terrain with *Calluna* (e.g. several *Micrelus ericae* (Gyllenhal)); some pools to support modest numbers of aquatics (e.g. *Ochthebius*). Numerous mites.	Larger sub-sample (?3kg) would give useful group, allowing clear recon-struction of vegetation. P1B
	3742 2/T Box 3	Very large flot, mostly plant detritus. Very restricted fauna but clearly from swamp. Probably different conditions from above and below.	Large sub-sample (3–5kg) would give small but useful group. Difficult identifications. P1B
	55105 1 /T Box 1	Flot of modest size, mainly plant fibres. Restricted but characteristic fauna, with planthoppers (Cicadellidae, Delphacidae) prominent. Suggesting damp acid terrain, with local pools, and vegetation including *Calluna* and probably grasses or rushes. No dung beetles. Numerous mites.	Large sub-sample (at least 3kg) would give useful group but difficult identifications (e.g. of the bugs) P1B
Chilton Trackway	1318 3/T Box 4	Flot of moderate size, herbaceous detritus. Limited number of insects, some aquatics but predominantly from moist semi-terrestrial conditions.	Large (3–5kg) sub-sample would give useful group and clarify local ecology. Difficult identifications. P1B
	1823 1/T Box 5	Quite small flot, mostly herbaceous detritus, perhaps some rhizome fragments. Rather few insects, predominantly aquatics (e.g. *Ochthebius* sp., *Hydraena*, *Hydroporus* spp.) and waterside taxa.	Very large sub-sample needed to determine water quality in detail; difficult identifications; limited potential. P2
	4449 2/T Box 6	Very large flot, herbaceous detritus. Moderately large numbers of insects, dominated by aquatics (e.g. Hydroporinae spp., *Ochthebius* sp., *Limnebius* sp., various Hydrophilinae, *Microvelia* sp.). Remaining fauna all able to utilise swamp litter or emergent vegetation.	Larger sub-sample (3kg) would give good fauna; refined data concerning water quality obtainable, but little beyond this. Difficult identifications. P1B
Street Causeway	05 1/T Box 7	Trace flot with rootlets; no more than traces of very decayed invertebrates other than earthworm (Oligochaeta) egg capsules.	No further action. P0
	2328 3/T Box 8	Minute flot with crumbs of undisaggregated organic sediment and traces of plant detritus. A few beetles and traces of very decayed cuticle; probably many remains lost.	No interpretative value beyond aquatic deposition. P3
	4550 2/T Box 9	Small flot of plant detritus and abundant invertebrate fragments. Aquatics dominant (e.g. *Ochthebius* and *Hydraena* sp.; *Tanysphyrus lemnae* (Paykull)) but also an appreciable terrestrial or damp ground component. No heathland/bog taxa noted. Some unfamiliar beetle remains.	Larger sub-sample (3kg or more) would give a useful representation of the non-aquatics; overall would give useful ecological reconstruction; difficult identifications. P1A
Saul Platform, Sharpham Park	1015 1/T Box 10	Small flot of herbaceous detritus. Few insects (others probably completely decayed), no good ecological indications.	No further action. P0
	2126 3/T Box 11	Small flot, fine plant fibres and abundant insect fragments. Many remains borderline for identification through decay. Appreciable and fairly diverse aquatic component (e.g. several *Ochthebius* and *Limnebius*), remaining taxa mainly able to live in swampland.	Larger sub-sample (3kg) would give good account of local ecology, but narrow ecological range means probably of limited value. P1B
	4247 2/T Box 12	Small flot, well decayed herbaceous detritus, seeds, snails, abundant invertebrate fragments. Some aquatics (especially *Octhebius*), but mainly terrestrial or damp ground taxa. Hints of trees (*Scolytus* sp.) and shade (*Drymus brunneus* (Sahlberg)).	Larger sub-sample (3kg) would give good ecologi-cal resolution, including clearer evidence of trees. Difficult identifications (result of taxa present and preservational condition). P1A
Glastonbury Lake Village	105110 2/T Box 16	Smallish flot, herbaceous detritus and appreciable component of invertebrate fragments. Aquatics important and diverse, including an elmid (flowing water). Remaining fauna indicative (or tolerant of) swampland, with some indication of trees or shrubs.	Larger sub-sample (3kg) would give detailed local ecological reconstruction, but probably of limited value. P1B
	6671 4/T Box 13	Smallish flot, mainly fragments of immature stages of insects. Aquatic and terrestrial beetles, but in small numbers, often reduced to very small fragments. One wood-associated taxon (*Anobium* sp.).	Larger sub-sample (3–5kg) would give useful local ecological reconstruction, perhaps of more interest than other samples in this sequence. P1B
	7580 3/T Box 14	Fairly small flot, plant tissue and invertebrates (50:50). Filmy objects, probably cladocerans. Aquatics important, most of remaining fauna at home in swampland. One dead wood taxon (*Anobium* sp.).	Larger subsample (3kg) would give useful local ecological reconstruction, but probably of limited value. P1B
	8590 1/T Box 15	Moderately large flot, some plant detritus and seeds but mainly invertebrate remains, mostly immature stages of insects. Varied aquatic component including a flowing water taxon (*Oulimnius*). Remaining fauna all able to exploit swamp habitats.	Larger sub-sample (3kg) would give detailed local ecological reconstruction, but probably of limited value. P1B

Within each site, samples are arranged in stratigraphic order, older down the page. CN – PRS context number; SN – PRS sample number; Box – sample box number. Priorities are defined in the text

Table 167. continued.

Site	CN, SN, Box	Description of flot and its fauna	Interpretative potential and priority
Harding Alignment, Harters Hill	914 4/T Box 17	A small flot, mainly plant fibres, seeds and some ?rhizome fragments. Modest numbers of cladoceran ephippia (resting eggs of water fleas). Most of the beetles aquatics, the few non-aquatics being able to live in swamps.	Limited potential: a very large sub-sample (5kg or more) would give useful numbers of remains but many would be very time-consuming to identify. P2
	1823 3/T Box 18	Small flot, seeds, yellowish plant detritus, invertebrate fragments. Numerous water fleas (Cladocera), aquatic beetles (*Ochthebius* the most abundant). *Trechus ?micros* (Herbst) perhaps post-depositional invader. Remaining taxa able to live in swampland.	Limited potential: very large sub-sample (5kg or more) would give useful numbers of remains. Many would be very time-consuming to identify. P2
	3237 2/T Box 19	Small flot, mostly fragments of immature insects, but some seeds. Aquatic and swamp taxa.	Limited potential: very large sub-sample (5kg or more) would give useful numbers of remains. Time-consuming to identify. P2
	3742 1/T Box 20	Small flot, fine plant and invertebrate debris. Restricted beetle and bug fauna: aquatics (*Ochthebius* the most abundant) and swamp taxa. Indications of trees or shrubs (*Rhynchaenus*)	Difficult to work on but larger (3–5kg) sub-sample would probably give useful group. P1B
Tinney's Track	712 5/T Box 21	Small flot, plant detritus and crumbs of organic sediment. Few insects: mostly aquatics, others swmp forms.	Little potential even using a very large sub-sample. P3
	1823 4/T Box 22	Very large flot with abundant moss leaves and stems. Mites moderately numerous but almost no insects.	No significant potential even using a very large sub-sample; immensely time-consuming to sort. P3
	5055 3/T Box 23	Small flot with twig fragments, crumbs of humic sediment and rootlets. Very limited fauna of aquatic and swamp-tolerant forms.	Little potential even using a large sub-sample. P3
	6267 1/T Box 24	Small flot with lumps of humic sediment, plant fibres and some insect fragments. Mostly aquatic and marsh taxa, a single dung beetle (*Aphodius*).	Very limited potential unless to address some specific question. Large sub-sample (3–5kg) needed. P2
	7176 2/T Box 25	Very large flot of plant fibres. Mites quite common. Few insects, aquatic and marshland.	Evan a large sub-sample would probably not give useful numbers of remains. Very difficult to sort. P3
Abbot's Way Track	712 2/T Box 26	Flot small, consisting of herbaceous detritus with appreciable numbers of insects. Mites quite common. Some aquatics but an appreciable terrestrial component of ground beetles and plant feeders: more terrestrial than most samples examined in this study; heathland indicated.	Large sub-sample (3–5kg) would give useful group, though identifications often challenging. P1B
	1722 1/T Box 27	Small flot, plant fibres and fragments. Few insects, including trace of wetland forms, and several ants and some beetles suggesting drier conditions.	Rather limited potential even from a large sub-sample (>5kg). P3
The Bell Track	1318 1/T Box 28	Small flot, woody and herbaceous detritus. Aquatics and damp ground taxa, with a few suggesting drier conditions. Wood associated taxa present (*Anobium* sp. and a rhyncholine weevil). Clearly more terrestrial than most assemblages examined here.	A large sub-sample would probably give a useful and interesting group, though some identifications would be difficult. P1B
	3843 2/T Box 29	Flot small, with crumbs of organic sediment, ?rhizome fragments, moss leaves. Few insects: aquatics and swamp-tolerant forms.	Very large sub-sample (>5kg) would give just usable group, but very difficult to identify and a large proportion beyond identification. P3

Within each site, samples are arranged in stratigraphic order, older down the page. CN – PRS context number; SN – PRS sample number; Box – sample box number. Priorities are defined in the text

further detailed information regarding the complex stratigraphy of this area.

The MARISP sites in their geographical setting

The sites considered in this report all lie within the central Brue valley. Three are on the valley margins at, or close to, the junction with higher land. Sharpham Park lies on the edge of the Polden ridge to the south of the main valley. The two Harter's Hill locations are on the northern edge of Queen's Sedgemoor, in the broad tributary valley that joins the Brue to the north of Glastonbury. The 2003 site is close to the break of slope between the moor and Harter's Hill, with the 1997 site 50m further south. The Street Causeway site is at the point where the valley narrows to less than 600m wide, between the high land of Street and Glastonbury. In contrast to these marginal locations, Glastonbury

Lake Village lies in the middle of the Brue valley, more than 1km from the higher land and as a consequence the pollen record for dry land vegetation at this site is regional in character compared with the more local records from the other sites.

The Lower Wentlooge is not represented at any of the MARISP sites. Dates for the regressive boundary of the alluvium, reported by Coles and Dobson (1989), have been calibrated to 4680–4350 cal BC and 3970–3660 cal BC (Housley *et al.* 2000). The basal sediments from all the MARISP sites post-date this, though the clay either underlies, or reaches very close to all four locations. The organic formation of the Middle Wentlooge is represented by woody peat or mud containing woody detritus at all the MARISP sites, though this grades up into better-humified sediments dominated by herbaceous remains at Harter's Hill, Glastonbury Lake Village 2003 and Street Causeway. Housley *et al*. (2000) suggested that the distribution of the woody detritus deposits found in the Glastonbury area might reflect the earlier drainage pattern that existed before the medieval diversion of the Brue.

The Upper Wentlooge alluvium was deposited by a marine transgression that entered the upper Brue valley through the Panborough–Bleadney gap in the Wedmore Ridge. The alluvium has been traced south to within 40m of the site of Glastonbury Lake Village, where Housley (1988) found a thin clay band approximately 1cm thick in trench SLP 2. There was no evidence of any clay deposition 150m further south at the Glastonbury Lake Village 2003 site and the lack of any diatoms indicative of estuarine conditions suggests that the transgression did not reach this far.

At Sharpham Park, some 4km away, on the extreme southern margin of the upper Brue valley a clay band 5–6cm thick was deposited in the period between 1045–905 cal BC and 800–540 cal BC. These dates are very similar to those bracketing the Upper Wentlooge at Housley's site of Long Run Farm, just south of Godney Island (1210–900 cal BC and 810–440 cal BC, Housley *et al*. 2000). However, the position of the Sharpham site, on the edge of the Poldens, suggests that the clay deposition here must be a result of freshwater flooding, no halophytic indicators were found in the pollen assemblage from this horizon; unfortunately diatoms not were preserved.

The chronology of the MARISP sites

The radiocarbon dates have established that the sites examined for this report span the period from the early Bronze Age (Harter's Hill 2003), through the later Bronze Age (Harter's Hill 1997, Sharpham Park, and the early part of Glastonbury Lake Village 2003), to the Iron Age and Roman periods (Glastonbury Lake Village 2003 and Street Causeway) and into the Dark Ages (the uppermost assemblage from Street Causeway) (Table 168). If the regional pollen chronology is considered, all the pollen diagrams appear to focus on regional pollen Zone F of Beckett and Hibbert's (1979) system. Zone E is represented in the basal assemblages at Harter's Hill 2003 (HH03 1 and 2) and this is the only MARISP site that shows the characteristically low values for herbaceous pollen typical of this zone.

The pollen records from the upper part of Harter's Hill 2003 (HH03 3) and from Harter's Hill 1997 (HH97 1, HH97 2), Sharpham Park (SP 2–SP 4) and the lower assemblage at Glastonbury Lake Village 2003 (GLV03 1) are all within regional pollen assemblage Zone F, which Beckett and Hibbert (1979, 589) characterised as having a '*wide range of herb pollen present consistently and in some quantity*'. Beckett and Hibbert (1979) chose the Abbot's Way as their type site for Zone F and there it is dated to between 1007–906 cal BC and 419–365 cal BC (Coles and Dobson 1989). Regional pollen assemblage Zone G, characterized by substantially increased herbaceous pollen values, is represented towards the top of the Glastonbury Lake Village 2003 diagram (GLV03 2) and at Street Causeway (SC 1, SC 2), though neither site shows the increase in *Betula* pollen used to define this zone at the Abbot's Way. Housley's pollen diagrams also lacked the *Betula* increase and he commented that the importance of birch at the Abbot's Way site might be a local, rather than a regional feature (Housley 1988, 74).

The palaeoenvironment of the upper Brue valley from the early Bronze Age

The pollen, macrofossil and insect analyses (along with the data from snails and diatoms) have demonstrated that the wetland vegetation at each of the sites studied varied, largely reflecting local conditions. At Harter's Hill 2003, on the margin of the wetland close to the foot of Harter's Hill, alder and oak woodland grew around 2125–1935 cal BC. As the oaks declined in response to increasingly wet conditions, alder expanded forming carr woodland which remained established until after 1300–1110 cal BC when the record from this site ends. This wet woodland fluctuated, opening somewhat after 1500–1320 cal BC when bur-reeds and aquatic taxa spread in the ground flora, but later increasing again in density. Fifty metres away, out into the wetland at Harter's Hill 1997, alder carr survived until some time before 1130–920 BC, but at this site there was a greater representation of sedges in the ground flora. After 1130–920 cal BC there is some evidence for an expansion of *Cladium mariscus* (great fen sedge) probably reflecting the development of *Cladium* sedge fen in the area that is known from stratigraphic investigations in central Queen's Sedgemoor (Housley *et al*. 2000).

Table 168. The chronology of the MARISP sites showing local variation in the Upper Brue Valley rom the Early Bronze Age to Early medieval period. All heights in mOD.

	Harters Hill 2003		Harters Hill 1997		Sharpham Park		Glastonbury Lake Village (GLV 03)		Street Causeway	
Early Medieval									causeway	AD 650–900 AD 640–780
Romano-british							silting of channels	5.12–5.13m cal AD 70–225		
Iron Age/ Romano-british									open water	4.02–4.03m 100 cal BC –AD 50
Iron Age					sedge + reed beds	5.52–.5.53m 400–260 cal BC	open water, pools, channels	5.01–5.02m 200–50 cal BC	open wet sedge fen	3.55–3.56 m 410–260 cal BC
								4.80–4.81m 510–395 cal BC		
Late Bronze Age/ Iron Age					willow–alder carr/sedge beds	5.41–5.42m 800–540 cal BC				
					flooding episode					
Late Bronze Age			**HARDING ALIGNMENT** 1076/5 (oak dendro)		sedge & reed beds	5.34–5.35m 1045–905 cal BC	alder–willow carr/swamp/ pools	4.44–4.45m 1125–940 cal BC		
			sedge fen/ pools	4.55–4.56m 1130–920 cal BC	**SAUL PLATFORM**	5.19–5.27m 1260–910 cal BC				
					alder carr	5.03–5.04m 1190–920 cal BC				
Middle Bronze Age	alder carr	4.54–4.55m 1300–1110 cal BC	open alder carr/sedge beds/pools	4.08–4.09m 1400–1130 cal BC						
	sedge & bur-reed beds									
	open alder carr, reedbed/ pools/ marsh	4.36–4.37m 1500–1320 cal BC								
Early Bronze Age	damp alder & oak woodland	4.18–4.19m 2125–1935 cal BC			alder+willow carr	4.91–4.92m 1690–1520 cal BC				
					tufa: spring deposit					

At Sharpham Park on the southern margin of the upper Brue valley, the presence of a tufa depositing spring influenced the vegetation succession at the immediate site, possibly maintaining an open area in which herbaceous species were able to flower. Subsequently, when the spring position appears to have changed, presumably associated with a change in the position of the ground water table, dense carr woodland developed from around 1190–920 cal BC, restricting the flowering of herbs. However, given the evidence from the snail assemblage from just above this dated horizon it is clear that these wet woodlands fringed an open water body. The alder carr at Sharpham Park contracted markedly at the time when the site was flooded, between 1045–905 cal BC and 800–540 cal BC, it later re-established for a short period, but was in decline at this site by 400–260 cal BC when the pollen record ends.

Other studies have identified alder carr woodlands at the margin of the upper Brue valley around Glastonbury in this period. At Benedict Street, Glastonbury they occupied the edge of the wetland adjacent to the island from 3370–2920 cal BC, through to some time after 1370–1000 cal BC, varying in density during this period. By 510–200 cal BC they had been replaced by fen and aquatic communities (Brunning *et al.* 1995). An assessment of pollen and plant macrofossils from Dyehouse Lane, Glastonbury, close to Benedict Street, suggested a similar situation, with carr woodlands replaced by wet fen at some time before 350–40 cal BC (Jones 2007; Tinsley 2007).

At Common Moor Farm, about 200m out into the wetland from the edge of Glastonbury Island, there is pollen evidence of alder carr from the earliest dated horizon of 1738–1517 cal BC, but by 1040–825 cal BC this had declined as sedges and grasses spread (Housley 1988). At Glastonbury Lake Village 2003, in the centre of the upper Brue valley, pollen and macrofossil records indicated that from 1125–940 cal BC stretches of open water, 3–4 m deep in places, were present, supporting communities of white and yellow water-lilies and other floating plants. From around 510–395 cal BC, the deeper water appears to have extended and it seems likely that the channel of the Brue may have meandered around through pools or lakes.

If the evidence from both the marginal valley sites and Glastonbury Lake Village are considered together it is clear that from the beginning of the 1st millennium cal BC the whole of the upper Brue valley was becoming wetter, the response of the vegetation communities on the margin of the valley appears to have been a reduction in carr woodland and the spread of sedge beds with areas of relatively shallow open water occupied by aquatics. In contrast, at the Lake Village site the environment appears to have been significantly wetter with more substantial areas of open water. The exact timing of these changes varied from site to site, presumably dependent on small differences in topography and the position of the tributary water channels that, in this flat landscape, must have been frequently altering. Aalbersberg *et al*. (in press) discussed a mechanism for water table rise in the upper Brue valley, associated with the backing up of river water as a result of the marine incursion which deposited the Upper Wentlooge alluvium.

The stratigraphic evidence from Glastonbury Lake Village 2003 indicates that the channels around the site began to silt up by cal AD 70–225. To the south of the Lake Village, where the Brue valley narrows between Glastonbury and Street, the palaeoenvironmental evidence from Street Causeway has established that the gap through which the river flowed was a wet, open sedge fen from 410–260 cal BC. By Saxon times, the molluscan evidence indicated that this had, in part, been replaced by open water.

Evidence for the exploitation of the dry land marginal to the Brue valley can be seen in the pollen diagrams from the slope foot sites of Harter's Hill 2003 and Sharpham Park, which have evidence for agriculture (including cereal cultivation) on Harter's Hill and the Poldens during the middle–late Bronze Age. At Harter's Hill this agricultural phase appears to have been accompanied by soil erosion and consequent deposition of colluvium at the slope foot. From the site of Glastonbury Lake Village 2003, a regional picture emerges of relatively open woodland on the low hills around the Brue valley in the late Bronze Age, which was then reduced further in the Iron Age and declined further again in the Roman period. This supports the conclusion of Housley (1988) that clearance of the dry land margins of the upper Brue valley was extensive by the late 1st millennium cal BC. More recently, pollen diagrams from Panborough to the north of the Lake Village and from South Moor upstream from the Glastonbury–Street gap, have also revealed evidence for major deforestation around the Brue valley at this time (Aalbersberg 1999). At Panborough this event is dated to around 370–110 cal BC and at South Moor to around 400–140 cal BC (V. Straker pers. comm.) linking it to the period in which the Lake Village is believed to have been occupied.

8. Research and Management Strategies

Richard Brunning

Overall the MARISP project has been extremely successful in advancing our knowledge of the condition of the most important sites in the area and establishing their potential for future preservation. The future possibilities for each location are briefly discussed below. It is hoped that a Heritage Lottery Fund Landscape Partnership project for the Avalon Marshes (the peat moors west of Glastonbury) will help to deliver sustainable management for the nationally important sites in the area. This project startd in 2012. The project has also helped to refine monitoring and assessment techniques for wetland rural monuments.

Although the project was primarily focused on issues of preservation it also achieved considerable success in adding to our understanding of the sites investigated. The work at the Harding Alignment and the Saul Platform has helped to clarify the character of those sites and their landscape setting has been resolved through detail palaeoenvironmental investigation. The palaeoenvironmental work at Street causeway and Glastonbury Lake Village has also been very productive and taken together it has been possible to significantly advance our understanding of the changing wetland environments of that part of the valley in later prehistoric and early medieval periods. The dating of Street causeway had also confirmed its importance as an extremely rare early medieval structural type and has helped to elucidate the extent and significance of changes brought about by the Abbots of Glastonbury at that time. The work at Glastonbury Lake Village had confirmed the potential of the site and raised the possibility of being able to resolve the problematical dating of the settlement.

Bell Tracks

The survival of the trackway is surprising, considering its proximity to the ground surface and the seasonal drawdown of the water table below the structure for several months every summer. It seems likely that the structure is at great risk from destruction by desiccation and associated biological and chemical decay and physical collapse. However, the trackway's survival defies such pessimistic expectations and it may be that the structure could survive for many further decades.

Previous excavations have provided very good evidence for the character of the structure and it is unlikely that any further excavation will add to this knowledge. The dating of the structure could be significantly improved if any large ash timbers could be recovered, suitable for tree-ring dating. The character of the ash timbers sampled in the MARISP excavation suggests that such material is perhaps unlikely to be present.

The wooden 'God Dolly' figurine discovered under the trackways is the earliest known representation of a human being and the earliest wooden sculpture in the UK. The discovery of the artefact suggests that other votive objects may exist. The great significance of the God Dolly suggests that the possible existence of additional wooden votive objects should be explored because of the perceived threat to the survival of organic objects in that location.

The inability to trace the trackway in the field further to the east raises questions about the extent, alignment and character of the structure. The comparative level of the Abbot's Way trackway suggests that the Bell Track, which is earlier in date, should still survive, if it was originally present. Further investigation of the possible existence of the trackway further to the west should be undertaken to identify the *in situ* extent of the monument.

The key research questions about the trackways can be summarised as follows:

- Is the 'God Dolly' just part of a larger collection of votive objects beneath the trackways?
- What is the true extent of the trackway?
- What is the precise date of the trackway and the 'God Dolly'?

Research and management priorities can be summarised as follows:

- Evaluation excavation to determine if any additional votive objects are present under the trackways and to recover any ash timbers that may be suitable for tree-ring dating.
- Investigation of the western extent of the trackway using minimally intrusive techniques (e.g. large bore coring supplemented by keyhole trenches if appropriate).

Abbot's Way Track

The Abbot's Way trackway has been well studied through numerous excavations and subsequent post-excavation analysis, including wood studies and palaeoenvironmental analysis. The eastern terminal of the Abbot's Way trackway has been shown to be suffering enormously from the effects of desiccation, to the point where very little significant archaeological information still survives.

To the west of the MARISP investigation site, the trackway has been destroyed over most of its length. It is only likely to survive in three areas. The two fields adjoining the MARISP site are under arable cultivation, which is likely to have caused considerable peat wastage and peat shrinkage. Even though the trackway is at a slightly lower OD height than at its eastern terminal, the effect of arable cultivation is likely to have destroyed the structure. This could be proved one way or the other by minimal excavation and, if the trackway is not found, radiocarbon dating of the peat immediately beneath the ploughsoil.

Further west the trackway is known to survive in a field immediately north of the Godwin's peat factory. Permission exists for peat extraction in this field but the planning permission includes clauses that will hydrologically isolate the trackway during extraction and an afteruse as a freshwater water body that should help to ensure the survival of that section of the monument for the foreseeable future.

The section of the structure north of the peat factory has suffered from periods of desiccation and tree root penetration in the past but a better preserved section of the trackway exists in a single Scheduled field further west, where the trackway has a greater surviving depth of peat above it than anywhere else along its length. This is in permanent pasture and no excavation of the trackway has previously taken place. This location is the most favourable and secure for long term preservation *in situ* of the monument.

The key research question about the trackway can be summarised as follows:

- Does the trackway still survive in the arable fields west of the MARISP investigation site?

Research and management priorities can be summarised as follows:

- Small scale evaluation excavation to presence or absence of the trackway in the arable fields west of the MARISP investigation site.
- Determination of the correlation between trackway depth and the fluctuating water table in the western Scheduled area, to assess the possibilities for preservation *in situ* in that field.

Tinney's Tracks

It is likely that the Tinney's complex of trackways only survives in the field where they were examined as part of the MARISP project. Some remains may exist in the corner of the peat field to the north and under the modern road but in both locations any waterlogged remains are highly likely to have been adversely affected by the lowering of the water table associated with peat extraction. The continuing preservation of the structures in the southern field is therefore a high priority.

The key research questions about the trackways can be summarised as follows:

- Is it possible to obtain a more precise relationship between the observed periods of wetter conditions on the raised bog and the construction of the trackway?
- How did the form of the trackways change as they approached the southern, dryland terminal?
- Where were the trackways going to? Did they continue on the western side of the raised bog?
- Was there contemporary settlement at the southern end of the trackways?

Research and management priorities can be summarised as follows:

- Slightly increasing the summer water table within the field through improved field irrigation.
- Brief examination of the structures closer to the dryland.
- Geophysical survey of the dryland at the southern terminal.
- Prospection in ditch and river edges for evidence of western continuation of the trackways.
- Comprehensive scientific dating strategy for the trackway and its associated palaeoenvironmental remains.

Chilton Tracks

Over Chilton Moor there has been extensive peat cutting from the Roman period to the 20th century. This has resulted in the survival of a comparatively thin depth of peat (less than 2m), with all the peat of Bronze Age and later date no longer in existence. The Neolithic Chilton Tracks have been subjected to varying levels of archaeological research. The group of trackways examined as part of the MARISP project have had small, but thorough excavations and associated scientific dating and palaeoenvironmental analysis (Coles *et al.* 1970). The trackways further to the east around Burtle Bridge have only been briefly recorded. Some of the latter structures are very significant structures because of their early Neolithic date and complex structure.

The northern ends of the Chilton Tracks have been shown to be suffering to varying degrees from desiccation and physical damage. The proximity of the trackways to the ground surface suggests that little additional hydrological management could be established to protect the structures and retain the land in a farmed regime. The present extent and condition of these structures south of the South Drain are unknown.

The key research questions about the trackways can be summarised as follows:

- What is the existing southerly extent of the structures and did they once reach all the way to the Poldens?
- What is the character, date, condition, extent and environmental setting of the trackways briefly described by Clements around Burtle Bridge?

Research and management priorities can be summarised as follows:

- Tracing the extent of the Chilton Tracks south of the South Drain and assessing their OD height against the seasonally fluctuating water table.
- Small scale evaluation excavation of a sample of the trackways around Burtle Bridge and assessment of their condition, burial environment and prospects for preservation *in situ*. Assessment of samples for tree-ring and/or radiocarbon dating.

Viper's and Nidon's Tracks

The trackways have been destroyed over most of the Scheduled field that once contained their southern terminal. To the north, it is extremely likely that all trace of the structures have been lost to peat cutting or have been subject to rescue excavation. There is a possibility that the extreme southern end of the structures may survive under colluvium in a narrow band at the edge of the southern terminal. If it does exist in this area, it is very likely to be suffering from desiccation and it is very unlikely to be able to be preserved *in situ*.

The key research questions about the trackways can be summarised as follows:

- Precisely when were the trackways created and for how long were they maintained?
- What was precise relationship between the structure and the observed changes in the wetland environment?
- Was there a relationship between the trackways and the later prehistoric enclosure known from a short distance up slope?
- Does any of the southern terminal survive?

Research and management priorities can be summarised as follows:

- Rescue excavation of the structure, if it still survives under colluvium at the southern terminal.
- Palaeoenvironmental analysis of peat associated with any such excavation, if justified by assessment of preservation.
- Dating of the upslope enclosure.

Meare Heath Track

There are four locations where stretches of the Meare Heath Track may still survive. The southern terminal was investigated as part of the MARISP project and it appears likely that the structure no longer survives in this area. There remains the possibility that part of the structure at its very southern end may still exist under a narrow band of colluvium but this is far from certain.

To the north of the terminal there is an area of old peat cutting where some peat remains. There is a slight possibility that the trackway exists in this area but it is more likely that peat extraction and its associated desiccation has destroyed all trace as far as the South Drain. Part of the structure may exist under the banks of the South Drain over very short stretches of *c.* 7m length on each side of the watercourse. Immediately north of the South Drain is an area of recent woodland that is growing on an area of former peat cutting. The Meare Heath Track may exist in this area because a significant quantity of peat was left intact. The area around the woodland has high water levels because it is part of the reedbed area of Shapwick Heath National Nature Reserve.

The northern terminal has been partially excavated by the Somerset Levels Project and shown to very close to the present ground surface. Photographs of the excavation clearly illustrate the effects of very severe desiccation on the structure. The archaeological potential of this northern terminal may therefore be quite low because of the destruction of organic and palaeoenvironmental remains.

The key research question about the trackway is:

- What was the precise relationship between the construction of the trackway and the observed changes in the bog/fen environment?

Research and management priorities can be summarised as follows:

- Examination of the possible existence of the trackway within the area of woodland north of the South Drain.
- Assessment of the preservation of the monument and associated palaeoenvironmental remains, if it does exist in the woodland area, and assessment of preservation *in situ* conditions.
- Small scale excavation to obtain samples for palaeoenvironmental analysis and dendrochronological dating (if justified by assessment).
- Improvement of preservation *in situ* conditions if preserved remains of the trackway are located.

Withy Bed Copse Track

The available evidence suggests that none of the Withy Bed Copse trackway still survives. There is a slight chance that part of the structure may exist under colluvium at its southern terminal or under droves or the banks of the South Drain in Shapwick Heath National Nature Reserve. The intermittent character of the excavated parts of the trackway suggests that such preservation is unlikely however.

It is hard to justify further work on the structure because of the small chance of anything surviving. If any further work was to be carried out the southern terminal is probably the best focus for investigation.

Saul Platform, Sharpham Park

The MARISP excavations confirmed the existence of late Bronze Age timbers and woodworking debris but were not able to define the limits of the site. The nearby dryland edge must define one side of the site but its limits in the other directions are unknown.

The exact purpose of the material is also uncertain. It may be the remains of a dismantled structure, the product of the deliberate destruction of a beaver dam or the creation of an irregular platform at the edge of an area of open water. Only larger scale excavation is likely to resolve which of these possibilities is closest to the truth.

The structure is highly vulnerable to destruction if it dries out. The summer water table dips just below the level of the worked wood for several months during the summer. Despite this the wooden material seems to be capable of retaining enough water throughout the summer to prevent shrinkage and cell collapse.

Research and management priorities can be summarised as follows:

- Raising of the local water table by *c.* 0.2m during the summer months.
- Excavation to establish the true character of the site and help to define its extent.

A drainage ditch runs alongside the road on the eastern side of the site. It may be possible to locally raise the water levels in this ditch over the stretch beside the site. This would also help to feed water into a small cut feature on the southern side of the site that acts as a drinking pond for the deer and park cattle. Its presence should help to bring the local water table up slightly. The water levels in the drainage ditch could be raised by the use of a simple low dam, to pen water upstream while still allowing the drainage function to continue. It is currently uncertain who has the authority to grant permission for such work.

The simple procedures for improving the potential for *in situ* preservation of the site, coupled with the absence of evidence for active degradation of the structure suggest that there is no need for any rescue excavation on this site. Further excavation would help to answer many research questions about the site but must be considered a lower priority than the research excavations suggested for some of the other sites.

Harding Alignment, Harter's Hill

The complete length of the Harding Alignment is not known. It has been traced from its northern landfall across one field over a distance of 100m. It is highly likely that the structure continues further to the south. Towards its southern known limits the top of the piles existed at increasing low OD heights and are therefore increasingly further below the ground surface. Palaeoenvironmental remains are therefore likely to exist in a better state of preservation at the southern end of the structure and sapwood is more likely to survive on the oak piles.

The stretch within the northern field is likely to be the part of the structure most at risk from desiccation. The northern end is the highest and most vulnerable, which was why it was selected for examination in the MARISP project. The very large width of the structure at its northern terminal and the deposit of burnt twigs on the eastern side suggests that special activities were taking place at the dryland/wetland interface that were not occurring elsewhere along the structure. It is also uncertain if the post row continued onto dryland or was replaced by a different feature such as a trackway.

Key research questions can be summarised as follows:

- What is the extent of the structure?
- How did the character of the structure vary over its length?
- What forms of deposition took place along the structure?
- How did the contemporary environment vary along the structure?
- Over what time intervals were the piles inserted?

- What was the temporal relationship between the deposition of the horizontal material and the vertical piles?
- What happened at the dryland end of the structure?
- Was the changing environment a significant factor in the construction and abandonment of the structure?

Research and management priorities can be summarised as follows:

- Establishing the southern end of the structure (by probing, coring and test pits).
- Excavation of the wetland/dryland interface at the northern end of the structure to recover information that is being lost to desiccation.
- Establishment of summer water levels above the level of the horizontal material over at least two thirds of the field.
- Removal of the tops of the piles over the whole field down to the level of the horizontal material and sampling for dendrochronological analysis.
- Palaeoenvironmental analysis of deposits at the southern end of the structure.

Meare Lake Villages

Significant parts of both Meare East and Meare West remain unexcavated but the preservation assessment and hydrological monitoring suggest that the organic potential of the occupation areas has been steadily degrading, possibly for over a century, because of desiccation of the deposits. The wooden material that still exists is in a very poor condition. It seems likely that only the lower parts of vertical posts may remain in a fair condition.

The deposits surrounding the occupation areas have only been investigated in a narrow trench between the two settlements by the Somerset Levels Project. The density of finds from the occupation areas suggests intense activity. It therefore seems reasonable to presume that midden deposits may exist at the edges of the occupation areas. In addition it seems likely that constructed routeways probably exist between the two occupation areas and to the dryland to the south. A narrow tongue of hard geology projects towards the eastern end of Meare East and the narrow gap between it and the occupied area is the most probable location for a trackway or causeway across the swamp.

The chronology of the occupation at Meare West and East is probably the most significant research topic. The existing chronology, based on artefact typologies, extends from 300 to 50 BC although a coin hoard was probably lost between AD 360 and 380. Oak timbers may still exist, especially in the unexcavated parts of Meare West and vertical stakes may retain traces of sapwood. Oak timbers may also exist in midden deposits and in any causeways or trackways that link the sites to each other and to the dryland to the south. The hearths present on the mounds may also be fired to high enough temperatures for archaeomagnetic dating.

Key research and management questions can be summarised as follows:

- What are the absolute and relative chronologies for the two occupation areas?
- Do any significant organic deposits remain in the occupation areas?
- Do middens containing significant organic deposits exist at the edges of the occupied areas?
- Do any causeways or trackways link the settlements to each other and to Meare Island

Research and management priorities can be summarised as follows:

- Limited excavation of a previously unexcavated part of Meare West with the primary objective of obtaining dating evidence from hearths and oak timbers for archaeomagnetic dating and dendrochronology.
- Evaluation excavation across the gap between the tongue of hard geology and Meare East and across the gap between the two settlements.
- Systematic coring around the perimeter of the two occupation areas to attempt to locate any dense midden deposits, followed by ground truthing (if needed) using small scale evaluation excavation.
- Examination of the relationship between any organic deposits encountered in the fieldwork and the known hydrological regime to determine the possibility for preservation *in situ.*

Glastonbury Lake Village

The MARISP fieldwork has identified a degree of *in situ* preservation of waterlogged remains that was unexpected because of the sections through the foundations drawn by Bulleid. The foundations of the settlement in the south-western corner of the settlement appear to have been entirely left *in situ* along with several lines of collapsed palisades. The fieldwork suggests that cultural deposits exist within and below the foundations, underneath the collapsed palisades and for tens of metres beyond the edge of the palisade.

During the project the Somerset County Council Heritage Service purchased some of Bulleid's original drawings. These showed that the length of the vertical piles on some of Bulleid's original drawings were extended for the published drawings. This suggests that Bulleid's section through the foundations may not have been as deep and extensive as they were illustrated. None of the excavation photos show a section through the foundations and in many pictures the ambient water table was visible at the level of the foundations and must have caused great difficulties if excavation was carried to the bottom of the foundations over a large area.

Bulleid and Gray are known to have reburied some of the larger wooden timbers at the end of their excavation. These timbers are exceptional in the evidence they contain for prehistoric woodworking techniques. Assessment of their burial location should therefore be a priority and will also provide evidence of the success or failure of possibly the only long term documented experimental reburial of waterlogged wood.

The date of the occupation of the settlement is probably the most significant research question. Currently there is wide discrepancy and conflict between the radiocarbon, stratigraphic and typological dates for the settlement. This could be resolved through the application of a suite of scientific dating procedures. Oak timbers are known to exist on the site and hold out the potential for dendrochronological dating, especially since the recent strengthening of the prehistoric tree ring chronology and the dating of timbers from Meare Lake Village. Radiocarbon dating has previously been limited to artefacts but it could be used on the structural remains, especially where stratigraphic relationships might allow the use of Bayesian statistics. Archaeo-magnetic dating may be achievable in one mound where a sequence of hearths was left *in situ*.

Key research and management questions can be summarised as follows:

- Is the preservation *in situ* of the wooden foundations in the south-west corner of the settlement representative of the whole excavated area?
- What is the extent of the deposition of cultural material beyond the settlement palisade and what does the Faxon Mound represent?
- When was the settlement created and when was it abandoned?
- Can the development of the settlement be determined through stratigraphic observation of the palisades and foundations?
- Is preservation and the character of the burial environment uniform across the site?
- Does the reburied wooden material survive and if it does, what is its state of preservation?

Research and management priorities can be summarised as follows:

- Additional preservation *in situ* assessment and hydrological analysis in other places in the settlement.
- Use of dendrochronology, archaeo-magnetic dating, radiocarbon dating to date the occupation at the settlement, facilitated through keyhole excavation.
- Examination of the wooden material reburied by Bulleid and Gray to assess its condition.
- Excavation across the palisade where significant stratigraphic relationships are thought to exist.
- Test pitting to examine the extent of cultural activity and evaluation trenching on the 'Faxon Mound'.

Street–Glastonbury Causeway

The hydrological monitoring has shown that there is a significant threat to the long term preservation of the organic component of the site. Enhancement of the summer ground water table would help to mitigate this threat.

The radiocarbon dating has given accurate but not very precise dating for the construction of the causeway. Greater precision could be obtained by trying to obtain additional samples for dendrochronological dating to improve the site chronology and obtain a match with reference chronologies. Alternatively the existing site tree-ring chronology could be subject to multiple radiocarbon assessment and the application of Bayesian statistics to precisely place it in time. The relationship of the causeway to the millstream for Northover Mill also requires investigation and may be able to provide an end date for the structure.

There is currently little evidence for the development and repair of the causeway, beyond what Morland reported. It may be that useful information is contained in the Glastonbury Abbey archives on its maintenance and its replacement by the subsequent causeway. These may also help to determine if a bridge was present or if the causeway led to a different crossing of the Brue such as a ford.

Examination of the wider floodplain landscape is probably critical to our understanding of the causeway and its link with other developments and manipulation of the floodplain. Determination of the extent of the open water body downstream of the causeway is crucial in this regard and may provide evidence of any possible link to a canal. The construction of a causeway, canal and artificial open water body in the mid to late Saxon period is a possibility that deserves investigation.

Key research and management questions can be summarised as follows:

- Precisely when was the causeway built and are there multiple phases of repair and rebuilding?
- What was the wider landscape setting of the causeway and how did its construction affect it?
- Of what significance was the construction of the causeway in the development of the Glastonbury Abbey estate?
- Was the construction of the causeway related to the creation of the open water body to the west and to the creation of the 'canal' into Glastonbury?
- Can the summer irrigation of the area be improved to maintain the survival of the organic elements?
- Do peat deposits contemporary with the causeway survive elsewhere on the nearby floodplain?

Research and management priorities can be summarised as follows:

- Discussion with landowner and IDB about improving summer irrigation through installation of sub surface irrigation if water supply can be guaranteed.
- Examination of documentary evidence in Glastonbury estate archives.
- Examination of evidence in the banks (and bed) of the River Brue and the New Cut drain.
- Examination of the relationship between the causeway and the millstream through coring and keyhole investigation.
- A coring survey of the local floodplain to characterise and date any early medieval deposits present, with special focus on determining the extent of the open water body downstream of the causeway and any potential relationship with the canal and millstream.
- Keyhole excavation to obtain more tree-ring samples and/or radiocarbon dating and use of Bayesian statistics to pin down the site chronology.

Crannel Farm

The site excavated by Bulleid in 1893 appears to only exist under the present causeway to the farm. It is therefore probably inaccessible to further research for the foreseeable future. The condition of the monument and its continued existence, remain uncertain.

A strategy for Somerset's peatland archaeology

The waterlogged archaeological resource in the Somerset peat moors is composed of a combination of discrete 'sites' and extensive bodies of palaeoenvironmental data in the form of peats and clay deposits. The known waterlogged sites represent a very small portion of the total number that probably exist in the area. For this reason, and in order to protect the palaeoenvironmental resource, a management strategy for the waterlogged resource must aim to achieve sustainable *in situ* preservation on a landscape scale, rather than purely focusing on individual sites.

The archaeological resource in Somerset's peatlands exists in an agricultural landscape largely owned by private individuals with very little state ownership. With the exception of West Sedgemoor the extensive landholding of nature conservation bodies is largely restricted to the areas where peat has been extracted or has been severely wasted by arable farming. The economics of farming are therefore a major determinant on land management. A number of factors constrain the possibilities for land management. There are very significant complications of geography, variable land heights, lack of available water in summer months and fragmented land ownership. There are also numerous considerations to be taken into account including the objectives of national and international designations, the responsibilities of the Environment Agency and Internal Drainage Boards for hydrological management and the agri-environment schemes run by Defra (Department for Environment Food and Rural Affairs). A realistic archaeological strategy for the area must operate within these significant constraints and can only be achieved through a consensual approach.

The typically fragmented and small scale character of land ownership is a significant obstacle to strategic land management. Past variations in land management between different owners has also created a situation where land surface heights vary significantly over a small distance. This makes it difficult to achieve ditch water levels that are acceptable to all the land owners within a hydrological block. Nature conservation organisations, most notably the RSPB, the Somerset Wildlife Trust and Natural England, also directly own and manage a significant proportion of Somerset's peatlands. These organisations have aims that are generally compatible with achieving hydrological systems that would result in little or no peat wastage. The ability to achieve these aims is constrained by financial considerations and by the wishes of neighbouring landowners who are part of the same hydrological system.

Global variations in commodity prices and climate change both have the potential to induce radical land management change in the area. The agri-environment agreements for the Somerset Levels Environmentally Sensitive Area (ESA) are drawing to an end (in 2011–2013). New Environmental Stewardship Higher Levels Scheme (HLS) agreements will not cover such an extensive area, while the more widely available Entry Levels Scheme (ELS) will not provide the financial return of the lower tiers of the ESA agreements. This means that the peat areas outside the SSSIs could experience a dramatic shift in landuse, away from extensive grassland and towards intensive (well drained) grazing, energy crops or arable farming. All these options are likely to lead to an increase of peat wastage and associated destruction of the archaeological record. This pattern towards intensification of the local farming regime may be exacerbated by international commodity price fluctuations (Rawlins and Morris 2010) and by the increasing proportion of farmers in the area who are beyond retirement age.

Designations have a significant effect on management policies for the area. As this study has shown, Scheduled Monument status offers only limited protection. Nature Conservation designations, especially Sites of Special Scientific Interest (SSSIs) and RAMSAR sites, have a more practical and wide ranging effect on the landscape and on Environment Agency, Internal Drainage Board and Natural England policy implementation.

Although all the peatland SSSIs have not achieved the government PSA (Public Service Agreement) target of 95% in 'favourable condition' (or unfavourable recovering) by 2010, the existence of the targets has been a major driver in the Water Level Management Plans (WLMPs) being drawn up by the Internal Drainage Boards and the Environment Agency Catchment management Plans (CMPs). The maintenance of wet grassland habitats and the prevention of peat wastage and its associated damage to the waterlogged archaeological resource are significant aims of these plans in Somerset. As the land surface height varies significantly over each moor, the establishment of optimum hydrological conditions is not easy. The existence of lower lying land in private ownership, often created because of peat wastage from arable farming, can restrain the establishment of effective hydrological management. Strategic land acquisition has been effectively used to circumvent this problem and will continue to be needed in the future.

The WLMPs attempt to hydrologically isolate areas sharing a similar range of surface heights so that they can benefit from water levels appropriate for their topography. Generally this will include some winter and spring flooding and then summer ditch water levels that are penned at specific heights until the autumn. The summer pen levels vary significantly but are generally designed to be *c*. 45–50cm below average land surface height within each hydrological unit.

It would be very difficult to improve upon this situation without needing much expensive water control infrastructure and having a significant effect on farming economics. The effectiveness of these plans to protect waterlogged archaeology is limited by two main considerations. The first of these is the limited effects of ditch water levels upon the in field water table. Ditch levels only affect the in-field water table over a distance of about 10–20m depending on the hydraulic conductivity of each area. To raise the water table across the whole field, additional surface or sub surface irrigation is required. The effectiveness of these methods has been trialled in West Sedgemoor and in several places in the Netherlands. Sub-surface irrigation is preferable from a farming point of view, while surface gutters can bring nature conservation benefits.

The installation of improved in-field irrigation on a landscape scale would be beneficial for archaeology, nature conservation and the prevention of peat wastage and would outweigh the possible damage to near surface archaeological remains that it might cause. It would require a very significant initial capital outlay with significant maintenance costs every decade. Even if this was achievable it is uncertain if there is sufficient water available in the river system to achieve this hydrological regime (A. Baines pers. comm. 2009). Summer abstraction of water from the main rivers is already at its maximum. One possible solution may be the creation of storage areas for winter flood water to allow its retention for summer irrigation. The economic benefit from maintaining the river defences in the central Brue valley has, for a long time, not been able to justify the expense involved, because the potential flood areas are agricultural land with very few dwellings. As flood defence budgets become more stretched and focused on the needs of settlements and infrastructure, there is likely to be pressure to reduce the flood defence budget in the area. This could potentially have a positive effect on the protection of the peat resource. These possible hydrological management scenarios would all be heavily influenced by future climate change.

Climate change

The latest climate change predictions for the UK were published at the end of 2009 (UKCIP09). These give a range of predictions with varying levels of certainty. The most relevant aspects of the climate for consideration in regard to this project are probably summer temperature and summer rainfall. By 2080 the, rather optimistic, medium emissions scenario suggests that south-west England will enjoy 30–40% less summer rainfall than present levels and will suffer summer temperatures 3–4° C higher. This suggests that more winter rainfall will have to be retained on the floodplain in some form to provide summer irrigation. These predicted changes could drastically increase peat wastage in Somerset and increase the probability of a shift to intensive (drained) grassland and arable farming.

Management strategy

The probability of long term preservation of the waterlogged archaeological resource varies greatly across Somerset's peatlands. In general terms, the areas directly owned by nature conservation organisations probably benefit from the most sustainable management regimes. Of these, the RSPB holding on West Sedgemoor is probably the only area where long term landscape scale sustainable management on peat soils seems relatively secure. The considerable overlap in the hydrological requirements for nature conservation and waterlogged archaeology suggest that these areas will continue to enjoy more favourable preservation conditions as long as the financial resources of the organisations permit. As Natural England and the Somerset Wildlife Trust, two of the largest landowning organisations, have suffered substantial cuts in their funding recently, the maintenance of favourable conditions for preservation cannot be guaranteed.

The varying depth of surface clay above the peat deposits is also a very significant consideration. This varies from nothing to over 1.5m, with the deepest

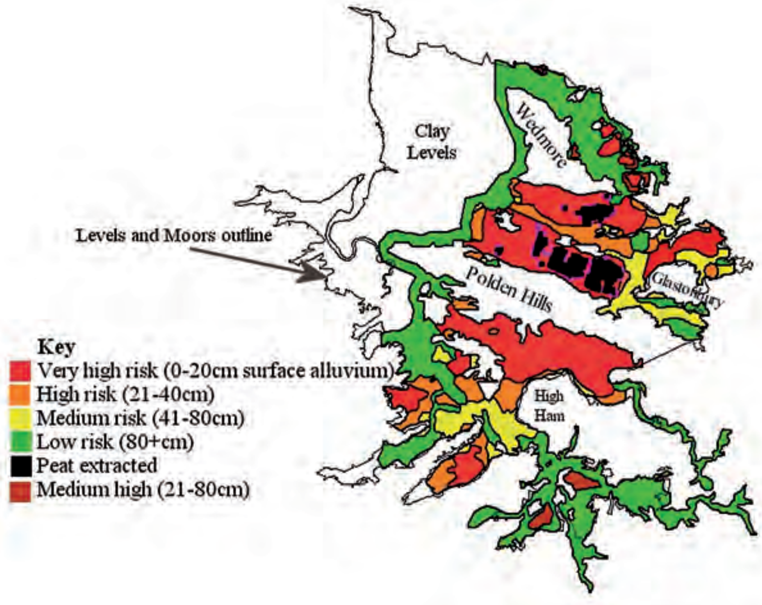


Figure 216. Peat wastage risk map for the Somerset moors.

alluvial deposits fringing the main rivers. The deeper the clay cap the less likely peat wastage will occur. This is because the top of the peat in these areas is more likely to be beneath the top of the water table. Those areas with over *c*. 0.8m of surface clay can therefore probably be considered as low risk environments in this regard (Figure 216). Such risk mapping is constrained by the existing data set for peat and clay depths. Data for the extensive moors upstream of Langport and downstream of the Bleadney Gap is noticeably lacking and the collection of information on the gross stratigraphy for those areas should be a priority.

In areas where the water table is kept high through Raised Water Level Areas (RWLAs) and other agri-environment agreements that encompass high ditch levels in summer, the prospects for continuing survival are also good, but only in the short term, as anything can happen after the ending of the particular agri-environment agreement. Future Environmental Stewardship funding is moving away from RWLAs towards schemes for larger areas, on the basis that they would represent a more efficient use of public money. The recent Water Levels Management Plans (WLMPs) developed by the Somerset Drainage Boards for the wetland SSSIs are a significant advance in the ability to deliver a more sustainable future for those areas, which cover a significant proportion of the peatlands. The focus for these schemes has been the provision of additional infrastructure, such as tilting weirs (Figure 217), to allow a more flexible control of ditch water levels and the division of the moors into hydrological blocks that reflect

In virtually all the peatlands however, the existing ditch spacing is unlikely to be able to deliver summer water tables that will completely prevent peat wastage. The installation of effective in-field irrigation on a landscape scale should be a medium term strategic aim, underpinned by some more research into the most effective techniques. In the short term improved summer irrigation for some fields containing nationally important archaeological remains should be considered in ditch water levels can be maintained high enough to feed them. The availability of summer water in the ditches is vital, otherwise irrigation becomes drainage.

The areas at most risk of peat wastage are those where arable farming is carried out on peat soils at or close to the ground surface. This is currently a very small area within the peat moors but it could expand rapidly in response to the changing economics of farming. There has recently been a large shift from dairy farming to beef and there could equally be a shift from beef to arable. The most vulnerable areas to such a potential shift are those outside the SSSIs and not in existing agri-environment agreements. The rate of loss to peat wastage in arable areas is likely to be between 1cm and 2cm per year, or 1–2m over a century.

To better inform the long term management of the peat resource, further landscape scale analysis is needed. This would use information on ground surface height (from Environment Agency LIDAR

Figure 217. New weir structure.

data), summer penning levels on main rivers and IDB controlled rhynes and RWLAs, existing ditch spacing, land use, hydraulic conductivity and depth of surface clay. When combined, this data could be used to identify areas where peat wastage is likely to occur at negligible, slow, medium or rapid rates. This could be compared to other data sets such as land ownership by public bodies and nature conservation organisations or radiocarbon dates of the top of peat deposits or sites of known waterlogged archaeological remains. It is hoped that an evolving 'Wetland Vision' for the Brue valley may be able to deliver this sort of future opportunity mapping. Related work is also taking place on the southern moors, tied into the national Wetland Vision for England (http://www.wetlandvision.org.uk/).

The production of such a GIS based tool could help to identify the areas where there is most need for increased provision of additional irrigation features (ditches or sub-surface). It would also be able to provide evidence of the likely effectiveness of varying penning proposals and the ability of agri-environment options to deliver in field water tables that would prevent peat wastage. It would also enable calculations to be made about the total water quantity that would be needed in summer months to provide sustainable hydrological management of peat soils. This would help to determine where water shortages are likely to be a problem and therefore where extra storage capacity may have to be created. These results could be fed back into the review processes of agri-environment schemes.

Such landscape scale management methodologies might be able to deliver sustainable management over large areas but would take many years to achieve such benefits. The known waterlogged sites not examined as part of the MARISP project and not subject to previous assessment, should therefore be rapidly assessed to determine their existing state of preservation and the possibility for their continued preservation *in situ*. This could be done using a reduced MARISP methodology to deliver cost effective answers for key monuments. The most significant monuments in need of such assessment are:

- three prehistoric trackways between Chedzoy and Westonzoyland;
- the complex of Neolithic trackways south of Burtle;
- Strangways causeway between Othery and Greinton;
- six prehistoric trackways between Chedzoy and the Polden hills;
- two wooden structures on Kings Sedgemoor;
- two prehistoric wooden structures between Othery and High Ham;
- a Late Bronze Age pile alignment (and possible Saxon bridge) between Athelney and West Lyng; and
- the Sweet Track north of the South Drain.

The investigations would focus on obtaining the information needed for decision making while making best research use of any keyhole excavations undertaken.

The methodologies would be informed by the current monitoring work being undertaken on the Sweet Track and Glastonbury Lake Village by Reading University in partnership with Somerset County Council and English Heritage.

Research priorities

The establishment of comprehensive research priorities for Somerset's peatlands is beyond the remit of the MARISP project and the scope of this publication. Current understanding of the Holocene deposits is only very good for the Brue valley. The southern moors have benefited from some recent work but should remain a focus for palaeoenvironmental analysis, particularly in the floodplain upstream of Langport where current knowledge is virtually nil. The research priorities for the individual MARISP sites have already been presented above.

The project has identified several areas of continuing uncertainty in our understanding of the decay trajectory of waterlogged deposits and the factors within the burial environment that influence it. Some widely held preconceptions, such as the destructive effect of a seasonally fluctuation water table, have been shown to be over simplistic. The results of the project have been used to help inform a subsequent monitoring project in Somerset's peatlands by Reading University in partnership with Somerset County Council and English Heritage. The results of that project will also hopefully help to refine future monitoring strategies in wetlands.

Management priorities

The priorities for the management of the archaeological resource in Somerset's peatlands can be summarised as follows:

1. archaeological input into IDB Water Levels Management Plans (WLMPs), Environment Agency Catchment Management Plans (CMPs) and agri-environment policy implementation;
2. more research on the effectiveness of in-field irrigation methods to prevent peat wastage and carbon loss;
3. collection of data on the gross stratigraphy of the floodplain upstream of Langport (upper Parret catchment) and downstream of the Bleadney Gap (lower Axe catchment);
4. creation of a GIS tool to identify areas at varying levels of risk from peat wastage;
5. collective agreement on a long term land use strategy that can deliver sustainable peat soil management in the face of climate change;
6. the establishment of baseline condition information on all the known waterlogged archaeological sites of national importance;
7. site specific hydrological improvements for archaeological monuments where appropriate and feasible;
8. rescue recording of information from sites which cannot be protected from ongoing desiccation in the short term; and
9. continuing efforts to raise understanding of the cultural importance of the peatlands and the factors affecting their preservation with landowners, organisations and the general public.

The landscape scale priorities appear daunting but they overlap with many other existing national priorities, such as achieving favourable condition for SSSIs, reducing the impact of climate change, safeguarding soils, sustainable flood management and the wise us of wetlands (e.g. Defra 2009).

Such ambitious landscape scale programmes are being implemented in other countries such as the Netherlands and Denmark and their successful implementation in the UK is achievable. In the Netherlands the National Spatial Strategy had a policy for peat areas that suggested ditchwater levels of 40cm below the soil surface to reduce subsidence to expected levels of 4–8mm per year (Verhagen *et al*. 2009, 27). The Dutch peatlands are mainly used (85–90%) as permanent grassland for dairy farming. This predominance of permanent pasture is similar to the current position in the Somerset peatlands and the same target (40cm below ground surface) for ditch water levels is realistically achievable. Despite the vagaries of farming economics and government policy the area is therefore well placed to be able to avoid the catastrophic destruction of peatland heritage that has occurred in the last 50 years around the world and in other areas of England (Clarke and Joosten 2002).

Appendix 1

Key for habitat groups and scale of abundance for plant macrofossil analysis tables

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Habitats

A:	Aquatic	a:	acidic
B.	Bankside	bp:	base poor
C:	Cultivated/Arable	br:	base rich
D:	Disturbed	c:	calcareous
E:	Heath/Moor	d:	dry soils
F:	Fens/Bogs	h:	heavy soils
G:	Grassland	l:	light soils
H:	Hedgerow	n:	nitrogen rich soils
M:	Marsh	o:	open habitats
P:	Ponds, ditches – stagnant/slow flowing water	p:	phosphate rich soils
R:	Rivers, streams	s:	coastal
S:	Scrub	w:	wet/damp soils
W:	Woodland		

Scale of abundance

occ:	occurring only a few times or 2–5 records
freq:	occurring regularly or 5–20 records
v. freq:	occurring in every portion of the sample examined or 20+ records
abund:	occurring in field of view all the time and dominating the sample or 40+ records

Appendix 2

Abbreviations for ecological codes and statistics used for interpretation of insect remains in text and tables

Lower case codes in parentheses are those assigned to taxa and used to calculate the group values (the codes in capitals). Indivs: individuals (based on MNI); No: number.

No taxa	S
Estimated number of indivs (MNI)	N
Index of diversity (α)	ALPHA
Standard error of alpha	SEALPHA
No >certain= outdoor taxa (oa)	SOA
Percentage of >certain= outdoor taxa	PSOA
No >certain= outdoor indivs	NOA
Percentage of >certain= outdoor indivs	PNOA
No OA and probable outdoor taxa (oa + ob)	SOB
Percentage of OB taxa	PSOB
No OB indivs	NOB
Percentage OB indivs	PNOB
Index of diversity of the OB component	ALPHAOB
Standard error	SEALPHAOB
No aquatic taxa (w)	SW
Percentage of aquatic taxa	PSW
No aquatic indivs	NW
Percentage of W indivs	PNW
Index of diversity of the W component	ALPHAW
Standard error	SEALPHAW
No damp ground/waterside taxa (d)	SD
Percentage D taxa	PSD
No damp D indivs	ND
Percentage of D indivs	PND
Index of diversity of the D component	ALPHAD
Standard error	SEALPHAD
No strongly plant-associated taxa (p)	SP
Percentage of P taxa	PSP
No strongly P indivs	NP
Percentage of P indivs	PNP
Index of diversity of the P component	ALPHAP
Standard error	SEALPHAP
No heathland/moorland taxa (m)	SM
Percentage of M taxa	PSM
No M indivs	NM
Percentage of M indivs	PNM
Index of diversity of the M component	ALPHAM
Standard error	SEALPHAM
No wood-associated taxa (l)	SL
Percentage of L taxa	PSL
No L indivs	NL
Percentage of L indivs	PNL
Index of diversity of the L component	ALPHAL
Standard error	SEALPHAL
No decomposer taxa (rt + rd + rf)	SRT
Percentage of RT taxa	PSRT
No RT indivs	NRT
Percentage of RT indivs	PNRT
Index of diversity of RT component	ALPHART
Standard error	SEALPHART
No >dry= decomposer taxa (rd)	SRD
Percentage of RD taxa	PSRD
No RD indivs	NRD
Percentage of RD indivs	PNRD
Index of diversity of the RD component	ALPHARD
Standard error	SEALPHARD
No >foul= decomposer taxa (rf)	SRF
Percentage of RF taxa	PSRF
No RF indivs	NRF
Percentage of RF indivs	PNRF
Index of diversity of the RF component	ALPHARF
Standard error	SEALPHARF
No synanthropic taxa (sf + st + ss)	SSA
Percentage of synanthropic taxa	PSSA
No synanthropic indivs	NSA
Percentage of SA indivs	PNSA
Index of diversity of SA component	ALPHASA
Standard error	SEALPHASA
No facultatively synanthropic taxa	SSF
Percentage of SF taxa	PSSF
No SF indivs	NSF
Percentage of SF indivs	PNSF
Index of diversity of SF component	ALPHASF
Standard error	SEALPHASF
No typical synanthropic taxa	SST
Percentage of ST taxa	PSST
No ST indivs	NST
Percentage of ST indivs	PNST
Index of diversity of ST component	ALPHAST
Standard error	SEALPHAST
No strongly synanthropic taxa	SSS
Percentage of SS taxa	PSSS
No SS indivs	NSS
Percentage of SS indivs	PNSS
Index of diversity of SS component	ALPHASS
Standard error	SEALPHASS
No uncoded taxa (u)	SU
Percentage of uncoded indivs	PNU
No indivs of grain pests (g)	NG
Percentage of indivs of grain pests	PNG

Appendix 3

MARISP pollen assessment plates

All photographs were taken at ×1000 magnification, with the exception of Plate 17 which is at ×400.

Plate 1. Corrosion. Tilia with perforated exine. Chilton Track, 1.03–04m OD.

Plate 2. Well-preserved grain. Quercus. Tinney's Track, 3.12–13m OD.

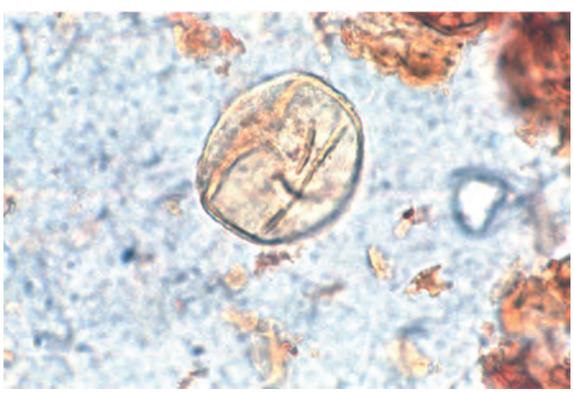

Plate 3. Degradation. Extensively thinned Quercus, Tinney's Track, 2.80–81m OD.

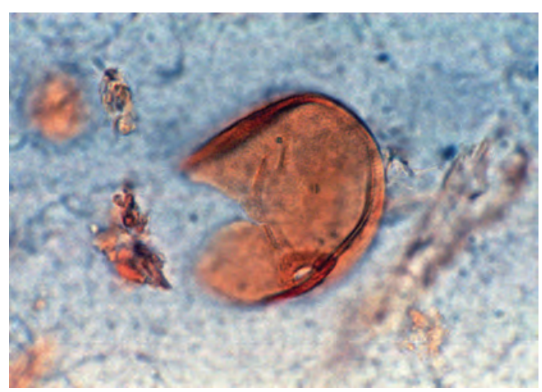

Plate 4. Partly broken grain. Poaceae, Tinney's Track, 2.90–91m OD.

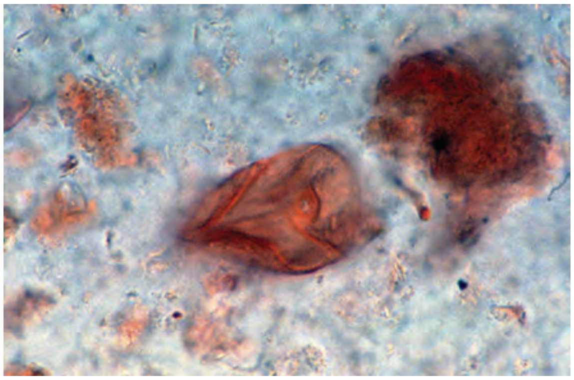

Plate 5. Extensively crumpled grain. Poaceae, Street Causeway, 3.99–4.00m OD.

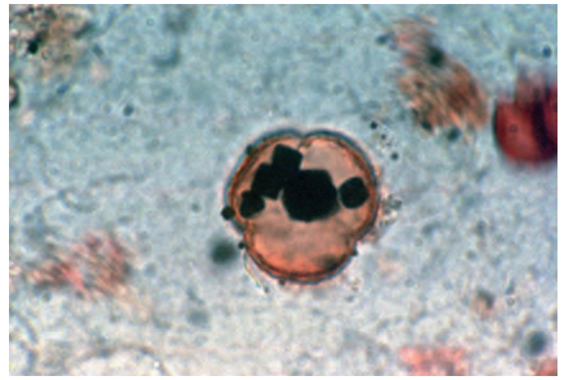

Plate 6. Authigenic mineral deposition. Quercus, Sharpham Park, 5.11–12m OD.

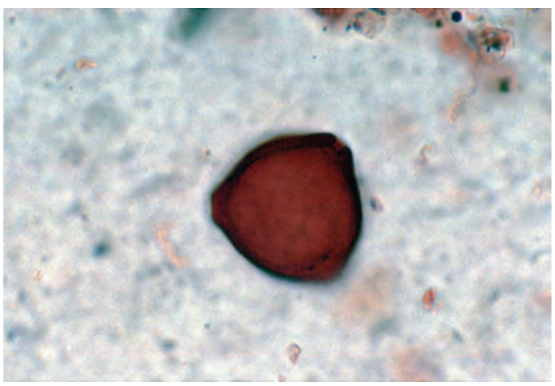

Plate 7. Well-preserved Corylus, preservation score 0. Meare Village East, 2.86–87m OD.

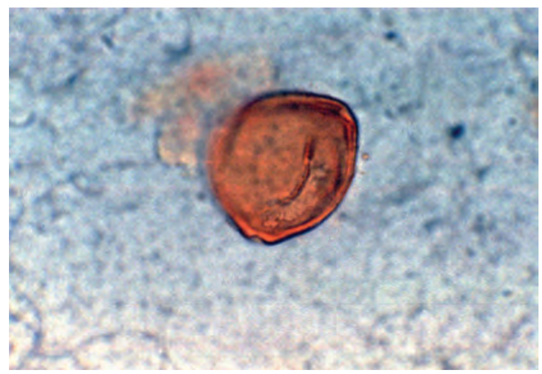

Plate 8. Partly corroded Corylus (<¼), preservation score 1. Tinney's Track, 3.12–13m OD.

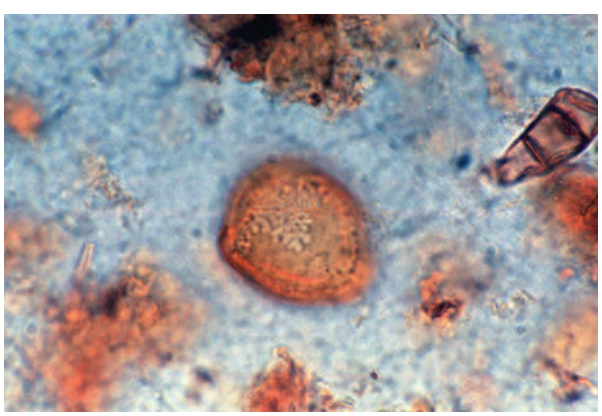

Plate 9. Partly corroded Corylus (¼–½), preservation score 2. Tinney's Track, 2.80–81m OD.

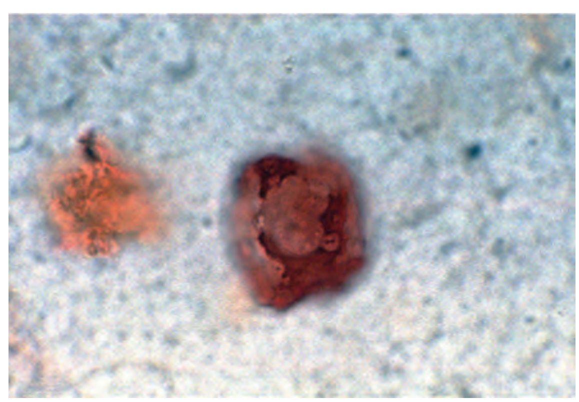

Plate 10. Extensively corroded Corylus (>½) preservation score 3. Chilton Track, 1.29–30m OD.

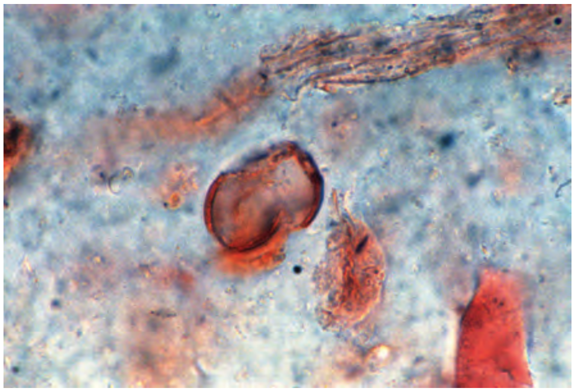

Plate 11. Broken Poaceae, with an obviously deteriorated exine, both corrosion and degradation could be involved. Street Causeway, Context 5.

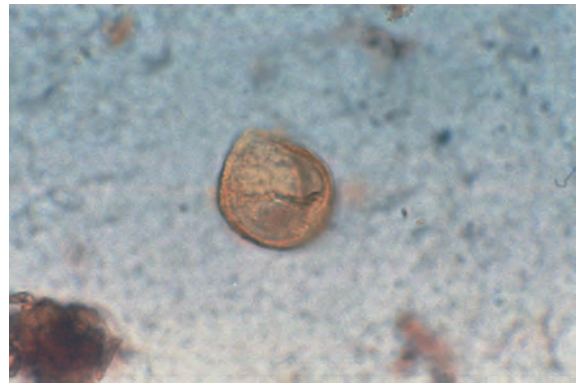

Plate 12. Partly degraded Quercus, Tinney's Track, 2.59–60m OD.

Plate 13. Extensively degraded Typha latifolia, Chilton Track, 1.03–04m OD.

Plate 14. Well-preserved Calluna vulgaris, the fold is caused by squashing from the slide cover slip. Tinney's Track, 3.12–13m OD.

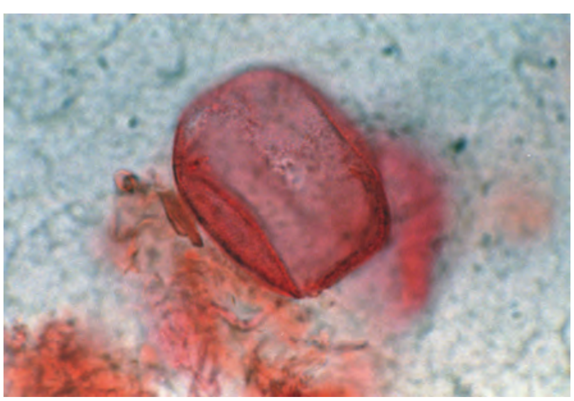

Plate 15. Well-preserved Cyperaceae, Bell Track, 1.68–69m OD.

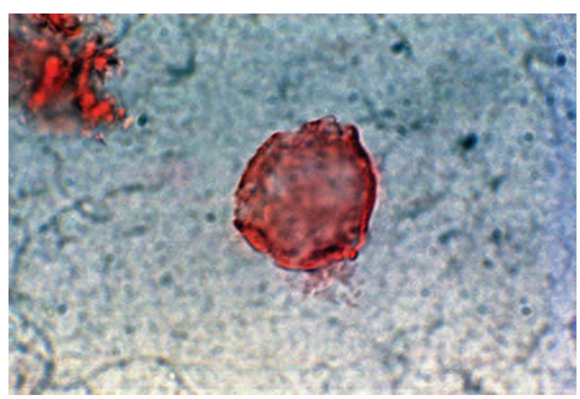

Plate 16. Extensively corroded (>½) Betula, Bell Track, 1.68–69m OD.

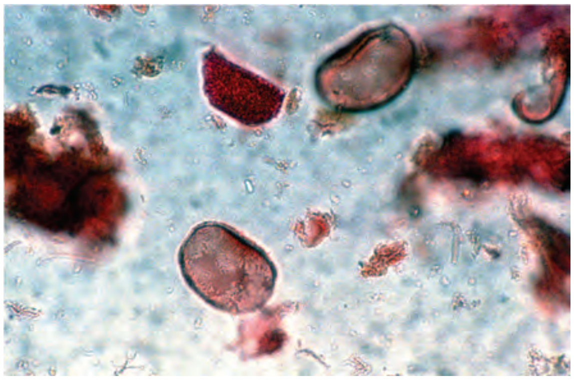

Plate 17. Etched (degraded) undifferentiated fern spores, Chilton Track, 1.29–30m OD (×400).

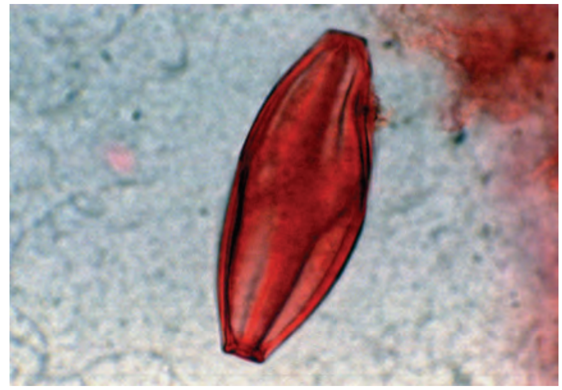

Plate 18. Spore of the fungal taxon Diporotheca, Street Causeway, 3.55–56m OD.

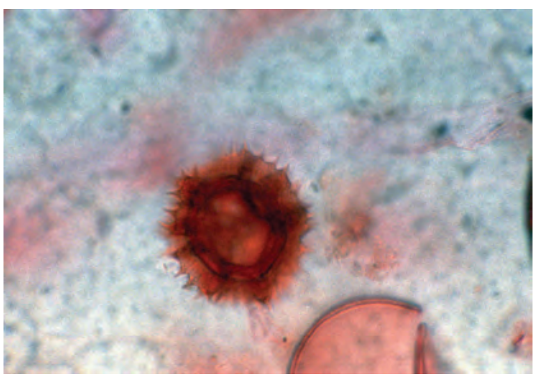

Plate 19. Well-preserved Lactuceae grain, a particularly robust taxon, Sharpham Park, 4.95–96m OD.

Plate 20. Well-preserved spore of Thelypteris palustris, showing preservation of the fine spines, Tinney's Track, 3.12–13m OD.

Appendix 4

MARISP plant macrofossil assessment figures

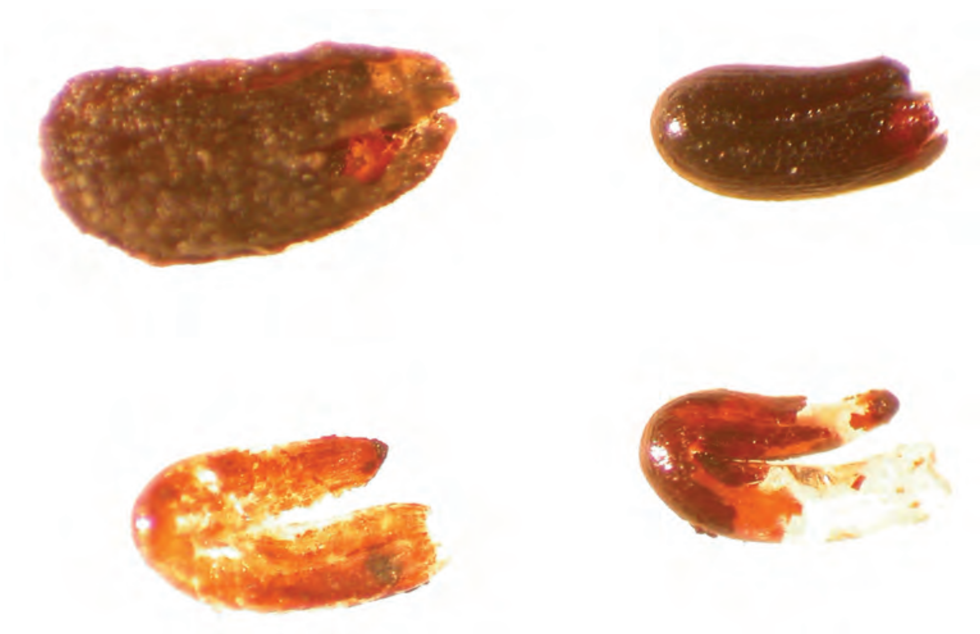

Figure 1. Alisma plantago-aquatica *(Water-plantain).*

Top   <25% fragmented/<25% erosion
(Sharpham 5.09–5.14m OD)

Alisma sp.
>50% fragmented/<25% erosion
(Harter's Hill 4.44–4.49m OD)

Alisma sp.
Bottom   >50% fragmented/25–50% erosion
(Harter's Hill 4.44–4.49m OD)

Alisma sp.
>50% fragmented/>50% erosion
(Harter's Hill 4.44–4.49m OD)

All at 33× magnification: Shutter speed 1/3th

Description
The flat wedge-shaped fruits are obovate in outline, *c*. 2.4 × 1.2mm.
Often only flimsy darker brown U-shaped embryo preserved (does not exceed 1.8mm)
still identifiable to *Alisma* sp. (all classified as >50% fragmented)

Figure 2. Alnus glutinosa *(Alder).*

Top	whole fruit/no erosion (Sharpham 5.09–5.14m OD)	whole fruit/25% erosion (Sharpham 5.09–5.14m OD)
Bottom	whole fruit/25–50% erosion (Sharpham 5.09–5.14m OD)	whole fruit/>50% erosion (Sharpham 5.09–5.14m OD)

All at 20× magnification: Shutter speed 1/60th

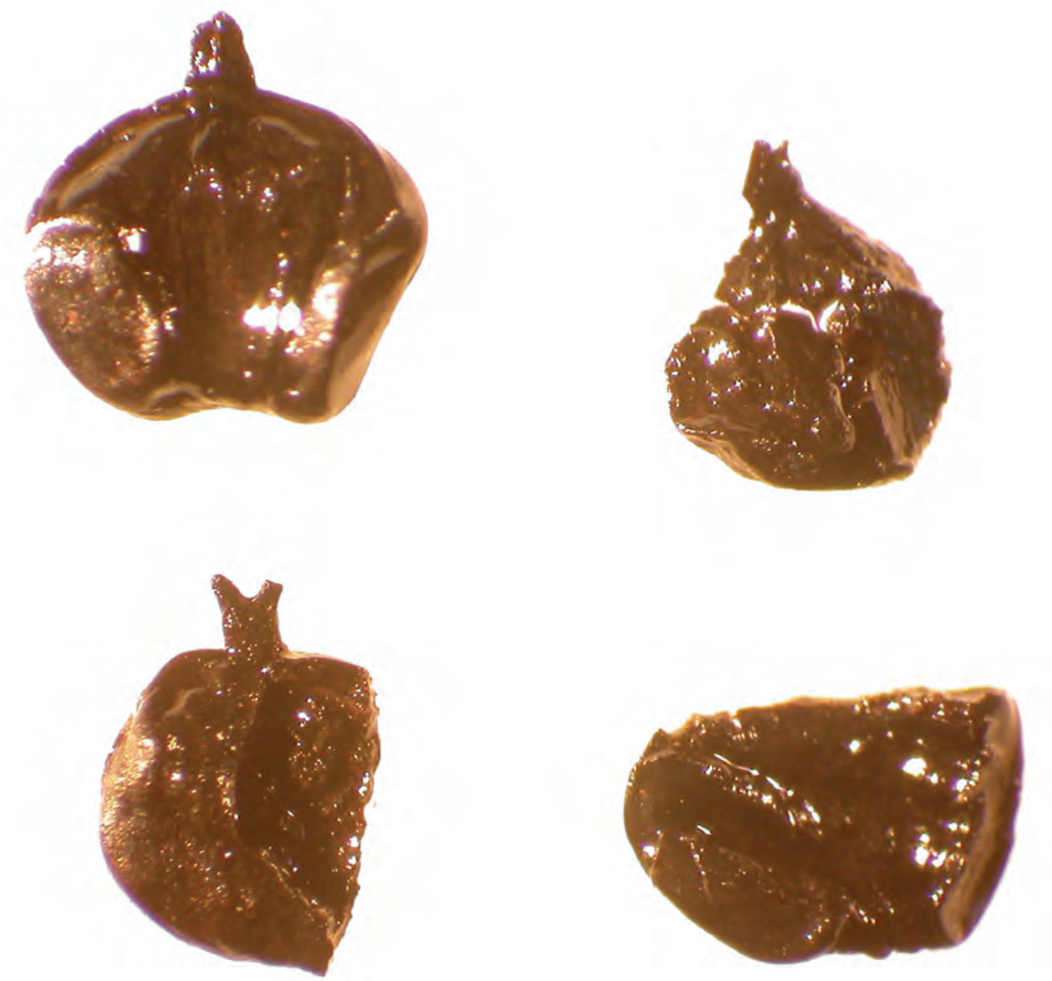

Figure 3. Alnus glutinosa *(Alder).*

Top	whole fruit (Sharpham 5.09–5.14m OD)	<25% fragmented (Sharpham 5.09–5.14m OD)
Bottom	25–50% fragmented (Sharpham 5.09–5.14m OD)	>50% fragmented (Sharpham 5.09–5.14m OD)

All at 21× magnification: Shutter speed 1/60th

Description

Flat fruits approx 2.5 × 2mm, are rounded pentagonal in outline with a blunt tip. The dorsal face often has one faint longitudinal keel and two lateral ones. The fruit wall is thick and corky and appears to be very resilient.

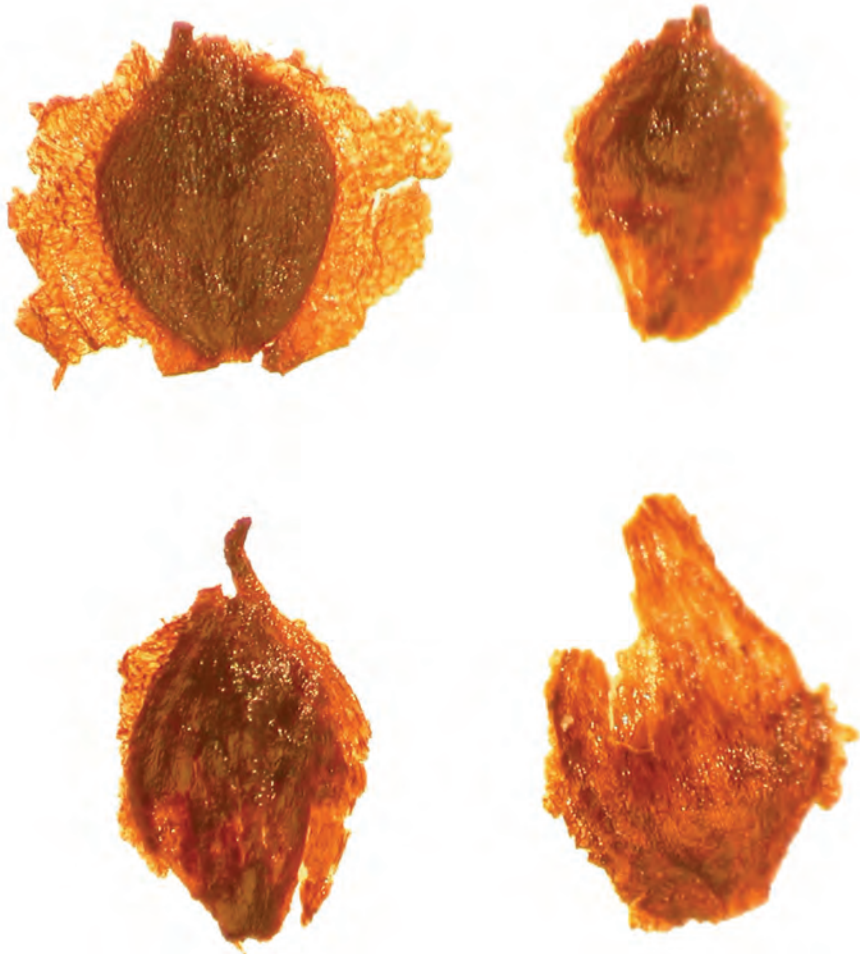

Figure 4. Betula *erosion.*

Top	*Betula* sp. (birch) No erosion (Bell Track 1.66–1.71m OD)	*Betula* sp. <25% erosion (Bell Track 1.66–1.71m OD)
Bottom	*Betula* sp. 25–50% erosion (Bell Track 1.66–1.71m OD)	*Betula* sp. >50% erosion (Bell Track 1.66–1.71m OD)

All at 35× magnification: Shutter speed 1/30th

Figure 5. Betula.

Top	*Betula pendula* (silver birch) Whole fruit (Chilton Trackway 1–1.05m OD)		*Betula pubescens* (downy birch) Whole fruit (Bell Track 1.66–1.71m OD)
Bottom	*Betula* sp. <25% fragmented (Bell Track 1.66–1.71m OD)	*Betula* sp. 25–50% fragmented (Bell Track 1.66–1.71m OD)	*Betula* sp. >50% fragmented (Bell Track 1.66–1.71m OD)

All at ×15 magnification: Shutter speed 1/30th

Description

In *Betula pubescens* fruits each wing is 1–1.5 times as wide as the body, with the wings not extending beyond the stigmas at the apex of the body. In *Betula pendula* fruits the wings are more than twice as wide as the body and extend well beyond the stigmas at the apex. Where no wings were preserved

Figure 6. Calluna vulgaris *(Heather).*

<25% erosion
(Abbot's Way 1.83–1.88m OD)

25–50% erosion
(Abbot's Way 1.83–1.88m OD)

>50% erosion
(Abbot's Way 1.83–1.88m OD)

All at 45× magnification: Shutter speed 1/30th

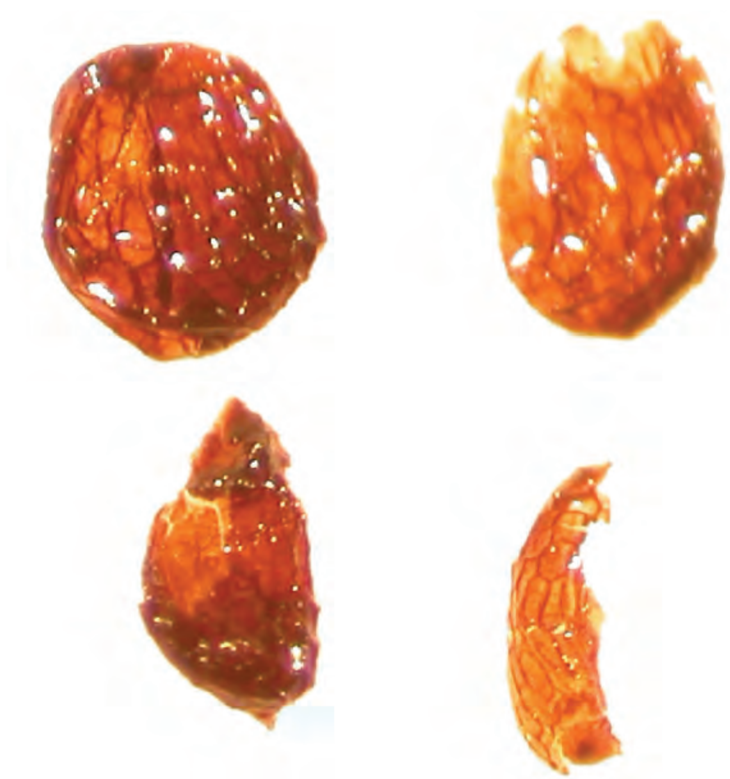

Figure 7. Calluna vulgaris *(Heather).*

Top	whole seed (Abbot's Way 1.83–1.88m OD)	<25% fragmented (Abbot's Way 1.83–1.88m OD)
Bottom	25–50% fragmented (Abbot's Way 1.83–1.88m OD)	>50% fragmented (Abbot's Way 1.83–1.88m OD)

All at 45× magnification: Shutter speed 1/30th

Description

Calluna vulgaris seeds are small, *c.* 0.5 × 0.3mm, elliptic in outline, rounded at one end and somewhat truncated at the other. The epidermis cells are relatively large and of elongate shape. They appear to be fairly delicate.

Figure 8. Carex *spp. (Sedge).*

Top	whole nutlet/no erosion (Meare Village East 2.84–2.89m OD)	whole nutlet/<25% erosion (Meare Village East 2.84–2.89m OD)
Bottom	whole nutlet/25–50% erosion (Meare Village East 2.84–2.89m OD)	>50% fragmented/>50% erosion (Meare Village East 2.84–2.89m OD)

All at 22× magnification: Shutter speed 1/60th

Description

Example of biconvex sedge (*Carex*) fruit, with an elliptic outline to the achene, epidermal cells distinct on well-preserved achenes.

Figure 9. Ceratophyllum demersum *(Rigid Hornwort).*

Top	whole fruit/<25% erosion (Glastonbury Lake Village 4.79–4.84m OD)	<25% fragmented/no erosion (Glastonbury Lake Village 4.49–4.54m OD)
Bottom	25–50% fragmented (Glastonbury Lake Village 4.49–4.54m OD)	25–50% fragmented/>50% eroded (Glastonbury Lake Village 4.49–4.54m OD)

All at 13× magnification: Shutter speed 1/60th

Description

Fruits biconvex, oval in outline, *c.* 4–5mm long, smooth or slightly warty. They are apiculate to long spined at the apex often with two long spines at the base and of brownish-olive colour. Fruit appears to split exactly into two halves (25–50% fragmented). Varying degrees of erosion of the thick wall of the testa reveal a darker colouration beneath.

Figure 10. Cladium mariscus *(Great Fen-sedge).*

Top	whole with outer glumes <25% erosion (Meare Village East 2.99–3.04m OD)	<25% fragmented nutlet enclosed by glumes well preserved (Meare Village East 2.99–3.04m OD)
Bottom	25–50% fragmented (nutlet) (Meare Village East 2.99–3.04m OD)	>50% fragmented (nutlet) (Meare Village East 2.99–3.04m OD)

All at 20× magnification: Shutter speed 1/60th

Description

Fruits are elliptic to ovate in outline with a truncate base with thick lustrous coriaceous (leathery) walls which enclose the nut (recorded as whole). The distinctive; urn-like nut, has three grooves and three projecting flanges. Entire well preserved urn-shaped nuts are recorded as <25% fragmented. There are varying degrees of erosion to the porous woody nut wall.

Figure 11. Hydrocotyle vulgaris *(Marsh pennywort).*

Top	whole fruit/no erosion (Meare Village East 2.99–3.04m OD)	<25% fragmented/<25% erosion (Meare Village East 2.99–3.04m OD)
Bottom	<25% fragmented/25–50% erosion (Meare Village East 2.99–3.04m OD)	>50% fragmented/>50% erosion (Meare Village East 2.99–3.04m OD)

All at 30× magnification: Shutter speed 1/6th

Description

Semi-circular fruits, approx 1.75 × 1.25mm with two slender ribs along the narrow ventral side, varying degrees of erosion appear to have affected this surface ribbing.

Figure 12. Lycopus europaeus *(Gipsywort).*

Top	whole fruit (Sharpham 5.30–5.35m OD)	<25% fragmented (Sharpham 5.30–5.35m OD)
Bottom	25–50% fragmented (Sharpham 5.30–5.35m OD)	>50% fragmented (Sharpham 5.30–5.35m OD)

All at 34× magnification: Shutter speed 1/60th

Description

Seeds are quadrangular in shape, approx 1.5 × 1mm with a flat dorsal side and roof-shaped ventral side with a characteristic thickened margin of whiter tissue. Surprisingly small fragments remain identifiable.

Figure 13. Menyanthes trifoliate *(Bog-bean).*

Top	whole fruit/no erosion (Chilton Trackway 1.26–1.31m OD)	whole fruit/25–50% erosion (Chilton Trackway 1.26–1.31m OD)
Bottom	25–50% fragmented (Chilton Trackway 1.26–1.31m OD)	>50% fragmented/<25% erosion (Chilton Trackway 1.26–1.31m OD)

All at 16× magnification: Shutter speed 1/60th

Description

Flattened seeds, approx 2.8 × 2.3mm, elliptic in outline with slightly domed sides with a rounded edge. The surface is smooth and shiny in well-preserved examples.

Figure 14. Oenanthe aquatica *(Fine-leaved Water-dropwort).*

Top	Whole fruit/no erosion (Sharpham 5.09–5.14m OD)	<25% fragmented/<25% erosion (Sharpham 5.09–5.14m OD)
Bottom	25–50% fragmented/ 25–50% eroded) (Glastonbury Lake Village 4.69–4.74m OD)	<25% fragmented/ >50% eroded) (Glastonbury Lake Village 4.69–4.74m OD)

All at 15× magnification: Shutter speed 1/30th

Description

Fruits oblong to ovate in outline with a flat ventral side and domed dorsal side. In well-preserved examples, there are five ribs of spongy tissue, the lateral ones somewhat thicker than the inner ones. Degradation caused some loss to the longitudinal ribs on the domed dorsal side of the fruit.

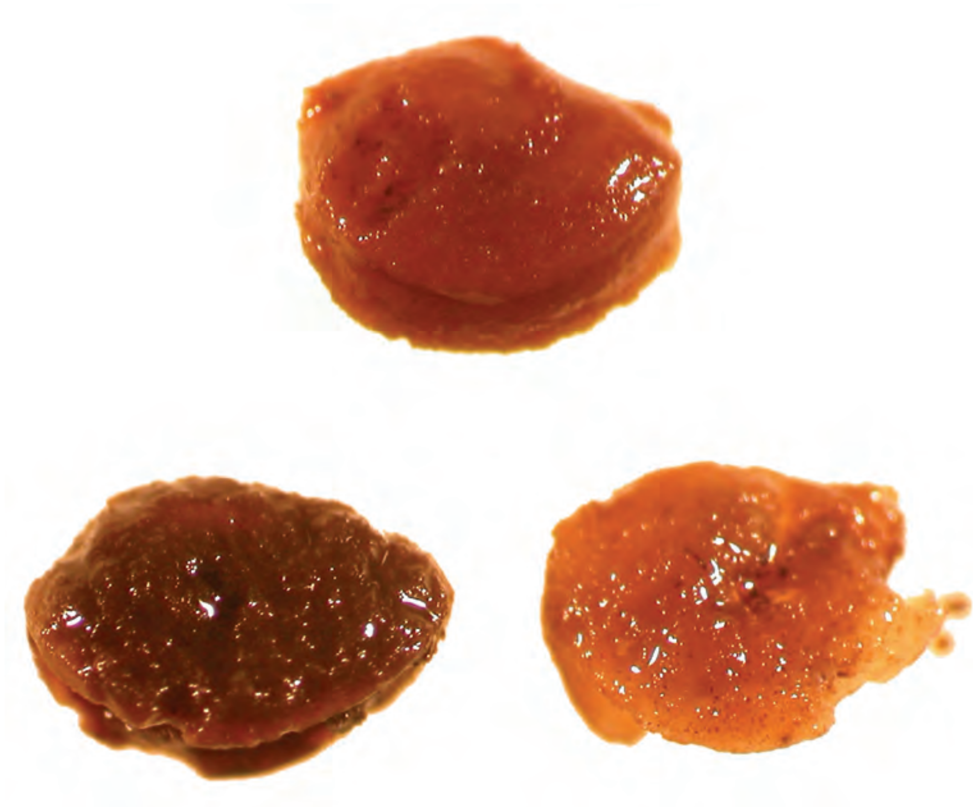

Figure 15. Potamogeton *spp. (Pondweed).*

Top <25% erosion
(Glastonbury Lake Village 4.49–4.54m OD)

Bottom 25–50% erosion
(Glastonbury Lake Village 4.49–4.54m OD)

>50% erosion
(Glastonbury Lake Village 4.49–4.54m OD)

All at 20× magnification: Shutter speed 1/60th

Figure 16. Potamogeton *spp. (Pondweed).*

Top	whole fruit (Glastonbury Lake Village 4.79–4.84m OD)	<25% fragmented (Glastonbury Lake Village 4.79–4.84m OD)
Bottom	25–50% fragmented (Glastonbury Lake Village 4.79–4.84m OD)	>50% fragmented (Glastonbury Lake Village 4.49–4.54m OD)

All at 20× magnification: Shutter speed 1/60th

Description

Laterally flattened fruits, semi-circular in outline, easily recognisable as a genus. Fragmentation included loss of spines and ventral margin (recorded as <25% fragmented). The surface of the fruits is of a spongy texture which had undergone varying degrees of erosion.

Figure 17. Ranunculus acris/repens/bulbosus *(Buttercup).*

Top	whole fruit/no erosion (Harter's Hill 4.16–4.21m OD)	whole fruit/25–50% erosion (Harter's Hill 4.16–4.21m OD)
Bottom	25–50% fragmented (Harter's Hill 4.16–4.21m OD)	>50% fragmented/25–50% eroded (Harter's Hill 4.16–4.21m OD)

All at 20× magnification: Shutter speed 1/60th

Description

Flat circular fruits, approx 2.5 × 2mm. The surface of the fruits, smooth to slightly rough, shows a reticulate pattern, the epidermal cells forming pits with clear margins. These show varying degrees of erosion.

Figure 18. Sparganium erectum *(branched bur-reed).*

Top	whole fruit/no erosion (Sharpham 5.30–5.35m OD)	<25% erosion (Harter's Hill 4.35–4.40m OD)
Bottom	25–50% erosion (Harter's Hill 4.35–4.40m OD)	>50% erosion (Harter's Hill 4.44–4.49m OD)

All at 14× magnification: Shutter speed 1/60th

Figure 19. Sparganium erectum *(Branched bur-reed).*

Top	whole fruit (Sharpham 5.30–5.35m OD)	<25% fragmented (Harter's Hill 4.35–4.40m OD)
Bottom	25–50% fragmented (Sharpham 5.30–5.35m OD)	>50% fragmented (Sharpham 5.30–5.35m OD)

All at 12× magnification: Shutter speed 1/60th

Description

Funnel-shaped fruits with 6–10 pronounced longitudinal ribs, which distinguish this from other Sparganium species, with spongy exocarp. Varying degrees of erosion reduce ribbing.

Appendix 5

Troels-Smith stratigraphic descriptions

Harter's Hill, 2003

Level m OD		Physical features								Components (total = 4)																	Comments Preservation index/indets
		0–4																									
Upper	Lower	Darkness	Stratification	Elasticity	Dryness	Humification	Colour	Structure	Upper boundary	Mosses	Woody plants	Herbs	Woody detritus	Herb detritus	Fine detritus	Charcoal	Organic lake mud	Humus	Organosilicates	Carbonates	Iron oxides	Clay	Silt	Mud	Sand	Gravel	
4.58	4.55	4	0	2	4	3	Mid reddish brown	Largely homogeneous with some fine fibres and roots						1	1			2					1				Oxidised very dry fibrous silty peat with roots which may be modern
4.55	4.37	4	1	2	3	4	Mid-brown	Largely homogeneous but with fine fibres	1					+				3					1				Very well-humified silty peat possible charcoal flecks, fine fibres could be modern
4.37	4.25	4	1	2	3	3	Dark brown	Heterogeneous peat with wood fragments	1		1		1					2									Wood fragments very decomposed
4.25	4.17	4	1	2	3	3	Dark grey brown	Largely homogeneous but with occasional flecks of rotted wood	0				+					3					1				Very well humified peat silty with wood fragments
4.17	4.08	3	2	1	3	2	Grey-brown	Homogeneous	0				1					1				2					Clay with woody fragments and organic detritus

Harter's Hill 1997

Level m OD		Physical features							Components (total = 4)																	Comments
		0–4																								
Upper	Lower	Darkness	Stratification	Elasticity	Dryness	Colour	Structure	Upper boundary	Mosses	Woody plants	Herbs	Woody detritus	Herb detritus	Fine detritus	Charcoal	Organic lake mud	Humus	Organosilicates	Carbonates	Iron oxides	Clay	Silt	Mud	Sand	Gravel	
5.02	4.64	4	0	2	3	Brown	Amorphous						+				3					1				Disturbed amorphous silty peat with small modern roots
4.64	4.49	4	0	2	3	Brown/ Black	Amorphous	1						+			4					+				Brown peat with black streaks, occasional modern roots
4.49	4.39	4	1	2	3	Dark brown	Fibrous	1					2				2									Fibrous peat
4.39	4.08	4	1	2	2	Dark brown/ Black	Woody peat	1		1		1					2									Twigs and wood fragments in peat

Sharpham Park

Level m OD		Physical features								Components (total = 4)																	Comments Preservation index/indets
		0–4																									
Upper	Lower	Darkness	Stratification	Elasticity	Dryness	Humification	Colour	Structure	Upper boundary	Mosses	Woody plants	Herbs	Woody detritus	Herb detritus	Fine detritus	Charcoal	Organic lake mud	Humus	Organosilicates	Carbonates	Iron oxides	Clay	Silt	Mud	Sand	Gravel	
5.56	5.55	4	1	1	3		Yellow brown	Homogeneous														4					colluvium
5.55	5.40	4	1	2	3	4	Dark brown	fibrous woody peat	2				1	+				3									Well humified peat with small fibres and wood fragments modern roots
5.40	5.35	4	2	1	3		Grey brown with buff mottles	Homogeneous clay with fine organic laminae	2				+					1				3					Alluvial clay band,
5.35	5.13	4	1	2	3	3	Dark grey brown	Heterogeneous peat with traces of clay	2				1					3				+					Peat with wood fragments and dispersed clay particles
5.13	5.02	4	0	0	3	3	Very dark brown	Heterogeneous granular peat with twigs	1				1	1				2									Snails present from 5.1m OD
5.02	4.91	4	0	0	3	2	Pale brown	Homogeneous	2					+	2									2			Detrital mud with snails throughout 1.40/14

4.91	4.82	1	1	0	3	2	Grey with buff mottles	Slightly banded	1				+	1						3							Calcareous tufa with organic detritus and wood fragments Occasional snails
4.82	4.72	0	0	0	3	1	Creamy buff	Homogeneous	1				+							4							Tufa with some large fragments of wood
4.72	4.66	0	0	0	3		Buff with orange mottles	Homogeneous	1													4?					Weathered tufa possibly mixed with Lias

Glastonbury Lake Village 2003

Level m OD		Physical features								Components (total = 4)																	Comments
Upper	Lower	0–4					Colour	Structure	Upper boundary	Mosses	Woody plants	Herbs	Woody detritus	Herb detritus	Fine detritus	Charcoal	Organic lake mud	Humus	Organosilicates	Carbonates	Iron oxides	Clay	Silt	Mud	Sand	Gravel	
		Darkness	Stratification	Elasticity	Dryness	Humification																					
5.59	5.21	3	2	0	3		Grey brown with orange mottles	Homogeneous														4					Fine grained mottled clay, probably alluvial
5.21	5.11	4	2	0	3	4	Red brown with frequent rusty mottles	Largely homogeneous, with occasional fibres	0									2				1	1				Organic mud with some silt and clay, fibres may be modern
5.11	5.03	4	0	0	3	4	Red brown	Homogeneous	0									2						2			Organic mud
5.03	4.97	4	0	0	3	4	Brown	Homogeneous	0									3						1			Organic mud, becoming increasingly peaty with depth
4.97	4.83	4	0	0	3	3	Dark brown	Homogeneous	1					1				3						+			Well-humified detritus peat becoming wetter towards the base
4.83	4.43	4	0	0	3	2	Black	Coarsely fibrous and woody	1				1	+				3									Poorly/ moderately humified peat, with wood fragments. Snails present throughout Worked wood at 4.49m OD and below, clay sling stones and small stones

Street Causeway

Level m OD		**Physical features**								**Components (total = 4)**																	**Comments Preservation index/indets**
Upper	Lower	0–4					Colour	Structure	Upper boundary	Mosses	Woody plants	Herbs	Woody detritus	Herb detritus	Fine detritus	Charcoal	Organic lake mud	Humus	Organosilicates	Carbonates	Iron oxides	Clay	Silt	Mud	Sand	Gravel	
		Darkness	Stratification	Elasticity	Dryness	Humification																					
4.03	3.83	4	0	1	3		Mid brown with orange mottles	Homogeneous						+				1				3					Organic clay, very dry
3.83	3.53	4	0	1	3	3	Very dark brown	Largely homogeneous but with some fine fibres and woody fragments	0				1	+				3									Well humified woody peat, becoming wetter with depth

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Index

Figures in italics indicate position of illustrations. All places are in Somerset unless otherwise stated