



McDONALD INSTITUTE MONOGRAPHS

# Must Farm pile-dwelling settlement

Volume 2. Specialist reports

*Edited by* Rachel Ballantyne, Anwen Cooper,  
David Gibson, Mark Knight & Iona Robinson Zeki

CAU Must Farm/Flag Fen Basin Depth & Time Series – Volume II

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*Edited by* Rachel Ballantyne,  
Anwen Cooper, David Gibson,  
Mark Knight & Iona Robinson Zeki

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Hermine Xhaufleur, Donald Horne, Vanessa Forte, Christian Casseyas, Michael Bamforth & Rachel Ballantyne

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Simon Timberlake & Giulio Lucarini

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#### **Chapter 31. Stable isotope analysis of seeds and bones**

Emma Lightfoot, Rachel Ballantyne & Tamsin C. O'Connell

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## Summary

The Must Farm pile-dwelling settlement (Cambridgeshire, UK) is one of the most extraordinary Bronze Age sites in Europe. The settlement, which was built over a slow-flowing, freshwater distributary of the River Nene, on the south-eastern edge of the Flag Fen Basin, comprised five stilt-raised houses, enclosed by a curving palisade. Built in the mid-9th century BC, the settlement was destroyed by fire less than a year after construction. Though the occupants escaped, the conflagration sent the remains of all five buildings and their artefact-rich contents to the riverbed. Fire, water and burial in oxygen-depleted silts provided the conditions for exceptional preservation. The site's stratigraphic simplicity, its short-lived duration and the vertical collapse of buildings gave the remains a pristine quality, allowing spatially and temporally coherent household inventories to be identified.

Amongst the wealth of things recovered were delicate textiles (yarns, cloth and knotted nets), wooden artefacts (bobbins, containers, withies, furniture, hafts for metal tools and wheels), complete pottery sets (jars, bowls and cups), bronze toolkits (axes, sickles, gouges, spears and razors) and numerous beads (glass, tin, amber and faience). The settlement's biological remains – animal bones (red deer, pig/wild boar, sheep and pike), charred plants and seeds, human and animal dung and microscopic remains (e.g. parasite eggs) – included elements seldom encountered in British prehistory. These challenge many of our ideas about the material worlds that people inhabited, shedding new light on aspects of architecture, foodways, woodland management, landscape change and the nature of wetland living.

This second volume presents detailed specialist analyses to accompany the narrative synthesis given in Volume 1. The specialist contributions are rich in detail and diverse in terms of the approaches taken, providing information in formats appropriate to differing fields of study. Volume 2 is split into six sections. Section

1, *Social and practical context*, presents the fieldwork methods used, in relation to the project's research aims, including that of public outreach (Ch1–Ch2). Section 2, *River*, provides detailed specialist perspectives on the history and character of the river that was the immediate setting of the Must Farm pile-dwelling settlement (Ch3–Ch8). Section 3, *Construction*, considers the materials used in the settlement's architecture, examining both the extensive use of structural wood and the more limited use of clay to augment the structures. Section 4, *Material culture*, details the various material assemblages of the settlement, exploring how the objects and materials which animated life in the settlement were made, stored, used and discarded (Ch12–Ch21). Section 5, *Biological remains*, focuses on the impressive, sometimes unparalleled, insights that biological remains such as animal bone, organic residues in pots, and coprolites, can shed on prehistoric life (Ch22–31). Finally, Section 6, *Aspects of time*, presents evidence relating to the duration of the settlement and to its premature destruction by fire (Ch32–33).

### Conventions and settlement terminology

#### *Conventions*

Context numbers are given in square brackets (e.g. [3208]).

Catalogue numbers are given in triangular brackets (e.g. <5600>).

Wood numbers are given the prefix WD (e.g. WD3601).

Spot finds are given the prefix SF (e.g. SF4230).

Feature numbers were not generally utilized during the project, but where used are given the prefix F. (e.g. F.901).



**Figure 0.01.** Collapsed remains of Must Farm pile-dwelling settlement, looking east: Structure 1 (foreground).

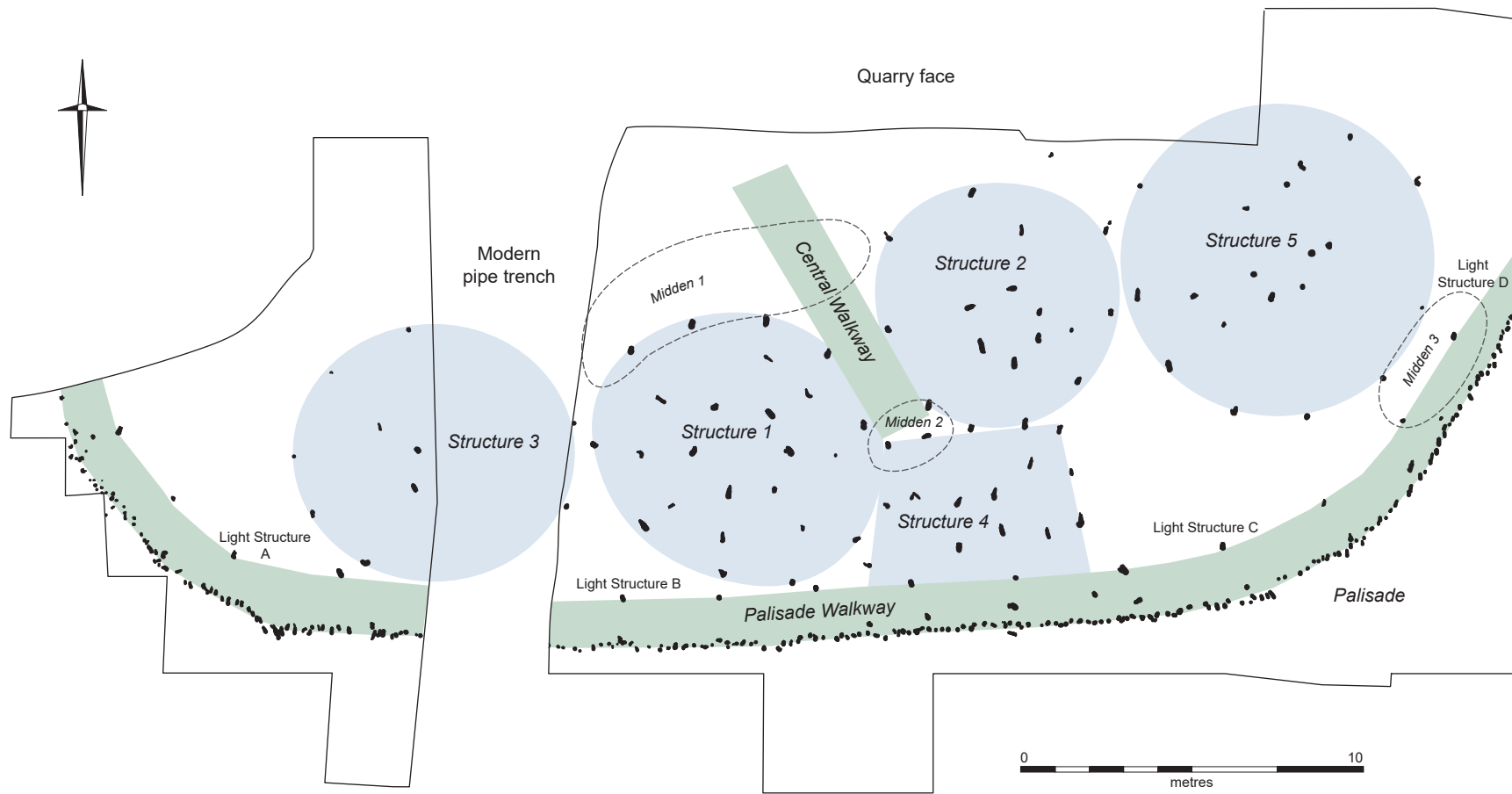
Site grid references are four-figure co-ordinates for 1 m square locations derived from the British National Grid. A site co-ordinate for the 1 m square 63E/22N = 523663E 296822N on the National Grid. In the text, spatial locations are given as eastings and northings on the 1 m site grid (e.g. 72E/25N). Where given in tables these are abbreviated (e.g. 72/25).

All calibrated radiocarbon dates are given as 'cal BC'. Radiocarbon dates from Must Farm, given in Chapter 33, were calibrated using the IntCal20 curve (Reimer

et al. 2020), applied using the OxCal v4.3 computer program (<https://c14.arch.ox.ac.uk/oxcal/>; Bronk Ramsey 1995; 2001; 2009; 2017). Uncalibrated radiocarbon dates, where cited by chapter authors, are given as 'BP'. Dates derived from dendrochronology are given as 'BC' or 'AD'.

#### **Settlement terminology**

The names used in this publication for the various elements of the pile-dwelling settlement are given in Figure 0.02.



**Figure 0.02.** Schematic plan of Must Farm Late Bronze Age pile-dwelling settlement (Image: CAU)

The term ‘Must Farm pile-dwelling settlement’, sometimes abbreviated to ‘Must Farm’ or ‘pile-dwelling’, is used to refer to the collective elements of the pile-built settlement, rather than to a singular dwelling. Where ‘Must Farm’ is used without further qualification, the term is referring to the Late Bronze Age pile-dwelling settlement. It is important to bear in mind, however, that ‘Must Farm’ is a substantial investigative area within a working quarry. Other remarkable features from Must Farm – the prehistoric boats and fishing equipment from the paleochannel upstream of the pile-dwelling and the dryland palaeo-landscape – will be published elsewhere.

### **Approach to the volume**

This rich body of work is, for obvious reasons, not a text to be read from cover to cover. Rather, readers are invited to make their own narrative journeys – to explore the extraordinary insights into Late Bronze Age life provided by rare survivals such as textiles, carved wooden objects and wild food remains; to dive into the detail of specialist approaches not usually encountered in the context of development-led investigations (from diatoms to ceramic petrography and fire investigations); to follow up curiosities sparked by their reading of the interpretative account provided in Volume 1.

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## Chapter 33

### Chronology

**Ian Tyers, Peter Marshall, Christopher Bronk Ramsey,  
Elaine Dunbar, Irka Hajdas, Sanne W. L. Palstra,  
Paula Reimer & Lukas Wacker**

#### 33.01. Introduction

The overall objective of the scientific dating programme was to construct a robust chronology for the causeway, pile-dwelling settlement, and the infilling of the palaeochannel. Therefore, dendrochronological and radiocarbon analyses were applied to a range of materials from these three features. In particular it was hoped to determine the dates of construction and demise of the structures. For this reason, in contrast to many other chapters in this volume, this chapter includes evidence from before and after the pile-dwelling settlement.

#### 33.02. Dendrochronology

The dendrochronological analysis of assemblages of excavated timbers is a technique that utilizes the patterns of growth rings in trees to match together contemporaneous timbers. It has been applied successfully to a range of archaeological and sub-fossil assemblages from a wide variety of prehistoric and historic periods. Similar studies of timbers from archaeological sites, standing buildings, art-historical items and living tree assemblages have been undertaken throughout the temperate zones of the world using a wide variety of timber types. Long sequences of rings and contemporaneous datasets of similar tree types from nearby areas are the basic requirements for success (Baillie 1982; Schweingruber 1988), and all analytical work goes hand in hand with using those data sets to extend and strengthen the existing reference framework.

A different strand of information derives from dendrochronology's ability to identify very short-term changes within a structure, since as a dating tool it can achieve annual and sometimes seasonal resolution. This requires the extensive recovery of timbers retaining bark-edge, since this alone allows the identification

of events constrained to a single year, or season. We can illustrate the range and potential of this type of approach using examples from a number of different prehistoric features. A Late Iron Age linear structure excavated at Beccles in Suffolk (Gearey et al. 2011) included a series of oak posts all felled in the same calendar year, 75 BC. A completely different outcome was obtained from the post-alignments at Fiskerton, Lincolnshire (Field & Parker Pearson 2003), which were found to include groups with separate felling years, there were 15 identifiably separate single year events across the period 456–339 BC. For both these sites there may have been other undatable events, either because the material was incomplete to bark-edge, or was constructed from undatable timbers, for example at Fiskerton the very last dated phase of timbers retained no bark-edges, but its felling occurred between 321 BC and 291 BC, whilst the finds evidence suggests the alignment was still in use into the Roman period. The lack of bark-edge on dated timbers leads to a blurring of tree-ring dating results sufficiently that on occasion it is impossible to identify whether a long-used and open structure was subject to periodic repair campaigns, as identified at Fiskerton, or was subject to continuous smaller scale modification. This can be illustrated by the Flag Fen and Fengate post-alignment, just 2–3 km to the north of Must Farm. Here none of the 137 dated timbers from Fengate had surviving bark-edge and just four of the 88 dated timbers from Flag Fen had an identifiable bark surface, along with a further six possibly intact timbers (Neve 1999). The broader interpretations given to 95% of the dated timbers, because we have to allow for unknown missing amounts of outer rings, lead to results for this alignment that are hard to interpret with any confidence (Pryor 2001). They might indicate steady small scale repair activity over an extended period across the 13th century BC through to the 10th century BC,

or they might indicate there were larger campaigns of activity spread intermittently across this period.

There are several further types of outcomes possible when applying dendrochronological analysis to archaeological assemblages. First are outcomes where material can be cross-matched to yield useful relative dating information, either within or between sites, but for which there was insufficient local reference data to identify its date. This was, and remains, a problem for much of the prehistoric period. Here, the extension of the regional historic period tree-ring sequences into the prehistoric period inevitably involved a combination of new data and the gradual integration of older and hitherto undatable datasets into the sequence. Such a scenario can be illustrated by the Middle Bronze Age Tinney's Ground Track A (Coles & Orme 1978a) and the Meare Heath Track (Coles & Orme 1978b; Coles et al. 1988), which are on different alignments and 3 km apart on the Somerset Levels. In the first instance these were separate tree-ring groups sampled and analysed over a number of years, with both undated (Morgan 1978a; 1978b; 1980; 1982; 1988). Radiocarbon analyses identified their approximate period (Morgan 1979), and they were found to dendrochronologically cross-match (Morgan 1988), identifying that Tinney's Track timbers were felled several decades later than those used at Meare Heath. It took some further time before they were found to be datable by reference to data from a new excavation in Hampshire (Tyers 2013). To get from excavation to absolute dating for Tinney's and Meare Heath took from 1974 to 2013, and this was for oak material with significant numbers of rings (these sites had composite sequences of 226 and 191 years length respectively).

Further layers of complexity can be added where either all the material is short-lived, and/or where oak is not used, since oak timber forms the basis of the dendrochronological sequence from Britain and Ireland, and not all non-oak types cross-match to it. Short sequences are like partial fingerprints, difficult to match exclusively to a single dating location. There are differences of approach to short-lived and non-oak material in different parts of the world. The oceanic climate in Britain and the relatively complacent, deep rooted, oak trees have led to all material with fewer than 50 rings being treated with some suspicion for dating purposes, although examples of timbers with as short as 30-year sequences that cross-match with each other have been identified. (The Fiskerton assemblage is almost entirely made up from short-lived material, but that site rather fortuitously had some long-lived material within it as well.) By contrast much shorter-lived alpine trees were used extensively for the construction of chronology sequences for the lake villages in Switzerland and elsewhere, and such material is routinely

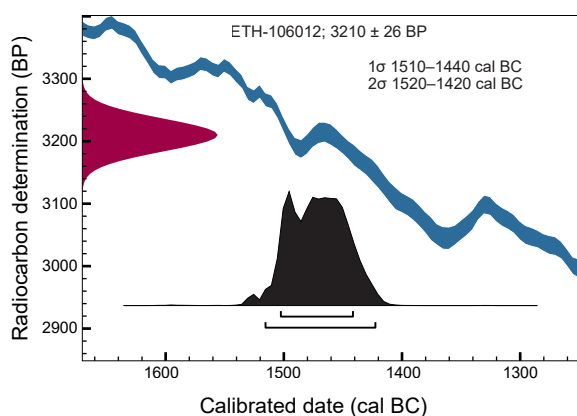
analysed and dated by dendrochronologists there. Such success may be due to the greater sensitivity of this material to the local climate, itself perhaps due to the greater tendency towards shallow roots in coniferous trees. Ruth Morgan's work on the brushwood non-oak structures on the Somerset Levels has previously demonstrated that useful information can be recovered by the analysis of non-oak types of roundwood, e.g. hazel, in Britain (Morgan 1989).

The Must Farm excavations revealed many hundreds of structural timbers from the causeway, the pile-dwelling structures and their palisade. These had a wide range of characteristics: the causeway included some larger oak timbers like those at Flag Fen, whilst the vast majority of the structural timbers that formed the pile-dwelling settlement's palisade and structures were small- to medium-sized roundwood stems of oak and ash. Very few long-lived timbers were used at the settlement and, by the time of the initial excavation exposures, it was clear that the potential for tree-ring analysis of the site was disappointingly low. What was quickly identified from the initial sampling programme was that the different groups of timbers might yield different examples of the outcomes described in the preceding paragraphs. The pile-dwelling settlement material was unfortunately extraordinarily short-lived, and its analysis would prove very challenging. It was abundantly clear that this material had extremely limited potential for absolute dating and, as the project developed, it subsequently became clear that the settlement was additionally unfortunate since it was found to date to somewhere within the poorest replicated period within the entire national reference tree-ring chronology. A comprehensive search was undertaken throughout the excavated materials for the most suitable samples amongst this group.

The recovery of intact bark-edges from much of pile-dwelling structural material has enabled dendrochronological analysis to provide a robust relative phasing of the construction of the palisade and internal structures. No absolute date was obtained by dendrochronology, but these same timbers have provided the sub-samples that have been used for the radiocarbon dating of the settlement.

### 33.03. Radiocarbon dating

Radiocarbon dating is based on the radioactive decay of carbon-14 and can be used to date organic materials, including wood, bone, and plant material. A small proportion of the carbon atoms in the atmosphere are of a radioactive form, carbon-14. Living plants and animals take up carbon from the environment, and therefore contain a constant proportion of carbon-14.



**Figure 33.01.** Probability distribution of a calibrated date (ETH-106012) from the causeway ‘in-the-round’ pile timber WD2944, heartwood ring 53 (Tyers et al. 2020). The radiocarbon measurement,  $3210 \pm 26$  BP (red distribution on the vertical axis) calibrates to 1520–1420 cal BC ( $2\sigma$ ) or 1510–1440 cal BC ( $1\sigma$ ) (in black on the horizontal axis). The blue band is the relevant part of the calibration curve (Image: Tyers et al.).

Once a plant or animal dies, however, its carbon-14 decays at a known rate. This makes it possible to calculate the date of formerly living material from the concentration of carbon-14 atoms remaining. Radiocarbon measurements and their associated errors are expressed in years BP. BP stands for ‘before present’, ‘present’ being conventionally fixed at AD 1950.

#### Radiocarbon calibration

Radiocarbon determinations are not the same as calendar ages, such as those derived from dendrochronology, because the concentration of carbon-14 in the atmosphere has fluctuated over time. Hence, due to the fluctuations in carbon-14 in the atmosphere, a radiocarbon measurement has to be calibrated against an independent scale to arrive at the corresponding calendar date (Figure 33.01). That independent scale is the IntCal20 calibration curve (Reimer et al. 2020), which for the Holocene (the last c. 11,700 years) is based on securely dated tree-ring data. Calibration has been applied here using the OxCal v4.3 computer program ([c14.arch.ox.ac.uk/oxcal/](http://c14.arch.ox.ac.uk/oxcal/); Bronk Ramsey 1995; 2001; 2009; 2017).

#### 33.04. The precision of dendrochronology and radiocarbon

While dendrochronology has the ability to determine the felling date(s) of a timber(s), and hence the calendar date of an event, to a single year, or even season,

a calibrated radiocarbon date from a single tree-ring, typically produces a calibrated date range which spans more than a century (Figure 33.01). Although the probability distribution (and range) of the calibrated radiocarbon date does estimate that point in time accurately to within the quoted uncertainty.

When we have a group of radiocarbon ages from samples that are in some way related, e.g. from a tree-ring sequence that could not be dated by dendrochronology, then more sophisticated statistical approaches are required. Bayesian statistics (McGrayne 2011) provide an explicit, probabilistic method for combining evidence such as that derived from dendrochronology to estimate the dates of past events and to quantifying the uncertainties of these estimates. The outputs from such a chronological model are known as posterior density estimates. These probability distributions can be summarized as ranges, which are known as Highest Posterior Density intervals and are expressed in italics to clearly distinguish them from date estimates that have not been produced by modelling.

Although chronological modelling of a series of radiocarbon dates can sometimes produce much more precise date estimates for events than the calibration of single radiocarbon determinations, e.g. a single human generation (c. 25 years), they are still an order of magnitude greater than that derived from dendrochronology.

#### 33.05. Chapter contents and further technical information

This chapter contains several separate sections concerning the application of dendrochronological analysis and radiocarbon analysis to separate groups of material from the causeway, and palaeochannel and to the linked application of both techniques to the pile-dwelling, and also to an earlier phase of the causeway.

A wide-ranging radiocarbon project on palaeochannel deposits provided an overall dating framework for the site (Section 33.08). Conventional tree-ring analysis was successfully applied to oak timbers from the later phases of the causeway producing absolute dates for some of these timbers (Section 33.06, *Dendrochronology of causeway timbers*). This sub-section is followed by the radiocarbon dating of an earlier phase of timbers, which had proved undatable by dendrochronology (Section 33.06, *Radiocarbon dating of causeway timbers* and *Radiocarbon wiggle-match dating of causeway timbers*). Further absolute dating was obtained from various oak artefacts and other non-structural timbers from within the channel deposits and disarticulated elements around the pile-dwelling (Sections 33.08 and 33.09). Remarkably precise relative

dating evidence was obtained from the analysis of structural timbers from the palisade and five of the internal structures, using an extensive range of both ash and oak timbers (Section 33.07). This provided a key insight into the construction of the pile-dwelling settlement. The sub-sampling and analysis of selected rings from this material for radiocarbon analysis has provided a scientifically robust date that can be applied to the construction of the pile-dwelling settlement.

Note: Dendrochronologists follow the classic BC scale that has the year 1 BC directly before AD 1, with no zero year. The radiocarbon cal BC scale is the same. For ease of calculations astronomers in particular use a scale with a year zero, events such as the lunar and solar eclipses catalogued for astronomical year -849 would have occurred in 850 BC of the classic calendars.

The technical archive report including methods, supporting tables and calculations for the components of this chapter are available in Tyers et al. (2020) and interested readers are referred there. This chapter does not repeat that text and instead provides a context for the challenges of working with the Must Farm material, illustrated with other British dendrochronological results for Late Bronze Age and Early Iron Age data sets.

### 33.06. Causeway

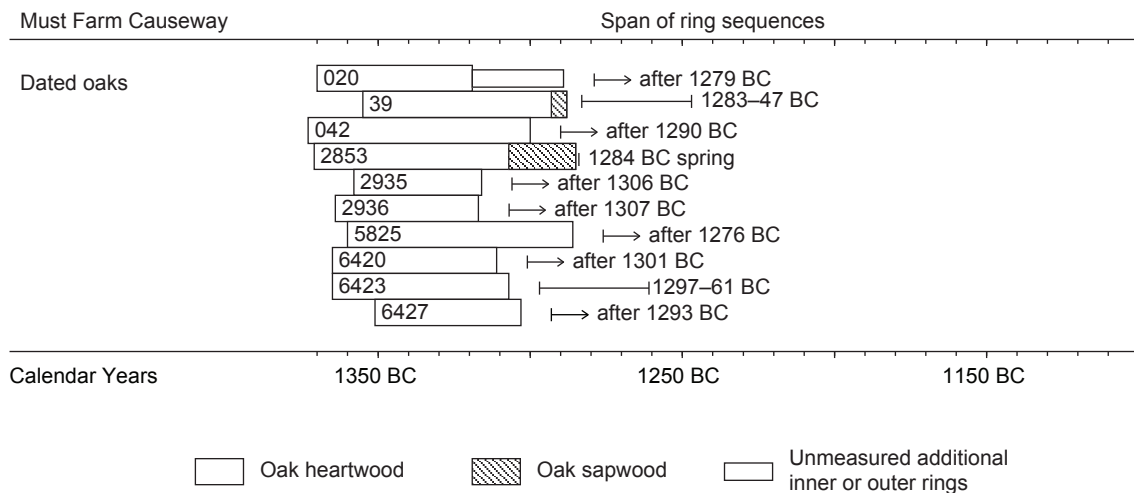
#### *Dendrochronology of causeway timbers*

The causeway comprised an assemblage of large oaks posts composed primarily of two distinct styles of pile: converted oak piles and massive ‘in the round’ oak piles with carved lugs (see Vol1 Ch2, *The Must Farm causeway*

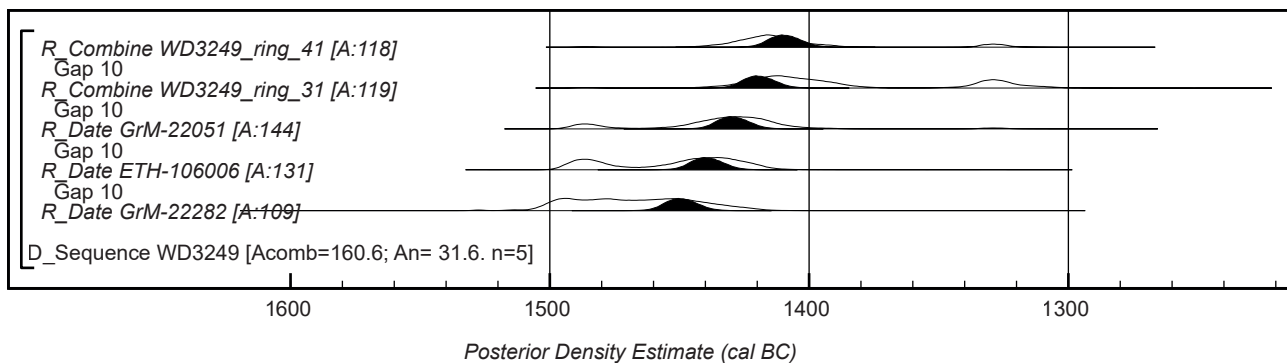
inset). 42 samples were selected for analysis from this assemblage. The selected samples comprised 41 oaks (*Quercus* spp.) and one ash (*Fraxinus* sp.) timber. These were found to contain between 35 and 174 annual rings. The selected assemblage was relatively short lived for dendrochronological analysis with a median of 56 rings. The unselected timbers had even fewer rings. The selected material included timbers with a wide range of cross-section sizes, from WD7122 which was 105 × 55 mm up to WD2933 which was 330 × 285 mm. The tree-ring width sequences from ten of these oak timbers were dated by reference to each other and to a small number of contemporaneous reference data sets, principally the Flag Fen/Fengate master sequence that spans 1363–937 BC (Neve 1999). The causeway dated timbers produced a composite sequence spanning 1373–1285 BC (Figure 33.02). Amongst these WD2853 retained bark and was felled in spring 1284 BC. WD6423 had the onset of sapwood at 1307 BC and its interpretation, felled between 1297–61 BC, is broadly compatible either with the felling date of WD2853, or with WD39, which also had sapwood and was potentially felled at the same time or slightly later, 1283–47 BC. The other seven datable sequences retained only oak heartwood, the latest of these, WD5825, ended at 1286 BC and thus likely dates from after 1276 BC.

#### *Radiocarbon dating of causeway timbers*

Following the failure of ring-width dendrochronology to provide absolute dating for any of the ‘in-the-round’ piles from the causeway two undated short-lived oak timbers from this group were sampled for radiocarbon dating and wiggle-matching (WD2944 (53 heartwood rings) and WD3249 (41 rings (?heartwood/sapwood



**Figure 33.02.** Bar diagram showing dated oak tree-ring sequences from the Must Farm causeway. Interpretations using a 10–46 year sapwood estimate (Image: Tyers et al.).



**Figure 33.03.** Probability distributions of dates from WD3249. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the wiggle-match sequence. The large square brackets down the left-hand side of the diagram along with the CQL2 keywords (Bronk Ramsey 2009) define the model exactly (Image: Tyers et al.).

boundary present)). In addition, samples were also submitted from the causeway's 7.8+ m long horizontal 'bridge' or deck timber that could not be dated by dendrochronology (WD6430 (53 heartwood rings)).

Seven radiocarbon measurements were obtained from five single annual tree-rings from each timber evenly spaced throughout their sequences. For each timber two of the rings sampled for radiocarbon dating were split and submitted to both Groningen and ETH Zürich.

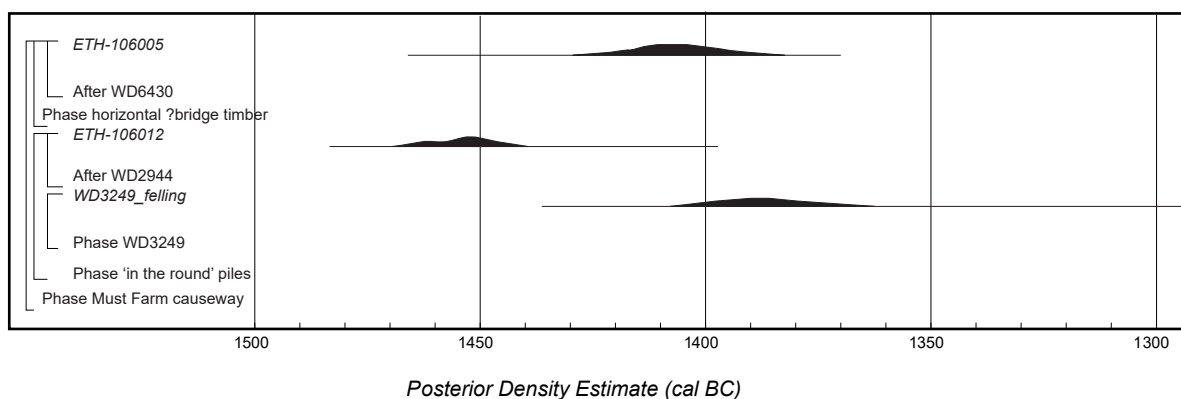
**Radiocarbon wiggle-matching of causeway timbers**

Wiggle-matching is the process of matching a series of calibrated radiocarbon dates which are separated by a known number of years to the shape of the radiocarbon calibration curve. At its simplest, this can be done visually, although statistical methods are usually employed. Undated tree-ring sequences are

particularly suited to this approach as the calendar age separation of tree-rings submitted for dating is known precisely by counting the rings in the timber.

Figure 33.03 illustrates the chronological model for one of the sequences (WD3249). This model incorporates the gaps between each dated annual ring known from tree-ring counting (e.g. that the carbon in Ring 1 of the measured tree-ring series (GrM-22282) was laid down ten years before the carbon in Ring 11 of the series (ETH-106006)), with the radiocarbon measurements (Tyers et al. 2020) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer et al. 2020).

As the ?heartwood/sapwood boundary was apparent on WD3249, a felling date range of 1410–1360 cal BC (95% probability; WD3249; Figure 33.04) could be estimated by the addition of a sapwood estimate (Bayliss & Tyers 2004). The other two timbers only



**Figure 33.04.** Posterior density estimates for the dates of the causeway 'in the round' piles and horizontal ?bridge timber (from the models defined in Tyers et al. 2020) (Image: Tyers et al.).

retained the oak heartwood and thus the estimates for the date of their final rings (WD2944: 1470–1420 cal BC (95% probability; ETH-106012; Figure 33.04) and WD6430: 1425–1395 cal BC (95% probability; ETH-106005; Figure 33.04)) only provide *termini post quos* (or dates after which) their felling occurred.

#### *Causeway chronology*

There is clear evidence therefore that the causeway is a multi-phase group of timbers. The radiocarbon wiggle-matching suggests that some of the material ('in-the-round' piles and the long horizontal timber) in the causeway dates from the late 15th or early 14th century cal BC whilst the dendrochronology indicates that the causeway was probably subject to several repair events (using converted piles) during the early half of the 13th century BC.

#### *Chronological relationship with the Flag Fen/Fengate complex, and the regional tree-ring sequence for the second millennium BC*

The Fengate/Flag Fen post-alignment is just 2–3 km away to the north/northwest of Must Farm. These sites were subject to an extensive tree-ring dating project (Neve 1999). Both Flag Fen/Fengate and the Must Farm causeway groups are notably lacking in sapwood which makes detailed comparison of the results difficult, but the radiocarbon evidence suggests that the construction of the Must Farm causeway was significantly before the main period of the datable timbers on the Flag Fen/Fengate post-alignment, and the dendrochronology suggests the repair phases of the causeway are in the period before the bulk of the dated dendrochronological material from Flag Fen/Fengate.

All the datable timbers from the Flag Fen platform site, at the eastern end of the alignment, potentially post-date the dated causeway timbers – the earliest heartwood end-date at Flag Fen is 1279 BC. There is a cluster of a dozen timbers from the Fengate site, at the western end of the post-alignment, that are broadly contemporaneous; their end-dates lying between 1311 BC and 1286 BC. This earliest Fengate material comprised split oak trunks of similar sizes and ages to the timber from the Must Farm causeway. The Must Farm causeway data slightly extends and strengthens the oldest end of the Flag Fen/Fengate tree-ring sequence. The Flag Fen/Fengate sequence extends across 1363–937 BC and is a composite of 225 timbers, only about 25 of those timbers give sequences that are in the section that overlaps with the causeway timbers. The Must Farm causeway provides ten further dated timbers for the period 1373–1285 BC. Causeway timbers WD39 and WD5825 give very high correlations with the Flag Fen/Fengate composite sequence (*t*-values

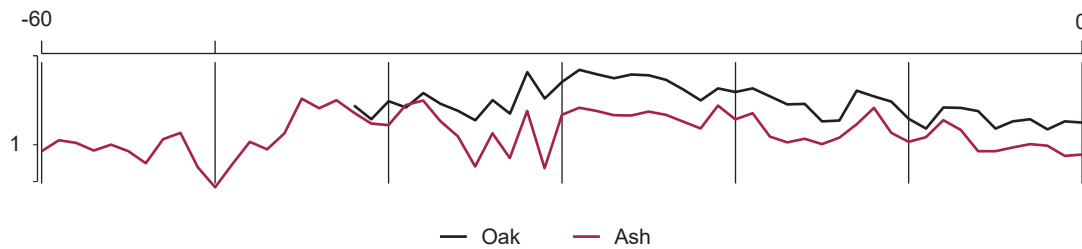
12.88 and 11.65 respectively). There is no suggestion these timbers are closely related since sites so close together should typically include strongly matching timbers where they are contemporaneous. These two groups of timber were perhaps collected from similar areas, or habitats, within the Flag Fen Basin. Other contemporaneous tree-ring datasets that some or all of this material match to a lesser extent are from Newington Quarry, Misson, Nottinghamshire (bog oaks dated 1853–883 BC, *c.* 110 km away (Tyers 2017)), Hasholme, Yorkshire (a bog oak dated 1687–1326 BC, *c.* 140 km away (Hillam 1987)), and Swalecliffe, Kent (a Bronze Age well which yielded an oak sequence dated 1432–1085 BC, *c.* 160 km away (Masefield et al. 2003)). These represent the entire current framework of contemporaneous tree-ring reference data for the second half of the second millennium for the eastern part of England. There are contemporaneous bog oak derived datasets from Lancashire *c.* 210 km distant and Northern Ireland *c.* 450 km distant and similar material from continental Europe, but these are each too distant to give statistically significant correlations to the causeway dataset.

The three radiocarbon dated timbers from the earlier phase of the causeway contained short tree-ring sequences, 41–53 rings each. There are currently no reference tree-ring datasets likely to overlap this material from any site within 100 km of Must Farm. We can safely predict that these distances are too great to expect to locate significant correlations to such short-lived material, though this aspect will be addressed further in the discussion relating to the dating of the pile-dwelling dataset.

#### **33.07. Pile-dwelling settlement**

##### *Dendrochronological relative dating of the pile-dwelling palisade and Structures 1–5*

The pile-dwelling structural assemblage comprised no long-lived material at all, instead it comprised mostly 20–60 year old ash trees (*Fraxinus* sp.) and 20–40 year old oaks (*Quercus* spp.), both used mostly either in the round, or as split halves (see Ch10, this volume; see also Vol1 Ch4). All 746 timbers from the pile-dwelling were reviewed for their potential usefulness for dendrochronological analysis by Iona Robinson Zeki and Michael Bamforth. The best material was sampled. These samples were then collected, prepared for analysis and re-assessed for potential. In total 89 of these timbers were then subjected to standard dendrochronological analysis, with the palisade contributing 45 ash and one oak, and Structures 1–5 contributing 30 oaks and five ash. The latter group can be subdivided into 17 samples from Structure 1, four each from Structures 2 and 3, five



**Figure 33.05.** *Pile-dwelling settlement composite tree-ring chronologies (Image: Tyers et al.).*

from Structure 4, and six from Structure 5. The final component of this assemblage were a group of four oak samples from the pile-dwelling not attributed to specific structures. This was an exceptionally uniform group of samples (with the reconstructed median diameters for different structural elements typically falling within 100–150 mm; see also Ch10, this volume, Tables 10.11, 10.17, 10.21, 10.26, 10.31 and 10.36). The analysis generally utilized single radii, recorded from single slices per timber, but included some sequences analysed from more than one slice of the same timber, and some sequences recorded along more than one radius of the same slice. The process of reviewing all the timbers on site, and sampling even the borderline material was intended to identify, and then analyse, all the most suitable material that was present within the Must Farm pile-dwelling excavation.

Almost all of the sampled material was intact from pith to bark-edge, some timbers had been crushed, some were charred, but most were intact. Almost all retained clear evidence for their final year of growth and their bark-edge. These timbers could therefore potentially identify the year, or years, that they were cut down.

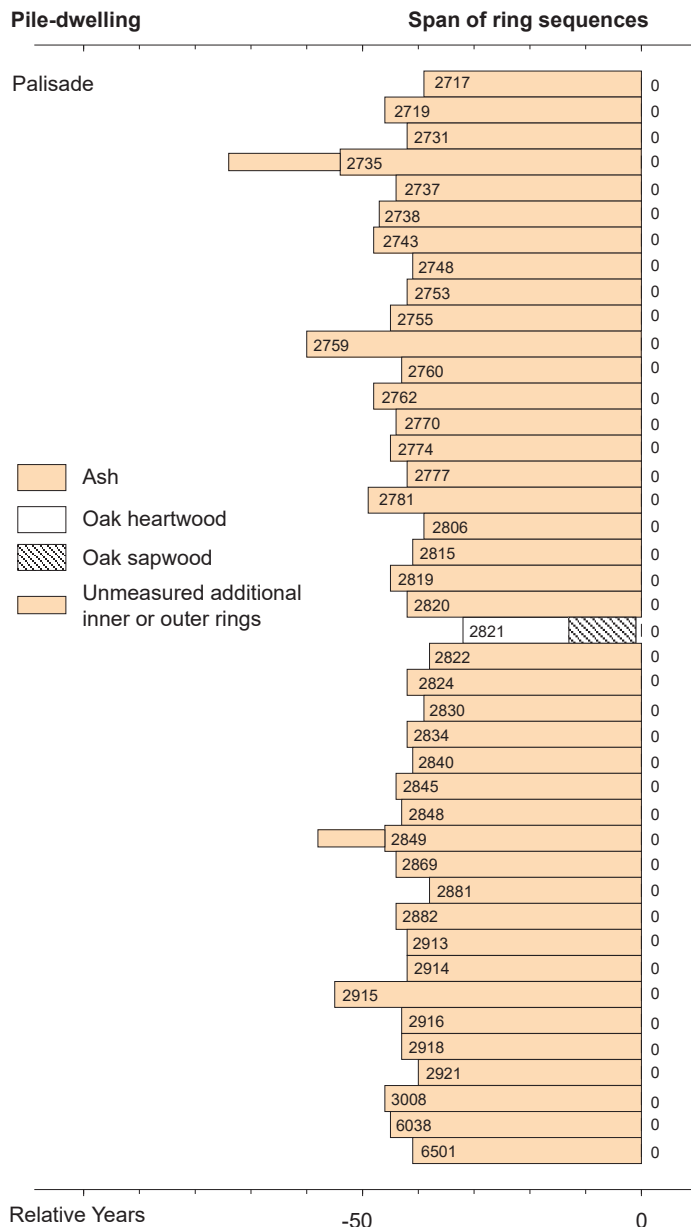
Using a combination of standard cross-matching algorithms and visual comparisons it was possible to dendrochronologically cross-match 27 oak timbers to form a 43-year oak site chronology and to separately cross-match 46 ash timbers to form a 61-year ash site chronology. These two series cross-match with each other,  $t$ -value 6.16 (Figure 33.05). This dendrochronological analysis indicates all 73 of these timbers were felled in the precisely same year (Figures 33.06 and 33.07). The remaining analysed samples from the pile-dwelling contain sequences that cannot be matched. Most of these are visually similar material, but some were incomplete to bark-edge and several were crushed or otherwise distorted. There is no reason to suggest that these represent separate felling events, though undated oak WD5309, attributed to Structure 2, contained 139 rings and is clearly completely different.

Identifying that the final ring present in most of these timbers is precisely co-eval has allowed the

relative dating analysis of this large assemblage of timber to provide strong evidence for a single site-wide year of construction. The palisade and Structures 1–5 as well as the non-structural material contained oak felled in this year, whilst the palisade and Structures 1, 3 and 4 also contained ash felled in this year.

Unfortunately, due to the lack of contemporaneous local tree-ring chronologies for this period, dendrochronological methods cannot presently identify the absolute dates for these two tree-ring sequences. We may never identify the identity of this year since these very short tree-ring sequences will undoubtedly require very local datasets to be successfully cross-matched.

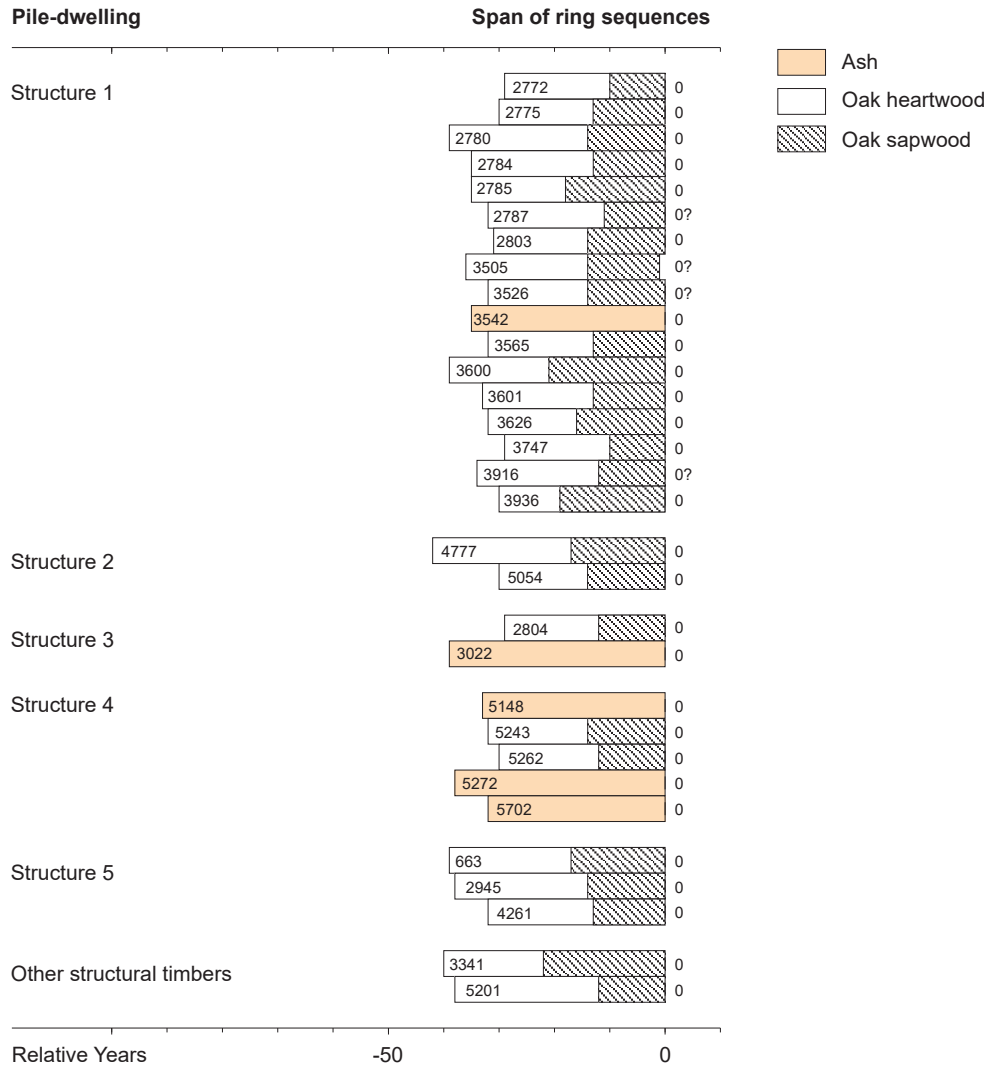
All of the oak and ash timbers from the pile-dwelling were assessed on site to identify the most suitable material for analysis. It was noted that there was a set of typical characteristics regarding the ring directly under the bark-edge, and what appeared to be a visibly common pattern for the last few rings. It was important to test as far as we could whether the shorter lived oaks and ashes, not selected for analysis, were contemporary with those that had been analysed in a more conventional sense. The correlation algorithm we use does not search using sub-30 year material, but we can visually compare these sequences, and statistically check the correlations at these locations. A group of ten sub-30 ring samples were selected to be recorded in order to test this possibility. These samples comprised two ash from the palisade, both with 19 rings, four oaks from Structure 1 with 27 and 28 rings, two ash from Structure 2 with 24 rings and 28 rings, a 28 ring oak from Structure 5, and a 28 ring oak from the pile-dwelling non-structural material. It was concluded that both the palisade ashes, three of the Structure 1 oaks, one of the Structure 2 ashes, and the non-structural oak appeared to be co-eval with the rest of the material (Figures 33.08 and 33.09). The remainder do not appear to be related to the others or anything else, again it is reasonable to assume they are simply further examples of undatable series contemporary with the rest. This is particularly the case given the limited usefulness of such short-lived sequences.



**Figure 33.06.** Bar diagram showing relatively dated oak and ash sequences from the pile-dwelling palisade. (Note the arbitrary horizontal scale of this and Figure 33.07 are the same, and deliberately use a zero-year to distinguish them from the absolute date diagrams. These sequences are much shorter than those in Figures 33.02 and 33.15.) (Image: Tyers et al.).

Figure 33.05 shows that the oak and ash terminal ring for relative year 0 is not significantly larger or smaller than the preceding five years. This suggests that this material was felled either close to the end of the growing season of year 0 or somewhere over the winter of years 0/1 but before the onset of spring growth in year 1 – this period covers approximately September–March inclusive. There were no obvious exceptions to this pattern amongst the entire assemblage of cross-matched material, nor as far as we are aware, was there any amongst the other settlement material assessed but not analysed from the site. The 41 matching palisade ash timbers can all be characterized

as containing a complete terminal ring for year 0, the single matched palisade oak was too slow-grown to be certain whether its last ring was complete or not. Timbers from Structures 1–5 have the additional complexity of some charred surfaces. 16 of the Structure 1 matched timbers were identified as having a final ring at the same year 0 as the palisade timbers, of these six had a charred edge, of which three were definite bark-edge and three have a charred edge that may or may not be bark-edge. The other ten matched timbers from Structure 1 were not charred, or at least were not charred where we sampled them. These all end at the same year, nine recorded with bark-edge and one

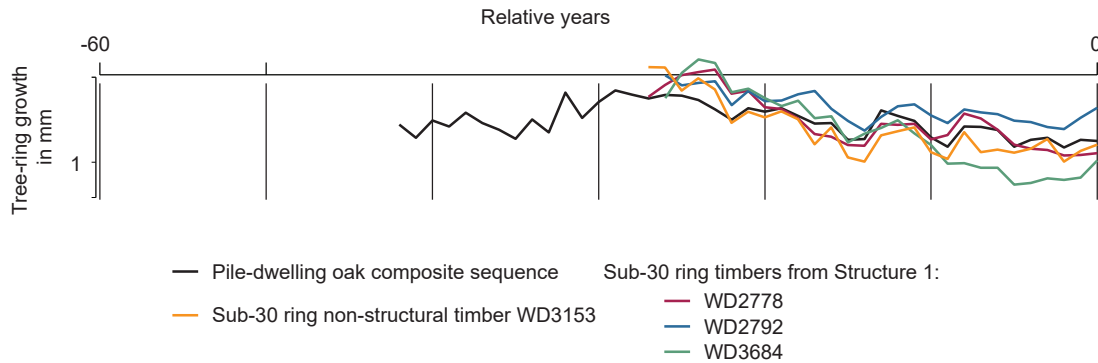


**Figure 33.07.** Bar diagram showing relatively dated oak and ash sequences from the pile-dwelling Structures 1–5 and other timbers. (Note the arbitrary horizontal scale of this and Figure 33.06 are the same, and deliberately use a zero-year to distinguish them from the absolute date diagrams. These sequences are much shorter than those illustrated in Figures 33.02 and 33.15. The heavy charring of several of the Structure 1 timbers has resulted in some potential loss of their outermost ring, these are given 0? Interpretations.) (Image: Tyers et al.).

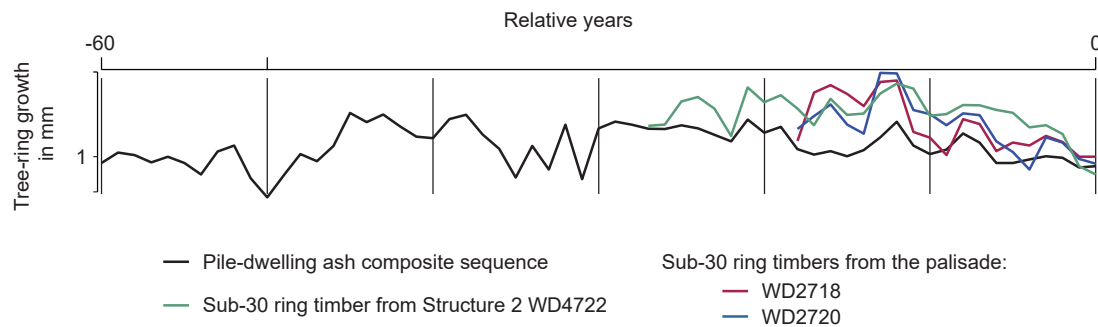
with a probable bark edge. Structures 2–5 similarly include a further 13 samples with a final ring for year 0, three of which were also charred, and another with a bark-edge for the same year but of indeterminate completeness. The two non-structural oaks also have the same complete ring for year 0, one of which was also charred.

There is no doubt from the dendrochronological analysis, therefore, that the excavated part of the settlement used a large group of oak and ash timbers felled in a single campaign, a felling campaign that either lasted just a few weeks somewhere between autumn and spring or perhaps lasted throughout the autumn,

winter and nearly through to the following spring. There are no parallels that we are aware of for such a large assemblage of contemporaneously felled timbers from any other excavation. Fiskerton (Field & Parker Pearson 2003) was a similarly well preserved and large assemblage which had a similar number of intact timbers with bark edges, these however comprised a series of discrete repairs to a structure spread across more than a century. A similar group of undated short-lived oaks was recovered from the excavation of a platform and causeway at Shinewater near Eastbourne (Hillam 2003), however, their relative tree-ring dating identified a widespread construction event followed by a repair



**Figure 33.08.** Visual comparison of four sub-30 ring oak series with the oak composite sequence from the pile-dwelling (Image: Tyers et al.).



**Figure 33.09.** Visual comparison of four sub-30 ring oak series with ash composite sequence from the pile-dwelling (Image: Tyers et al.).

phase a decade later. Chronological modelling of the available radiocarbon dates from Shinewater provides an estimate for the construction of the platform of 810–745 *cal BC* (95% probability; Tyers et al. 2020) probably 800–770 *cal BC* (68% probability), around half a century later than the Must Farm pile-dwelling.

The longest lived of the pile-dwelling timbers, that could be fully resolved, was an ash from the palisade with 61 rings, WD2759. This slice was sub-sampled into five-year blocks and these were used for the radiocarbon wiggle matching programme (*see below*). When combined with the other radiocarbon dates from the pile-dwelling this has provided an estimate for its construction date of 865–840 *cal BC* (95% probability). This dating indicates that the pile-dwelling tree-ring series most probably lie somewhere along the tree-ring sequence in the region between *c.* 915 *BC* at their older end and *c.* 845 *BC* at their younger end. The causeway discussion (above) illustrated that the chronological and geographical disposition of contemporaneous reference datasets is the key determinant for the likelihood of dating these sequences. Six oak timbers from Must Farm (Section 33.09, below), contain a composite sequence that runs from 1065–907 *BC*. The nearby Flag

Fen/Fengate sequence which used to end at 937 *BC*, now has two further oak timbers that cross-matched to Must Farm and other data such that it now runs through to 918 *BC*. Clearly neither Flag Fen/Fengate nor the Must Farm datasets can be expected to provide any significant overlap to either of the pile-dwelling oak and ash sequences. Virtually full overlaps to dated sequences will be required to date these series and the best either might achieve are overlaps of a decade or two to the ash sequence.

At greater distances from Must Farm, there are several more oak sequences that cover the same sort of period: Cambridge, St Clements Garden (1257–948 *BC*, *c.* 45 km away (Tyers 2016)), Caldicot, southern Wales (1131–998 *BC*, *c.* 205 km away (Hillam 1997)), Greylake, Somerset Levels (1108–952 *BC*, *c.* 245 km away (Hillam pers. comm.)) and Skinners Wood, Somerset Levels (1162–983 *BC*, *c.* 240 km away (Hillam 1993)). Each of these ends within the period 998–948 *BC*, just before the end of the Must Farm and Flag Fen/Fengate assemblages, and, just as with those sequences, they clearly cannot be expected to overlap with the pile-dwelling sequences. There are just three tree-ring series from the British Isles that give complete or almost complete

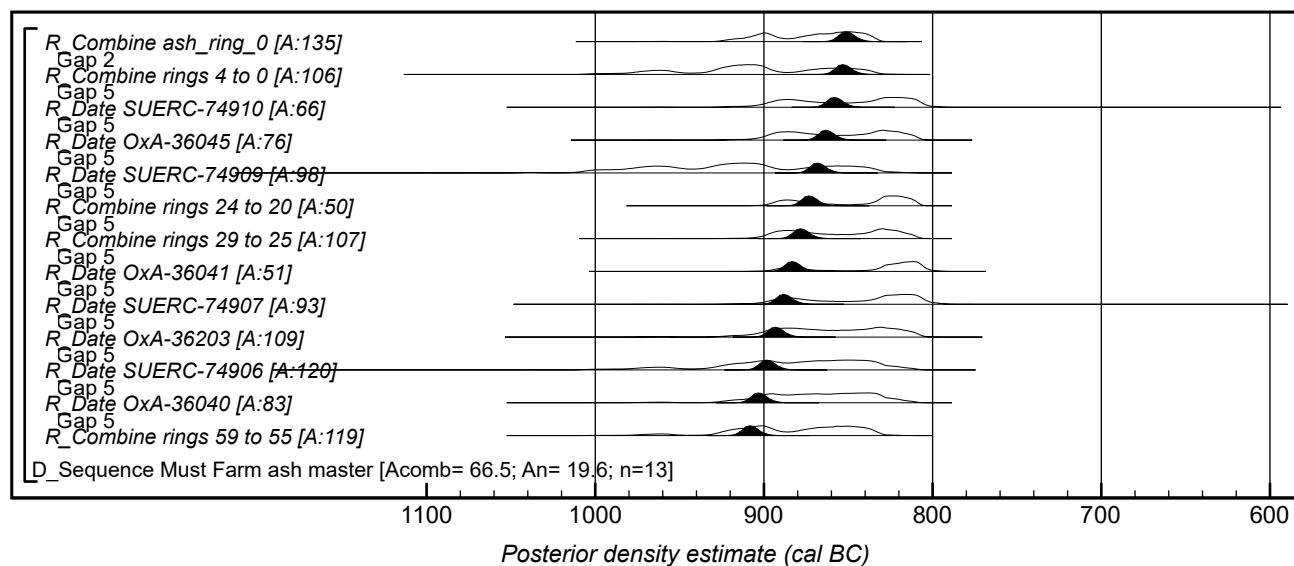
overlaps across the target period. One of these is the previously mentioned Newington Quarry material, from c. 110 km away, running to 835 BC, and a further English group is Swan Carr from County Durham, 1155–381 BC, c. 245 km away (Baillie & Brown pers. comm.). Swan Carr has approximately ten timbers and Newington has approximately five that cover some of our period of interest. Both these sites are almost certainly too distant to be any help with the pile-dwelling. The third site is Ballymacombs More, Northern Ireland, running from 947–633 BC, which as well as being even further away (c. 490 km), only includes one timber that covers the period of interest to us (Baillie & Brown pers. comm.). At the time of writing that is the entire British Isles data set for the first quarter of the first millennium BC, the weakest point in the 7000-year continuous tree-ring sequence. The Must Farm data has been run past all of this material, singly and in various combinations, and no statistically significant and replicated results have been noted. Various continental European datasets have also been examined with no evidence for the dating of these series.

Can this be resolved reliably? Perhaps not, these series are exceptionally short by normal British tree-ring standards, and it is not clear how nearby we would need to be to find matching data sets for these sequences. We could use short-lived modern oaks to model how close we might need contemporaneous data in order to get sufficiently high correlations to identify the date of the pile-dwelling sequences. That modelling process is not straightforward since the trees may have

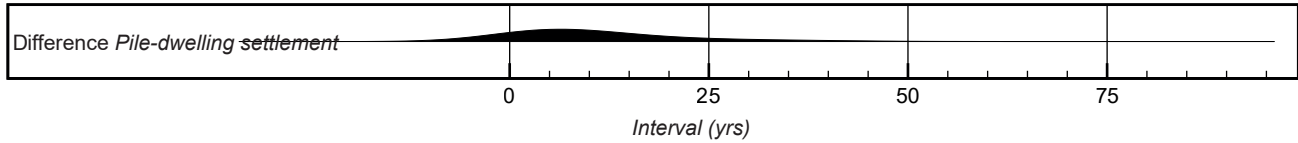
different sensitivities at different eras, and may need to be growing with a similar stand density and soil substrate. The answer is probably not very far at all. There was undoubtedly more timber that was growing at the time that was utilized somewhere, but both its subsequent preservation and subsequent excavation are needed in order to find it. We have exhausted the potential of the Must Farm pile-dwelling site, and the potential of nearby excavations, but timbers excavated in the future that lie within the Late Bronze Age–Early Iron Age period and come from an area up to c. 50 km from Must Farm could provide our answer. Datable tree-ring sequences of this period are evidently a very small resource. It has taken dendrochronologists 50 years to find just 15 contemporaneous and datable oak sequences, but these are from trees that grew on sites 100–500 km away. It is clear that any potentially similar material from nearby sites should be prioritized for analysis.

#### *Radiocarbon wiggle-matching of the relative dated tree-ring chronology*

Samples from two timbers that form part of the undated 61-year ash site chronology were submitted for radiocarbon dating and wiggle-matching: 12 contiguous blocks of five tree-rings from WD2759 and from the final ring (year 0) from WD2882. The wiggle-match incorporating the relative gaps between each dated sample provides an estimate for the formation of the final ring of the sequence, year 0, of 865–840 cal BC (95% probability; *ash\_ring\_0*; Figure 33.10).



**Figure 33.10.** Probability distributions of dates from the ash master sequence. The format is identical to that of Figure 33.03. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly (Image: Tyers et al.).



**Figure 33.11.** Probability distribution of the interval between the construction of the pile-dwelling settlement (ash\_ring\_0; Figure 33.10) and its estimated date of destruction (last\_pile\_dwelling\_settlement; Tyers et al. 2020) (Image: Tyers et al.).

#### Settlement duration: the radiocarbon evidence

The estimate for year 0, i.e. the date of construction of the pile-dwelling settlement, can be combined with a series of other radiocarbon dated samples from articulated lamb bones and burnt food remains on the interior of a ceramic vessel found within the structures to provide an indication, although it is likely to be an overestimate, for the length of time the settlement was in use before its destruction. The estimate of a couple of decades (median 10 years (Figure 33.11)) is extremely short for a chronology derived from radiocarbon dating and reinforces other lines of evidence that suggest the settlement was only in use for a very short period of time.

#### Curation of human remains

Recent research (Booth & Brück 2020, 15) has suggested that a high proportion of unburnt disarticulated human remains from British Bronze Age contexts were

probably already ‘old’ when they were deposited, providing the first clear evidence for the systematic curation of human bones in this period. The recovery of human skull fragments from two different individuals from the pile-dwelling settlement have allowed us to ascertain whether a similar practice was also taking place at Must Farm. The radiocarbon results do not provide a conclusive answer to how much older than the settlement the human remains are (Table 33.01; Figure 33.12), although they would not have been more than more than *c.* 100 years old when deposited.

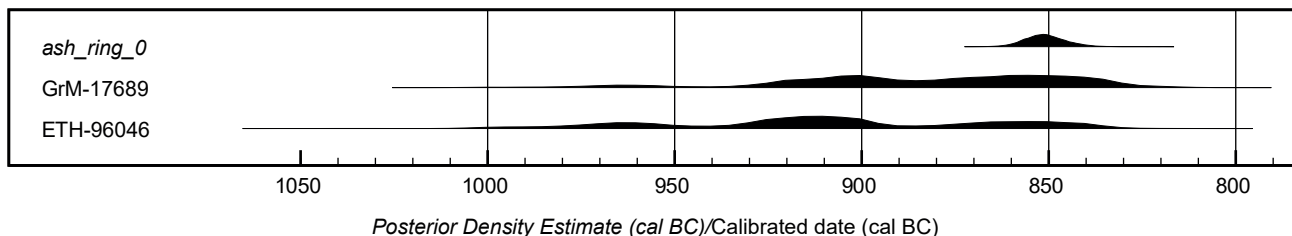
#### 33.08. Palaeochannel

In order to help understand the setting into which the causeway and pile-dwelling settlement were built an attempt was made to date the sequence of deposits found within the 2006 palaeochannel section (Ch1, this volume, Figure 1.17). Given the wealth of evidence

**Table 33.01.** Must Farm animal and human bone radiocarbon and stable isotope results. Replicate measurements of <4089> have been tested for statistical consistency and combined by taking a weighted mean before calibration as described by Ward and Wilson (1978;  $T'(5\%)=3.8$ ,  $\nu=1$ ).

Laboratory code	Sample identification, material and context	$\delta^{13}\text{C}_{\text{IRMS}}$ (‰)	$\delta^{15}\text{N}_{\text{IRMS}}$ (‰)	C:N	Radiocarbon age (BP)
ETH-96049	<4089> [3211]A Animal bone, sheep/goat, right mandible (V. Rajkovača) from a semi-articulated lamb skeleton <4089> within the footprint of collapsed Structure 1 [3211]	-23.5±0.1	10.7±0.1	3.6	2763±22
GrM-17691	<4089> [3211]B Replicate of ETH-96049	-23.3±0.15	10.7±0.3	3.4	2776±24
$^{14}\text{C}$ : 2747±17 BP, $T'=0.9$ ; $\delta^{13}\text{C}$ : -23.3±0.1‰, $T'=0.0$ ; $\delta^{15}\text{N}$ : 3.8±0.7‰, $T'=6.4$					
ETH-96048	SF4718 Animal bone, sheep/goat, right mandible (V. Rajkovača) <2818> SF4718 [3211] from part of a group of semi-articulated lamb skeletons (3–6 months) within the footprint of collapsed Structure 1 [3211]	-23.4±0.1	10.0±0.1	3.5	2787±22
GrM-17690	SF4118 Animal bone, sheep/goat, right mandible (V. Rajkovača) <2189> SF4118 [3231] part of a semi-articulated lamb skeleton (3–6 months) within the footprint of collapsed Structure 4 [3231]	-23.2±0.15	9.9±0.3	3.5	2776±24
GrM-17689	SF4504 Human skull fragment, left parietal (N. Dodwell), <2600> SF4504 [3208] from Midden 1.	-20.5±0.15	10.3±0.3	3.2	2750±25
ETH-96046	SF3167 Human skull fragment (no mandible and left temporal bone missing) (N. Dodwell), <1171> SF3167 [3207] from Midden 2	-20.5±0.1	10.7±0.1	3.5	2769±23

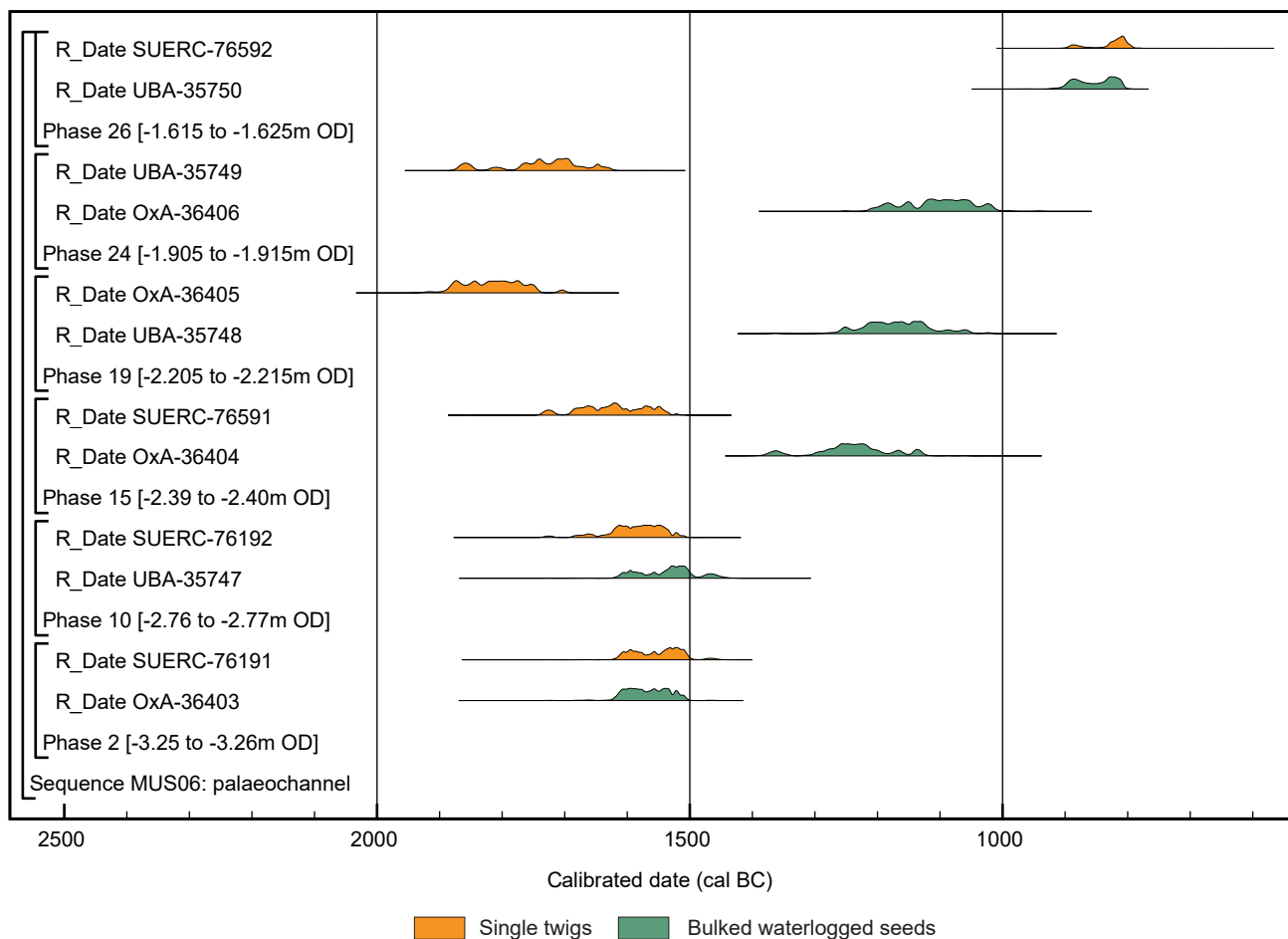
## Chronology



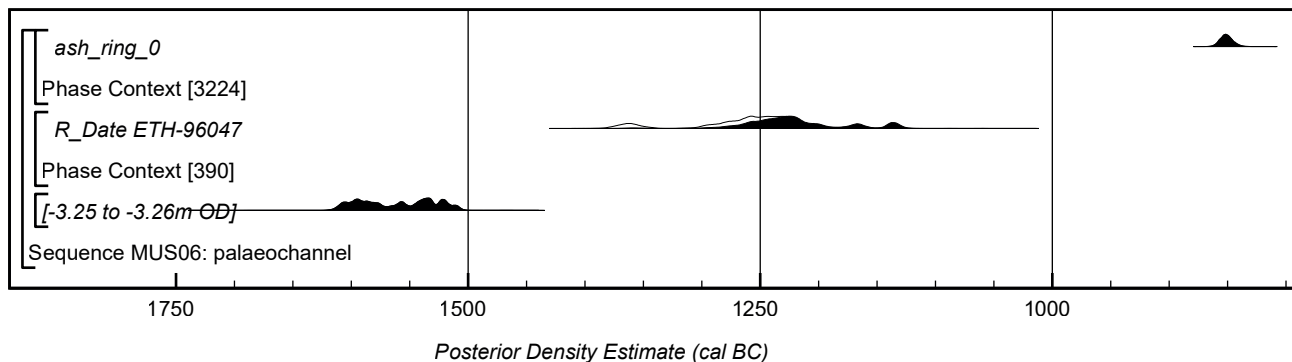
**Figure 33.12.** Probability distributions of the estimated date of construction of the pile-dwelling settlement (ash\_ring\_0; Figure 33.10) and dates of the two human skull fragments (these have been calibrated (Stuiver & Reimer 1993)) (Image: Tyers et al.).

for the local environment both within the channel and in its immediate vicinity understanding the chronology of the deposits it contained was a key aim of the radiocarbon dating programme. But understanding when different deposits formed within features such as the palaeochannel is far from straightforward. Although the palaeochannel contained a wealth of

organic material suitable for radiocarbon dating, evaluating its relationship to the formation of a deposit is problematic. An active freshwater channel, such as that at Must Farm, is by its very nature a dynamic environment with material continually being washed in, transported, deposited, eroded and redeposited. Thus, identifying suitable material for radiocarbon



**Figure 33.13.** Probability distributions of dates from the palaeochannel. (See Ch1, this volume, Figure 1.17 for sample locations. The distributions are the result of simple radiocarbon calibration (Stuiver & Reimer 1993) (Image: Tyers et al.).



**Figure 33.14.** Probability distributions of key dates for the infilling of the palaeochannel derived from the model defined in Tyers et al. 2020 (Image: Tyers et al.).

dating, that is close in age to when a deposit formed, requires a degree of trial and error.

Initially we obtained twelve radiocarbon determinations from six pairs of samples comprising waterlogged plant material and single twigs from six horizons (Table 33.02). Dating two different types of material allowed us to evaluate whether they could be of the same actual age or not. We had hypothesized based on work in similar environments (Chiverrell et al. 2009) that it was more likely that the fragile waterlogged plant material should be closer in age to the date when the deposit in which they were contained formed than the more robust twigs that could have been eroded from further upstream and redeposited (and hence be older than the deposit they were finally recovered from).

Three of the pairs of measurements are statistically consistent at the 5% significance level (Tyers et al. 2020) and thus the waterlogged plant material and twigs from these deposits could be of the same actual age, but for the other three pairs of measurements the twigs are considerably older (Figure 33.13). The fact that the twigs are in three cases many hundreds of years older than the waterlogged plant remains suggests that our original hypothesis, that due to their more robust nature they are more prone to being residual in the deposit they are recovered from, has some basis.

Given that AMS dates on plant macrofossils are inherently more reliable than those obtained from the sediment matrix, as the carbon sources of the former are known, and they are not composed of heterogeneous material that could be of different ages (Walker et al. 2001, 1007) no humic/humin radiocarbon determinations were obtained. The heterogeneous nature of the dated organic material in the sediments demonstrated by the AMS dating of paired plant macrofossils/twigs fully validates the approach we have employed.

Additional information on the chronology of the palaeochannel is also provided by a radiocarbon date

on the ‘disarticulated’ remains of a large dog found immediately below the shell-rich silt layer [367] (see Ch1, this volume, Table 1.02 for stratigraphic detail). Although the dog was not found in articulation the skeletal elements recovered (seven ribs, two mandibles, a tibia and femur) suggest it has not moved far from where it was originally buried. Finally, the estimated date for the construction of the pile-dwelling settlement (*ash\_year\_0*) can provide a constraint for the age of deposits above and below it.

Despite our best efforts we have only been able to reconstruct the chronology of the palaeochannel and its infilling in very broad terms using radiocarbon dating (Figure 33.14). The earliest dated sedimentary unit of the palaeochannel [378] was deposited in the late 17th–late 16th centuries cal BC, based on waterlogged plant macrofossils. The shell-rich silt layer [367] was deposited sometime after the 13th–12th centuries cal BC, based on the dog skeleton in [390] (ETH-96047). The proxy records obtained from environmental remains such as pollen, diatoms, and insects therefore do not have a precise chronological framework with which to reconstruct the changing conditions in the channel and in its immediate vicinity.

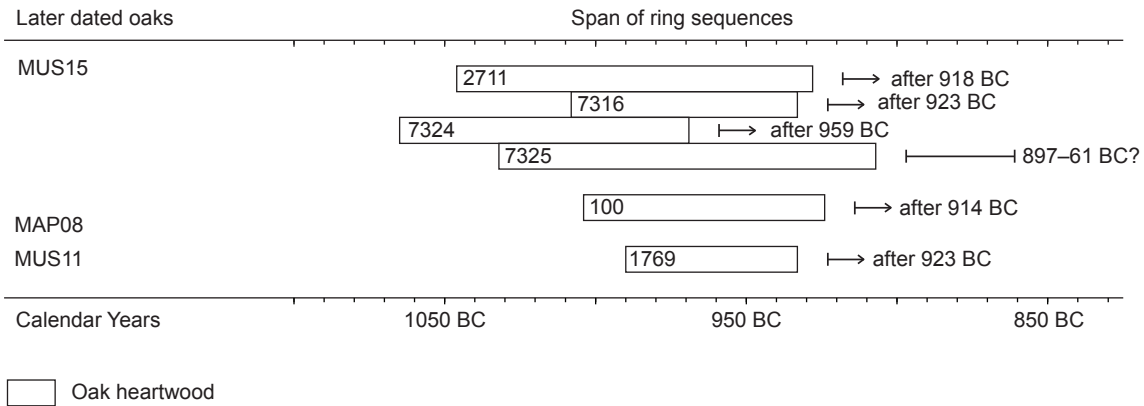
### 33.09. Dendrochronological dating of other timbers

As part of the process of searching through the timbers from Must Farm for datable sequences, a small group of timbers were identified where it seemed possible they might have useful dating potential, even though each was of limited direct interpretative value to the excavation project. Simultaneously, a number of timbers from nearby earlier excavations were assessed and, where appropriate, these were analysed. Twelve oak samples containing between 36 and 119 rings were analysed. Five of these timbers, derived from Must Farm, were dated by reference to

## Chronology

**Table 33.02.** *Must Farm 2006 palaeochannel section radiocarbon and stable isotope results.*

Laboratory code	Sample identification, material and context	$\delta^{13}\text{C}_{\text{IRMS}}$ (‰)	$\delta^{15}\text{N}_{\text{IRMS}}$ (‰)	C:N	Radiocarbon age (BP)
UBA-35750	26a [-1.615 to -1.625 m OD] Waterlogged plant remains, 2 <i>Ranunculus acris/bulbosus/repens</i> achene +4 <i>Rumex</i> sp. small achene + 1 <i>Alnus glutinosa</i> cone + 4 <i>Oenanthe aquatica</i> mericarp + 5 <i>Rumex maritimus</i> fruit + 13 <i>Schoenoplectus lacustris</i> nut + 1 <i>Rumex</i> sp. large achene + 2 <i>Carex</i> sp. trigonous nut, from context [356], 0.465–0.457 m down core; a silt with rare shell or wood fragments that formed in the palaeochannel long after the conflagration of the pile-dwelling settlement	-27.3±0.22	-	-	2698±30
SUERC-76592	26b [-1.615 to -1.625 m OD] Waterlogged unidentified twig fragment, from the same context as 26a	-28.0±0.2	-	-	2661±30
OxA-36406	24a [-1.905 to -1.915 m OD] 1 <i>Ranunculus acris/bulbosus/repens</i> achene + 4+1 frag <i>Rumex</i> sp. small achene + 2 frag <i>Alnus glutinosa</i> cone + 2 <i>Rubus</i> subgen. <i>Rubus</i> seed + 1 <i>Alnus glutinosa</i> seed + 5 <i>Oenanthe aquatica</i> mericarp + 2 <i>Chenopodium</i> sp. seed +1 <i>Sambucus</i> sp. seed + 1 <i>Rumex maritimus</i> fruit +30 <i>Schoenoplectus lacustris</i> nut + 2 <i>Rumex</i> sp. large fruit +6 <i>Carex</i> sp. trigonous nut + 5 <i>Rumex</i> sp. large achene, from context [357], 0.755–0.765 m down core; a shelly/woody silt that formed in the palaeochannel after the conflagration of the pile-dwelling settlement	-26.8±0.2	-	-	2911±28
UBA-35749	24b [-1.905 to -1.915 m OD] Waterlogged unidentified twig fragment, from the same context as 24b	-27.5±0.22	-	-	3430±30
UBA-35748	19a [-2.205 to -2.215 m OD] Waterlogged plant remains, 2 <i>Ranunculus acris/bulbosus/repens</i> achene +8 <i>Rumex</i> sp. small achene + 1 frag <i>Alnus glutinosa</i> cone + 1 <i>Oenanthe aquatica</i> mericarp+ 1 <i>Alnus glutinosa</i> seed + 1 <i>Oenanthe</i> sp. mericarp + 1 frag <i>Atriplex patula/prostrata</i> seed + 1 <i>Solanum dulcamara</i> seed + 2 <i>Persicaria</i> sp. achene + 29 <i>Schoenoplectus lacustris</i> nut + 2 <i>Rumex maritimus</i> fruit +2 <i>Carex</i> sp. trigonous nut +2+1 frag <i>Rumex</i> sp. large achene, from context [367c]; 1.055–1.065 m down core, a major shell-rich silt that formed in the palaeochannel prior to construction of the pile-dwelling settlement.	-26.5±0.22	-	-	2958±30
OxA-36405	19b [-2.205 to -2.215 m OD] Waterlogged unidentified twig fragment, from the same context as 19a	-28.2±0.2	-	-	3494±28
ETH-96047	<1349> [390] Animal bone, <i>Canis</i> , right rib (V. Rajkovača) from the 'disarticulated' remains (7 ribs, 2 mandibles, 1 tibia & 2 femurs) of a large dog found close together on the surface of river silt [368] and immediately below the shell-rich silt layer [367]	-20.3±0.1	7.6±0.1	3.5	3006±23
OxA-36404	15a [-2.39 to -2.4 m OD] Waterlogged plant remains, 1 <i>Ranunculus acris/bulbosus/repens</i> achene + 4 <i>Rumex</i> sp. small achene +1 small <i>Ranunculus</i> sp. achene + 1 <i>Rubus</i> subgen. <i>Rubus</i> seed + 1 frag <i>Alnus glutinosa</i> cone + 1 <i>Ilex aquifolium</i> seed + 1 <i>Alnus glutinosa</i> seed + 3 <i>Oenanthe</i> sp. mericarp + 1 <i>Chenopodium</i> sp. seed + 18 <i>Schoenoplectus lacustris</i> nut + 1 <i>Atriplex patula/prostrata</i> seed, from context [367a], 1.24–1.25 m down core; a major shell-rich silt that formed in the palaeochannel prior to construction of the pile-dwelling settlement	-26.4±0.2	-	-	3000±29
SUERC-76591	15b [-2.39 to -2.4 m OD] Waterlogged unidentified twig fragment, from the same context as 15a	-27.7±0.2	-	-	3349±30
UBA-35747	10a[-2.76 to -2.77 m OD] Waterlogged plant remains, 2+1 frag <i>Alnus glutinosa</i> cone + 3 <i>Oenanthe aquatica</i> mericarp + 5 <i>Rumex</i> sp. large fruit + <i>Sambucus</i> sp. seed + 1 <i>Rumex</i> sp. small achene + 7 <i>Schoenoplectus lacustris</i> nuts +1 <i>Rubus</i> subgen <i>Rubus</i> seed + <i>Carex</i> sp. trigonous nut, from context [380]; 1.61–1.62 m down core; a shell-rich silt lens within [381], a major deposit of freshwater silts laminated with thin bands of sand	-27.2±0.22	-	-	3267±34
SUERC-76192	10b[-2.76 to -2.77 m OD] Waterlogged unidentified twig fragment, from the same context as 10a	-27.0±0.2	-	-	3324±26
OxA-36403	2a[-3.25 to -3.26 m OD] Waterlogged plant remains, <i>Alnus glutinosa</i> 8x cones + 7x cone fragments, from context [378], 2.1–2.11 m down profile; a woody silt forming the first freshwater sediment in the palaeochannel underneath the pile-dwelling settlement	-26.2±0.2	-	-	3301±27
SUERC-76191	2b[-3.25 to -3.26 m OD] Waterlogged unidentified twig fragment, from the same context as 2a	-27.3±0.2	-	-	3282±29



**Figure 33.15.** Bar diagram showing other dated oak tree-ring sequences from the Must Farm area. Interpretations using 10–46 year sapwood estimate (Image: Tyers et al.).

Flag Fen/Fengate and other datasets (four from the pile-dwelling excavation (MUS15) and one from the Must Farm palaeochannel excavation (MUS11; Robinson et al. 2015)) (Figure 33.15). These series have heartwood end dates of 969 BC, 933 BC, 933 BC, 928 BC and 907 BC. The latest of those may have been intact to sapwood edge. WD1769 and WD2711 were derived from palaeochannel deposits outside the perimeter of the pile-dwelling. Their presence is difficult to interpret with any certainty, they perhaps suggest there is activity in the vicinity within the 900–850 BC period. WD7316, WD7324 and WD7325 were derived from the pile-dwelling settlement. None of these were charred and their precise relationship with the construction, occupation and conflagration of the pile-dwelling is unclear (see Ch10, this volume, Section 10.06, *Old wood*). Their recovery suggests we have successfully exploited the excavated assemblage for all its datable timbers. Together, these five timbers provided a composite tree-ring sequence spanning 1065–907 BC. This cross-matched to two hitherto undated timbers from Fengate and extended that sequence from 937–918 BC. A further oak heartwood timber from a pile-alignment at Horsey Hill (MAP08) (Gibson & Knight 2009) was found to date to 1004–924 BC (Figure 33.15).

### 33.10. Summary

There is a clear distinction between the larger, split oak timbers, usually made from heartwood with no, or incomplete, sapwood present, that have been excavated at a string of sites around the Flag Fen Basin and the perfectly preserved roundwood oak and ash timbers from the pile-dwelling. The former group includes many timbers that have proven suitable for dendrochronology and these have yielded absolute

dates throughout the 13th–10th centuries BC for several hundred timbers from Flag Fen and Fengate, a handful from Must Farm and one from Horsey Hill. These results are often difficult to compare and interpret because almost none of them retain sapwood and only a handful retain bark-edge. The pile-dwelling group by contrast can be shown to be precisely co-eval, with 73 examples of the same year of felling identified from an extensive programme of analysis across the excavation. Radiocarbon analysis indicates this is a mid-9th century BC assemblage, however, its precise dating has proved elusive.

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## Must Farm pile-dwelling settlement

The Late Bronze Age pile-dwelling settlement at Must Farm is one of the most important and best-preserved prehistoric sites to have been systematically excavated in Europe. The settlement comprised a curving palisade enclosing five stilt-raised houses erected above a freshwater river channel at the edge of one most Britain's most intensively studied and internationally renowned Bronze Age landscapes: the Flag Fen Basin.

Built in the mid-9th century BC, the pile-dwelling was engulfed by a catastrophic fire less than a year after construction, sending the buildings and their artefact-rich contents into the sluggish waters below. A combination of fire, water and rapid burial ensured extraordinary levels of preservation, whilst the manner of collapse and brevity of settlement gave the structural remains, and their vibrant material assemblages, a pristine quality. Each household had its own inventory comprising combinations of delicate textiles, wooden containers, hafts and wheels, complete pottery sets, bronze toolkits and the scattered remnants of necklaces of glass beads. Food remains included butchered wild and domestic animal bones, charred plants and seeds, and even the burnt residues of individual meals.

This comprehensive and methodologically innovative investigation, incorporating an array of scientific studies and collaborations amongst leading specialists, provides unprecedented insights into the nature of daily life and domestic practice in Bronze Age society. These challenge many expectations about the material worlds that people inhabited, shedding new light on aspects of architecture, material abundance, foodways, woodland management, landscape change and wetland living. The collective results are truly ground-breaking for Wetland Archaeology and wider Bronze Age studies. Volume 1 provides a thematic interpretive synthesis of the site, with a focus on landscape, architecture and occupation, whilst Volume 2 offers in-depth studies of the river setting, construction, dating, material culture and biological remains.

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