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Boxford, Newbury, Berkshire

Tree-ring Analysis, Radiocarbon Dating and Conservation of an Oak Timber

Gill Campbell, David Andrews, Roderick Bale, Judith Dobie, Derek Fawcett, Robert Howard, Angela Middleton, Nigel Nayling, Sarah Orr, Michael Dee, Cathy Tyers and Peter Marshall

Investigative Science

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Summary

A large piece of waterlogged carved wood uncovered during excavation of foundations for a residential garage in Boxford, West Berkshire has been radiocarbon dated to the mid-fifth millennium cal BC. It is the earliest known example of a carved timber from Britain.

Contributors

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Acknowledgements

We would like to thank Shahina Farid for managing the dendrochronological programme for Historic England.

Front cover image

Close up of the conserved timber showing details of the regular cut grooves, after conservation by Angela Middleton.

Archive location

West Berkshire Museum, The Wharf, Newbury, Berkshire, RG14 5AS

Historic Environment Record

Archaeology Team, Development and Regulation, West Berkshire Council, Market Street, Newbury, Berkshire, RG14 5LD

Date of research

The timber was discovered in late February 2019 with analysis and reporting completed in 2025.

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Introduction

In February 2019, one of the authors, Derek Fawcett, a local resident of Boxford contacted the West Berkshire council archaeology team to report that a large piece of timber had been uncovered during the excavation of foundations for a garage adjacent to water meadows of the River Lambourn (Fig. 1).

The waterlogged wood, maximum of 1.0m long, 0.42m wide and 0.2m deep, was found about 1.5m down in a layer of rich peat above a flint level. According to the building contractors the wood was found loose within the peat (i.e. not attached to anything else), but Derek had not been present when it was found. A few other small broken pieces of wood were also recovered from the foundations trench, but they did not seem to have been broken off from the large piece. The footings for the garage were filled with concrete shortly after the wood was retrieved and before it had been hosed down.

There were apparent signs of working or wear on several faces of the wood, notably about 10 notches about 25–30mm apart on one side (Fig. 2) and a deep groove with more widely spaced finer cuts on the other. At the request of the West Berkshire Senior Archaeologist, Sarah Orr, Historic England therefore agreed to examine the timber.

Figure 1: Maps to show the approximate location of the find (red dot). Top right: 1:300,000. Bottom: 1:3500.

Figure 2: Boxford timber. [© D Fawcett]

Wood identification

Following transportation of the timber to Fort Cumberland, Gill Campbell determined the wood was of deciduous oak (*Quercus* sp.), most likely one of our native species *Q. robur* or *Q. petraea*, and therefore possibly ancient. Given its size it was thought likely to be suitable for dendrochronological analysis.

The identification was carried out on a small fragment that had become detached from the main timber. Using a double-edged razor blade, the fragment was carefully squared off to produce smooth surfaces of the transverse section (TS), radial longitudinal section (RLS) and tangential longitudinal section (TLS); the three planes required for a wood identification. The material was mounted in water under cover-slips on glass slides, and examined under a high-power, light transmitting microscope (Leica DM2500). Identification was made using a combination of the texts and keys by Schweingruber (1982) and Gale and Cutler (2000) and the reference material from Historic England's Wood and Charcoal Reference Collection.

Dendrochronological assessment and analysis

Initial examination took place in May 2019 by Roderick Bale (DendroArch). The timber appeared to comprise the waterlogged remains of a tree at the point where two branches bifurcated from the main stem. The timber was assessed as in good condition with potentially sufficient rings to merit dendrochronological analysis although no sapwood or bark edge was identified. Prior to any destructive sampling for analysis the timber was fully recorded. To this end, it underwent preparatory surface cleaning by Angela Middleton prior to photography, laser scanning by David Andrews (https://sketchfab.com/3d-models/worked-timber-boxford-29a811f7a2d4402180750e74bbddd585) and illustration by Judith Dobie (Fig. 3) early in 2020.

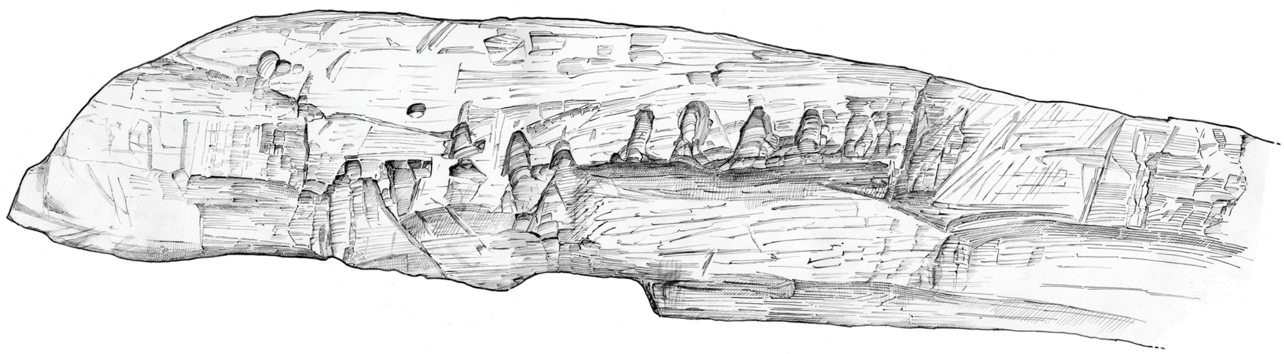

Figure 3: Illustration of the Boxford timber showing the regular cut grooves 1:10. [Judith Dobie]

In March 2021 sampling for dendrochronological analysis took place following a hiatus due to the pandemic. Attempts at recovering a core proved unsuccessful due to the very degraded/waterlogged outer part of the timber. Following discussions with Historic England staff, it was agreed to make a single saw cut to recover a slice sample for dendrochronological analysis. The sample was cleaned along two radii as the timber was double centred (Table 1). Both radii were then measured following standard procedures (English Heritage 1998). The ring-width series from the two radii matched with a *t*-value of 5.22 and a combined raw sequence of 184 years was calculated. Attempts at dating the individual ring-width series and the combined raw sequence against previously dated oak ring-width chronologies from the British Isles spanning the last 7000 years has proved unsuccessful.

Table 1: Details of the sample taken from the Boxford timber.

Sample	**Comment**	**Conversion**	**Dimensions (mm)**	**Total Rings**	**Sapwood**	**Average Ring Width (mm)**	**Date Range**
Boxford	Slice sample taken from end of parent timber	Whole	3740 x 170	185	-	0.94	Undated

The measured ring-width series exhibited repeated instances of narrow rings which, given the context of the timber's discovery in a peat layer could suggest repeated instances of waterlogging or impeded drainage during the parent tree's growth. This unusual growth may also have been why the timber was chosen for carving.

Such a ring-width pattern could be considered unlikely to date against ring-width series which are more closely correlated against climatic variables. It seems unlikely that ring-width dendrochronology will provide absolute dating of this timber.

Radiocarbon dating

To provide an indication of the age of the timber given the failure of the dendrochronological analysis, a programme of radiocarbon dating and wiggle-matching was undertaken.

Radiocarbon dating is based on the radioactive decay of ^{14}C, which trees absorb from the atmosphere during photosynthesis and store in their growth-rings. The radiocarbon from each year is stored in a separate annual ring. Once a ring has formed, no more ^{14}C is added to it, and so the proportion of ^{14}C versus other carbon isotopes reduces in the ring through time as the radiocarbon decays. Radiocarbon ages, like those in Table 2, measure the proportion of ^{14}C in a sample and are expressed in radiocarbon years BP (before present, 'present' being a constant, conventional date of AD 1950).

Table 2: Radiocarbon measurements and associated $\delta^{13}C$ values from the Boxford timber.

Laboratory Number	**Sample**	**Radiocarbon Age (BP)**	**$\delta^{13}C_{IRMS}$ (‰)**
GrM-30538	Box-F1, ring 1 (Quercus sp., heartwood)	5835±27	−24.6±0.6
GrM-30538	Box-F149, ring 149 (Quercus sp., heartwood)	5762±26	−24.0±0.3

Radiocarbon measurements have been obtained from two single annual tree-rings from the timber (Table 2). Dissection was undertaken by Robert Howard at the Nottingham Tree-Ring Dating Laboratory. Prior to sub-sampling, the tree ring-width data of the timber slice was obtained once again (Fig. 4; Appendix 2), with the ring-width series from Nottingham Tree-ring Dating Laboratory (NTRDL) and DendroArch (Fig. 5) for the two radii matching with a *t*-value of 22.93, resulting in a combined raw sequence of 185 years being calculated (Fig. 6).

The relative dates for the two radii from NTRDL and DendroArch are:

Radius 1

- BoxR01 (DendroArch, 152 heartwood rings) 32–183
- BOX-F01 (NTRDL, 153 heartwood rings) 33–185

Radius 2

- BoxR02 (DendroArch, 184 heartwood rings) 1–184
- BOX-F02 (NTDRL, 183 heartwood rings) 2–184

NTRDL then obtained each annual growth ring starting at ring 1 and going outward to ring 149 from BOX-F02 (radius 2, Fig. 4) from the rest of the timber slice using a chisel or scalpel blade. After that, on both radii, the rings were too narrow and wet to reliably cut up into single years. Each radiocarbon sample consisted of a complete annual growth ring, including both earlywood and latewood. Each annual ring was then weighed and placed in a labelled bag.

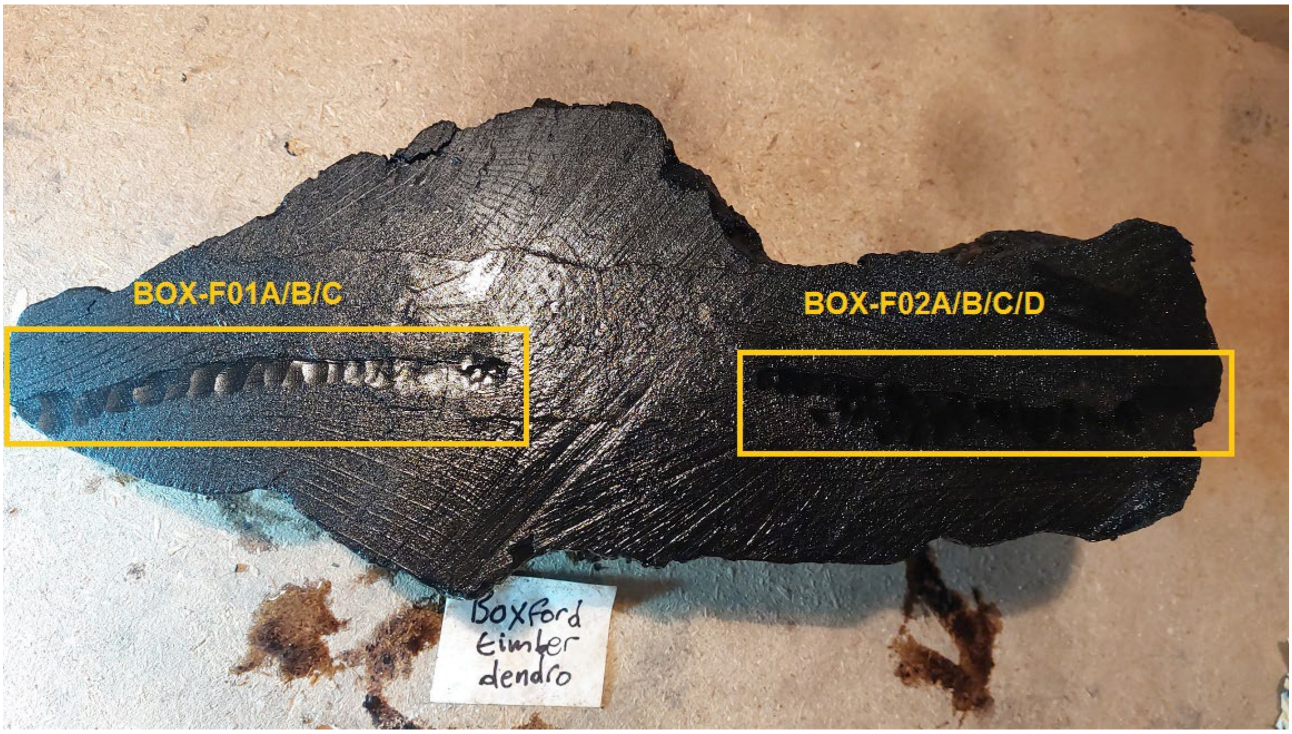

Figure 4: Boxford timber, slice taken for dendrochronological analysis showing the location of the two radii measured by NTRDL (BOX-F01 was measured three times and BOX-F02 four times). [© Robert Howard]

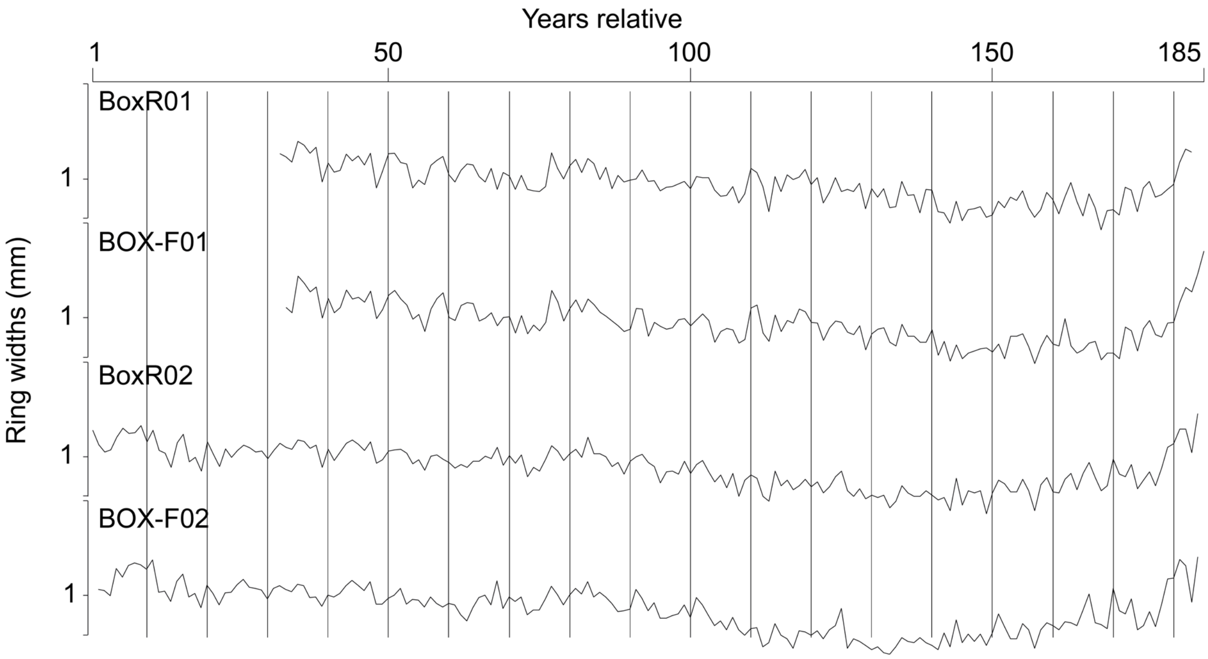

Figure 5: Plots of ring-widths (in mm on a logarithmic scale) of the two measured tree-ring series from the two radii (BoxR01 and BoxR02, DendroArch and BOX-F01 and BOX-F02, NTRDL).

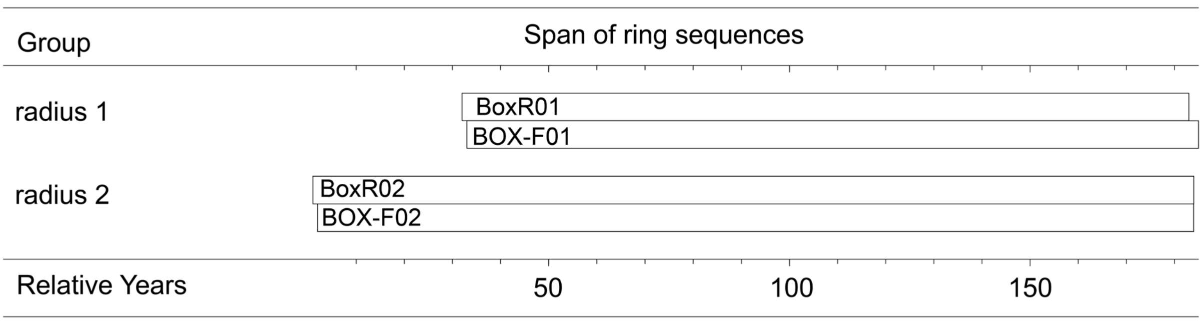

Figure 6: Bar diagram of the measured tree-ring series from the two radii (BoxR01 and BoxR02, DendroArch and BOX-F01 and BOX-F02, NTRDL).

Radiocarbon dating was undertaken by the Centre for Isotope Research, University of Groningen, the Netherlands in 2022. Each ring was pre-treated using an acid-base-acid protocol (Dee et al. 2020) and combusted in an elemental analyser (IsotopeCube NCS), coupled to an Isotope Ratio Mass Spectrometer (Isoprime 100). The resultant CO_2 was graphitised by hydrogen reduction in the presence of an iron catalyst (Wijma et al. 1996; Aerts-Bijma et al. 1997). The graphite was then pressed into aluminium cathodes and dated by AMS (Synal et al. 2007; Salehpour et al. 2016). Data reduction was undertaken as described by Wacker et al. (2010).

The Centre for Isotope Research maintains a continual programme of quality assurance procedures (Aerts-Bijma et al. 2021), in addition to participation in international inter-comparison exercises (Scott et al. 2017; Wacker et al. 2020). These tests demonstrate the reproducibility and accuracy of these measurements.

The results are conventional radiocarbon ages, corrected for fractionation using $\delta^{13}C$ values measured by Accelerator Mass Spectrometry (Stuiver and Polach 1977; Table 2). The quoted $\delta^{13}C$ values were measured by Isotope Ratio Mass Spectrometry and more accurately reflect the natural isotopic composition of the sampled wood.

Wiggle-matching

Radiocarbon ages are not the same as calendar dates because the concentration of ^{14}C in the atmosphere has fluctuated over time. A radiocarbon measurement has thus to be calibrated against an independent scale to arrive at the corresponding calendar date. That independent scale is the IntCal20 calibration curve (Reimer et al. 2020). For the period covered by this study, this is constructed from radiocarbon measurements on tree-ring samples dated absolutely by dendrochronology. The probability distributions of the calibrated radiocarbon dates from the Boxford timber, derived from the probability method (Stuiver and Reimer 1993), are shown in outline in Figure 7.

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. Floating 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. A review of the method is presented by Galimberti et al. (2004).

The approach to wiggle-matching adopted here employs Bayesian chronological modelling to combine the relative dating information provided by the tree-ring analysis with the calibrated radiocarbon dates (Christen and Litton 1995). It has been implemented using the program OxCal v4.4 (http://c14.arch.ox.ac.uk/oxcal.html; Bronk Ramsey et al. 2001; Bronk Ramsey 2009). The modelled dates are shown in black in Figure 7 and quoted in italics in the text. The Acomb statistic shows how closely the assemblage of calibrated radiocarbon dates as a whole agree with the relative dating provided by the tree-ring analysis that has been incorporated in the model; an acceptable threshold is reached when it is equal to or greater than An (a value based on the number of dates in the model). The A statistic shows how closely an individual calibrated radiocarbon date agrees its position in the sequence (most values in a model should be equal to or greater than 60).

Figure 7 illustrates the chronological model for the Boxford timber. 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-30538) was laid down 148 years before the carbon in ring 149 of the series (GrM-30539)) with the radiocarbon measurements (Table 2) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer et al. 2020).

The model has good overall agreement (Acomb: 114.2, An: 50, n: 2; Fig. 7), with both radiocarbon dates having good individual agreement (A > 60). It suggests that the final ring of the sequence formed in *4605–4500 cal BC* (*95% probability*; *Ring185*; Fig. 7), probably in *4585–4570 cal BC* (*10% probability*) or *4545–4505 cal BC* (*58% probability*).

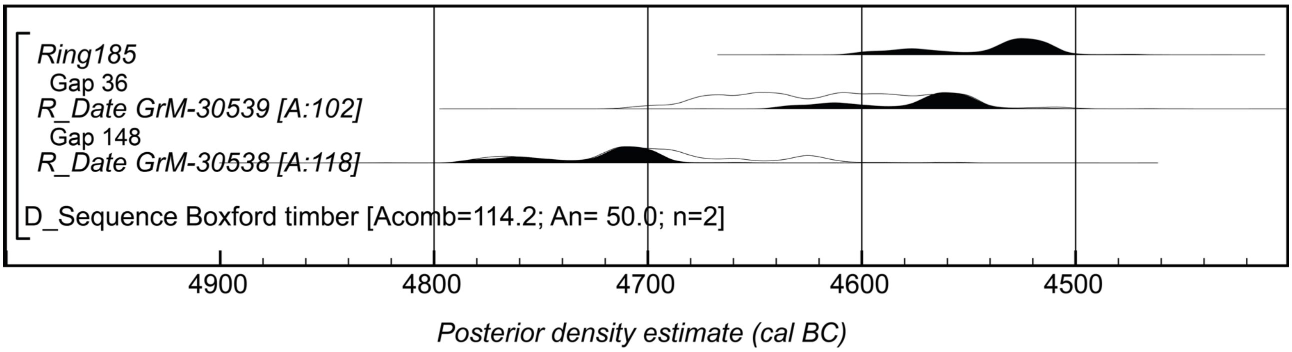

Figure 7: Probability distributions of dates from the Boxford timber. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the simple radiocarbon calibration, and a solid one, based on the wiggle-match sequence. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

As no sapwood survives on the Boxford timber, the estimated date obtained for the formation of its final ring provides a *terminus post quem* for its felling. However, even allowing for missing heartwood and sapwood rings on the timber it clearly was felled sometime in the mid-fifth millennium cal BC (late Mesolithic period).

Conservation

The Boxford timber was received wet (Figs 8–11), wrapped in polythene. Since its delivery to Fort Cumberland, Portsmouth it was stored wet, fully submerged in tap water. Surface cleaning was undertaken with sponges and brushes, using tap water.

Impregnation

The conservation of waterlogged wood usually follows the principle of impregnation followed by drying. If the size of the timber allows, impregnation is undertaken by full submersion and vacuum freeze-drying.

The Boxford timber was impregnated using polyethylene glycol (PEG) 2000, in three stages, where the concentration is increased in 10% increments to reach a final concentration of 30% (w/v). Each stage lasted two months. The total impregnation time was six months.

Vacuum freeze-drying

Following PEG impregnation, the timber was vacuum freeze-dried. This eliminated drying stress as the frozen water was removed by sublimation. The timber was first pre-frozen for one week, at −30°C. Freeze-drying commenced in a LyoDry Midi Freeze Dryer s/n F012. The chamber temperature was set to −30°C and the condenser temperature to −45°C. The drying cycle was interrupted regularly to weigh the timber. During this process the wood surface was regularly inspected for cracking. The endpoint was determined when weight loss plateaued or slowed down significantly.

During vacuum freeze-drying over 20 kg of water were removed from the Boxford timber and its final weight is just over 17 kg (Figs 12–16).

Curation and storage

Archaeological wood remains vulnerable to physical damage and care must be taken during handling, storage and possible display. Surfaces can easily be abraded, dented, or damaged. Special care should be taken to avoid touching or placing this timber on its carved surface.

As a hygroscopic material archaeological wood will react to fluctuations in the surrounding environment, especially relative humidity (RH), which is temperature dependent. Therefore, a stable environment should be aimed for, with RH around 40-60% and temperatures around 16–25°C (Bizot Group 2023). Daily fluctuations of +10 RH should be avoided, as should RH over 60% as this can lead to the development of mould. Unsuitable environments over prolonged periods of time can cause the development of cracks or surface spalling.

Figure 8: Boxford timber, side 1, before conservation.

Figure 9: Boxford timber, side 2, before conservation.

Figure 10: Boxford timber, side 3, before conservation.

Figure 11: Boxford timber, side 4, before conservation.

Figure 12: Boxford timber, side 1, after conservation.

Figure 13: Boxford timber, side 2, after conservation.

Figure 14: Boxford timber, side 3, after conservation.

Figure 15: Boxford timber, side 4, after conservation.

Figure 16: Detail of the regular cut grooves, after conservation.

Conclusion

The radiocarbon wiggle-matching of the timber from Boxford suggests that the final surviving tree ring formed in *4605–4500 cal BC* (*95% probability*; *Ring185*; Fig. 7), probably in *4585–4570 cal BC* (*10% probability*) or *4545–4505 cal BC* (*58% probability*). Even allowing for missing heartwood and sapwood rings, this dating in the mid-fifth millennium cal BC, means that it pre-dates the only other example know, found near Maerdy in Wales (https://www.archaeology.co.uk/articles/news/maerdys-mesolithic-masterpiece.htm; Museum -Wales -Collections-onlie-2015.9H) by between 250–500 years. This makes it the earliest known carved timber from Britain.

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Appendix 1: DendroArch tree-ring data

Measurements of individual tree ring widths, in 0.01mm units

BoxR01

152	144	132	186	175	153	169	95	130	112
115	151	135	146	126	153	86	113	152	153
131	128	86	98	91	125	136	145	107	95
115	128	126	104	95	119	84	111	105	84
106	84	82	81	88	154	119	100	124	138
111	140	129	99	121	85	106	95	98	100
116	96	97	82	87	88	92	96	85	104
102	102	83	75	76	88	67	78	119	111
88	58	104	81	107	99	103	117	91	102
67	80	102	81	84	81	93	61	85	74
85	62	63	96	76	77	57	84	83	58
57	48	69	50	60	61	63	53	55	69
62	74	70	82	62	53	60	80	71	56
74	94	69	54	78	62	43	59	60	55
87	83	58	86	96	74	77	84	91	131
164	156								

BoxR02

155	122	108	112	138	160	147	149	167	128
155	111	106	84	126	145	92	99	79	128
104	85	114	99	111	121	116	108	110	97
111	117	109	107	114	114	103	105	81	108
88	106	117	131	116	106	120	92	89	97
99	108	99	90	94	77	93	93	80	86
80	80	70	82	90	103	90	129	80	101
92	103	68	85	79	99	109	107	93	99
105	96	138	97	107	94	85	86	69	92
100	100	90	82	60	75	76	70	93	74
83	92	71	61	74	55	72	48	65	60
57	41	45	71	56	55	45	49	54	51
55	52	55	63	79	48	43	48	47	43
44	43	37	43	51	48	44	51	49	44
46	50	39	71	44	56	53	55	35	56
68	65	50	52	65	56	37	64	68	51
55	68	70	55	84	96	74	62	64	109
82	67	90	60	62	73	59	86	129	136
167	156	91	204						

Appendix 2: Nottingham Tree-ring Dating Laboratory tree-ring data

Measurements of individual tree ring widths, in 0.01mm units

BOX-F01A 153
118 108 198 168 150 170 93 142 108 117 153 133 144 121 161 97 109 144 170 134
114 93 101 86 124 140 142 102 96 130 128 133 91 103 108 89 99 100 81 111
63 83 82 100 157 123 96 119 135 121 130 115 114 107 91 93 81 81 123 115
62 89 87 87 80 98 98 87 95 109 99 75 79 92 67 63 72 126 131 84
54 108 75 108 89 120 101 96 96 70 90 99 87 78 76 84 65 75 93 90
62 72 95 62 76 73 51 90 49 79 42 61 53 59 59 64 62 57 54 64
71 79 82 64 37 67 75 62 65 82 64 50 65 54 75 50 48 59 57 81
81 63 83 100 74 72 95 94 128 178 148 225 328

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134 101 116 67 108 135 157 102 87 118 134 139 96 94 112 85 103 110 85 90
84 96 82 89 161 134 92 125 135 104 138 129 108 103 114 87 76 86 114 118
81 98 87 78 93 95 101 92 100 103 91 68 79 75 101 67 68 106 119 84
84 106 75 92 93 123 112 96 87 62 76 98 106 71 71 93 54 87 81 81
73 56 84 76 77 67 73 79 59 64 60 59 53 54 53 59 67 48 72 46
82 70 75 59 57 57 71 79 59 98 65 65 48 74 65 52 55 54 57 87
80 53 90 100 75 73 93 89 137 158 162 170 248

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84 89 79 90 158 136 99 109 137 107 145 133 110 101 82 85 85 82 114 115
81 93 89 85 82 100 100 85 97 109 100 60 82 85 78 70 71 123 123 68
66 101 90 89 96 107 120 89 94 76 89 90 87 90 82 89 60 70 76 84
68 63 92 84 70 62 78 77 54 62 46 73 48 56 62 59 54 67 71 45
70 73 76 65 48 64 81 56 67 117 60 54 65 70 65 50 65 56 41 92
84 60 79 89 81 76 89 96 127 162 153 230 334

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100 125 125 124 104 132 84 89 96 100 119 84 102 92 82 103 76 89 95 92
69 58 87 96 103 84 125 81 94 87 104 82 69 75 102 125 103 73 102 107
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80 107 110 120 132 110 105 121 96 104 116 110 110 118 114 96 107 83 100 99
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