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The Manor House
The Green
Frampton-on-Severn
Gloucestershire

Tree-Ring Analysis of Oak and Elm Timbers

Martin Bridge and Cathy Tyers

Discovery, Innovation and Science in the Historic Environment

Research Report Series no. 109-2019

Front Cover: The Manor House, The Green, Frampton-on-Severn, Gloucestershire. Photo: Martin Bridge

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SUMMARY
Two oak samples from the north range (flat) of the Manor House, Frampton-on-Severn dated, one retaining complete sapwood being found to be from a tree felled in spring AD 1547. This is nearly twenty years before the construction date of the large barn on the site, and provides an indication of the chronological development of the farm complex. None of the elm samples from either the north range or the main east-west and north-south roofs of the Manor House produced any dates.

CONTRIBUTORS
Martin Bridge and Cathy Tyers

ACKNOWLEDGEMENTS
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ARCHIVE LOCATION
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2018–20

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INTRODUCTION

The investigation of the elm timbers in the Manor House contributes to an on-going research programme, *Developing the dendrochronology of elm in historic buildings*, funded by Historic England through its Heritage Protection Commissions programme, and led by Martin Bridge from the UCL Institute of Archaeology.

Developing the dendrochronology of elm in historic buildings

Ring-width dendrochronology of oak timbers from historic buildings in England is well established, with dating having been obtained on more than 3000 buildings (or parts thereof), with nearly one third of these having been funded by Historic England (and its predecessors). Dendrochronological evidence is a valuable component underpinning the discovery and identification of assets in the historic environment, aiding decisions relating to protection, management, and conservation, and enhancing appreciation and enjoyment of these buildings.

During this work on oak timbers, a significant amount of historic fabric constructed from timbers other than oak, most notably elm, has been identified, but this has previously been rejected as unsuitable for dendrochronological investigation. Elm in buildings has been identified in counties from Cornwall to Kent and up into the Midlands and beyond, but formal records of the presence of elm are scant as such buildings were generally dismissed for dating purposes and thus the presence of elm in the published record is rare. The inability to date historic buildings (or sections of buildings) constructed of elm by ring-width dendrochronology is seen as problematic in some areas of the country which have a comparatively high proportion of such buildings; buildings which nevertheless form a significant part of the historic environment but could not be afforded the same level of understanding in comparison to their oak counterparts.

Prior to the start of this project, only four instances of dating elm by ring-width dendrochronology have been successful (Groves and Hillam 1997; Haddon-Reece *et al* 1989, 1990; Bridge and Miles 2015). Each of these studies involved matching elm with oak from the same site, although the Ashdon, Essex example matched oak chronologies over a wide area (Bridge and Miles 2015). This project aimed to establish whether the use of standard ring-width dendrochronology could be extended to the dating of historic buildings in England where elm (*Ulmus* sp.) is the sole, or predominant species used rather than oak (*Quercus* sp.). A systematic approach was adopted concentrating on elm in the geographical areas where it is most commonly found. Buildings were thus sought that contained a significant number of elm timbers with sufficient numbers of rings that might be matched against either oak timbers in the same building or oak chronologies from the surrounding area (Fig 1).

An article will summarise the overall outcomes of the project (Bridge and Tyers forthcoming). However, each building sampled for dendrochronology has an associated building survey report or similar publication, whilst the primary archive of the dendrochronological analysis is reported in the Historic England Research Report Series.

The Manor

The Grade I listed (List Entry Number 1154192) house is one of several buildings dendrochronologically investigated in Frampton-on-Severn as part the *Developing the dendrochronology of elm in historic buildings* project. It forms part of a house and farm complex to the west of the large area of common land at the centre of the village (Fig 2). The 'Wool Barn' to the north was the subject of a separate investigation (Bridge and Tyers 2019), and had oak timbers dating the likely construction to AD 1564, or within a year or two thereafter. Like the barn, the framework of the walls, exposed to the elements, was of oak (*Quercus* spp.), whereas the protected timbers, not exposed to the elements, in the roof were of contemporaneous elm (*Ulmus* spp.), which it was hoped might match the oak. Elm was very common in this part of Gloucestershire in historical times, the estate owner recalling that over 1300 elms were lost in the late twentieth-century when Dutch Elm Disease struck. It is often said that elm performs well in dry conditions, or continuously wet conditions, but does less well in areas where it is exposed to frequent wetting-drying cycles (eg Richens 1983; Rackham 2003).

The building has a range to the west which projects towards the barn, and is at present treated as a separate flat, although there is communication between the flat and the rest of the house. The south-east corner is thought to be the oldest part of the house and may be of fifteenth-century origin, with the main part of the house being early sixteenth-century, and the wing projecting north (the flat) being late sixteenth, or early seventeenth century. The roof to the main range has two tiers of butt purlins (8" x 6") and cranked collars (8" x 4") and large principal rafters (13" x 5.5"). Assembly marks are short (1/2 inch) chiselled Roman numerals. A sketch of the areas looked at, with the positions of the samples taken, is shown in Figure 3, with the general form of trusses being shown in Figures 4 and 5.

METHODOLOGY

Fieldwork was carried out in March 2018, following an initial assessment of the potential for elm dendrochronology some weeks beforehand. In the initial assessment, based on the general criteria used for oak timbers, accessible elm timbers with more than 50 rings and where possible traces of sapwood were sought, although slightly shorter sequences may be sampled if little other material is available. Those timbers judged to be potentially useful were cored using a 16mm auger attached to an electric drill. The cores were labelled, and stored for subsequent analysis. A small number of oak timbers were also sampled.

The cores were polished on a belt sander using 80–400 grit abrasive paper to allow the ring boundaries to be clearly distinguished. The samples had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). Cross-matching was attempted by a combination of visual matching and a process of qualified statistical comparison by computer. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted on the computer monitor to allow visual comparisons to be made between sequences.

This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one oak sample or site master against other samples or chronologies, *t*-values over 3.5 are considered significant, although in reality it is common to find demonstrably spurious *t*-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some *t*-value ranges of 5, 6, and higher, and for these to be well replicated from different, independent chronologies with both local and regional chronologies well represented, except where imported timbers are identified. Where two individual oak samples match together with a *t*-value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have originated from the same parent tree. Same-tree matches can also be identified through the external characteristics of the timber itself, such as knots and shake patterns. Lower *t*-values however do not preclude same tree derivation. Threshold values for elm samples are as yet unknown, but are likely to be of similar value.

Ascribing felling dates and date ranges

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. Depending on the completeness of the final ring, ie if it has only the spring vessels or early wood formed, or the latewood or summer growth, a precise felling date and season can be given. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date range can be given for each sample. In oak, the number of sapwood rings can be estimated by using an empirically derived sapwood estimate with a given confidence limit. If no sapwood or heartwood/sapwood boundary survives then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* (*tpq*) or felled-after date.

A review of the geographical distribution of dated sapwood data from historic oak timbers has shown that a sapwood estimate relevant to the region of origin should be used in interpretation, which in this area is 9–41 rings (Miles 1997). The equivalent values for elm are as yet unknown, but the results of this project suggest that the range of the number of sapwood rings in elm timbers is likely to be much lower. One problem that has been encountered in considering elm is that it has often proved very difficult to determine the position of the heartwood/sapwood boundary, even when it is known that the complete sapwood is present on a timber. It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure or object under study.

RESULTS AND DISCUSSION

With an established oak chronology, fswb-t10 (AD 1354–1563), being available (Litton *et al* 1999; Bridge and Tyers 2019) for the broadly contemporary 'Wool Barn' on the same site, a limited number of oak timbers were sampled in the Manor House to attempt to refine the felling date of timbers used in construction. Details of the samples are given in Table 1. The ring width measurements for each measured sample are given in the Appendix.

Two oak samples from the north range (flat) were dated independently (Tables 2 – 3; Fig 6) as they did not match each other sufficiently strongly statistically (fsft01 and fsft05, t = 3.1 with 60 years overlap) to be considered a reliable cross-match. Their similarity in growth can be judged visually in Figure 7. However the independent dating supported the cross-match and when combined at the dates derived independently the new sequence, fsft51m, gave stronger matches (Table 4). One (fsft05) retained complete sapwood, and was from a tree felled in spring AD 1547, the other having a likely felling date range that encompasses this date (Table 1; Fig 6).

The felling date is interesting as it dates the late development of the Manor House to two decades before the construction of the barn, giving a clearer idea of the development of the complex, although this is based on only two dated samples. The construction of the 'Wool Barn' having been dated to AD 1564 with additional oak samples (Bridge and Tyers 2019). It should also be noted that the two dated oak samples from the Manor House do not produce significant cross-matches with either the oak chronology, fswb-t10, from the 'Wool Barn' or the individually dated sample from the 'Wool Barn', fswb14.

Cross-matching among the elm samples was hampered by the number of short sequences. Statistically, fsmn04 and fsmn10 had a significant match (t = 4.1 with 49 years overlap), but this match was dismissed when comparing the plots for the two series. Samples fsmn03 and fsmn09 also matched statistically (t = 5.4 with 70 years overlap), and being more acceptable visually, (Fig 8) these were combined into a single sequence, fsmn93m, but none of the samples gave consistent acceptable matches against the available oak database, and all remain undated.

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TABLES

Table 1: Details of the samples taken from the Manor, Frampton-on-Severn

Sample number	Timber and position	No of rings	Dates spanning (AD)	h/s boundary (AD)	Mean ring width (mm)	Sapwood rings	Mean sensitivity	Felling date ranges (AD)
Elm samples – main range roof (trusses numbered from the west end)								
fsmn01	South upper purlin, bay 1	67	-	-	1.84	16	0.30	-
fsmn02	North lower purlin, bay 1	<30	-	-	NM	C	-	-
fsmn03	Collar, T2	75 +18NM	-	-	1.12	-	0.17	-
fsmn04	South principal rafter, T2	81	-	-	2.01	C	0.28	-
fsmn05	South principal rafter, T3	<30	-	-	NM	C-detached	-	-
fsmn06	Collar, T6	35	-	-	2.95	-	0.26	-
fsmn07	Collar, T4	72	-	-	1.28	-	0.20	-
fsmn08	Collar, T5	<30	-	-	NM	C-detached	-	-
fsmn09	Collar, T7	83	-	-	1.08	3	0.19	-
Elm samples – north-south range at east end (trusses numbered from the north end)								
fsmn10	East principal rafter, T2	49	-	-	1.98	4	0.27	-
fsmn11	East principal rafter, T3	97	-	-	1.21	C	0.25	-
fsmn12	West principal rafter, T3	<30	-	-	NM	C	-	-
Elm samples – north range (flat) (trusses numbered from the north end)								
fsft02	Tiebeam, T1	36	-	-	1.45	-	0.27	-
fsft04	Tiebeam, T3	<30	-	-	NM	h/s	-	-
fsft06	Tiebeam, T4	53	-	-	2.39	?C	0.29	-
fsft07	East principal rafter, T4	30	-	-	4.82	-	0.23	-
fsft08	West principal rafter, T2	<30	-	-	NM	h/s	-	-
fsft09	West post, T2	92	-	-	1.54	h/s	0.19	-

Table 1 :continued. Details of the samples taken from the Manor, Frampton-on-Severn

Sample number	Timber and position	No of rings	Dates spanning (AD)	h/s boundary (AD)	Mean ring width (mm)	Sapwood rings	Mean sensitivity	Felling date ranges (AD)
Oak samples – north range (Flat)								
fsft01	West post, T1	66	1457–1522	1522	1.79	h/s	0.21	1531–63
fsft03	East post, T3	<40	-	-	NM	-	-	-
fsft05	East post, T4	84	1463–1546	1521	1.10	25¼C	0.15	Spring 1547

Key: NM = not measured; h/s = heartwood-sapwood boundary; C = complete sapwood, winter felled; ¼C = complete sapwood, felled the following spring

Table 2: Dating evidence for the site sequence fsft01, AD 1457–1522

Source region	Chronology:	Reference	Filename	Span of chronology (AD)	Overlap (years)	*t*-value
Shropshire	St John the Baptist Church, Myndtown	Arnold *et al* forthcoming	myntsq03	1420–1568	66	5.9
Shropshire	Lower Spoad Farm, Clun	Miles *et al* 2003	spaod1	1460–1545	63	5.8
Shropshire	Buildwas Abbey	Miles 2002	BUILDWS2	1374–1547	66	5.7
Oxfordshire	Baltic Cottage, Henley	Miles *et al* 2008	HENLEY3	1449–1537	66	5.6
Dorset	Little Toller farmhouse, Toller Fratum	Arnold and Howard 2016	TOLFSQ01	1379–1539	66	5.3
Herefordshire	Forbury Chapel, Leominster	Arnold *et al* 2003	HFCASQ01	1432–1520	64	5.2
London	Broomfield House, Enfield	Bridge 1997	BROOMFLD	1446–1562	66	5.2
Somerset	Lancin Farmhouse, Wambrook	Tyers 1994	LANCIN	1374–1533	66	5.1
Shropshire	Abcott Manor, Clungunford	Miles and Worthington 2002	CGFA	1422–1545	66	5.1
Montgomeryshire	Kerry Church	Miles *et al* 2011	KERRY	1402–1567	66	5.0

Table 3: Dating evidence for the site sequence fsft05, AD 1463–1546

Source region	Chronology:	Reference	Filename	Span of chronology (AD)	Overlap (years)	*t*-value
West Midlands	Primrose Hill Farm, Birmingham	Arnold and Howard 2008	KGNBSQ01	1354–1593	84	6.5
Kent	Knole	Miles and Bridge 2010	KNOLE1	1431–1605	84	6.2
Hampshire	St Clair's Farm, Droxford	Bridge *et al* 2016	DROXFORD	1468–1610	79	5.7
Devon	Exeter Quay	Mills 1988	EX_QUAY	1407–1606	84	5.4
Cheshire	Overton Old Hall, Malpas	Miles and Worthington 1998	MALPAS1	1389–1588	84	5.3
Somerset	Broomfield Church	Miles *et al* 2005	BROMFLD1	1414–1520	58	5.3
Gloucestershire	42-44 Long Street, Wotton-under-Edge	Miles and Bridge 2014	WUE-LST2	1442–1573	84	5.2
Warwickshire	Cromwell Cottage, Tile Hill	Arnold and Howard 2007	COVBSQ01	1345–1575	84	5.1
Hampshire	The Vyne, Sherbourne St John	Bridge and Miles 2018	THEVYNE4	1328–1525	63	5.1
Hertfordshire	Priory Barn, Lt Wymondley	Bridge 2001	LWYMON2	1450–1540	78	4.9

Table 4: Dating evidence for the site chronology fsft51m, AD 1457–1546

Source region	Chronology:	Reference	Filename	Span of chronology (AD)	Overlap (years)	*t*-value
Shropshire	Buildwas Abbey	Miles 2002	BUILDWS2	1374–1547	90	7.0
Shropshire	St John the Baptist Church, Myndtown	Arnold *et al* forthcoming	myntsq03	1420–1568	90	6.0
West Midlands	Primrose Hill Farm, Birmingham	Arnold and Howard 2008	KGNBSQ01	1354–1593	90	6.0
Shropshire	56 Old Street, Ludlow	Miles *et al* 2006	LUDLOW10	1483–1620	64	5.8
Dorset	Fiddleford Manor	Bridge 2003	FIDDLE2	1433–1553	90	5.6
Shropshire	Hyde Farm, Middleton Priors	Miles *et al* 2004	DITTON6	1442–1547	90	5.6
Worcestershire	The Hyde, Stoke Bliss	Miles *et al* 2004	HYDE1	1413–1564	90	5.5
Gloucestershire	26 Westgate Street, Gloucester	Howard *et al* 1998	GLOBSQ01	1399–1622	90	5.4
Worcestershire	Church House, Areley Kings	Miles *et al* 2003	ARELEY	1365–1535	79	5.4
Dorset	Riding House, Wimborne St Giles	Bailiff *et al* 2017	WSGRIDHO	1411–1615	90	5.3

FIGURES

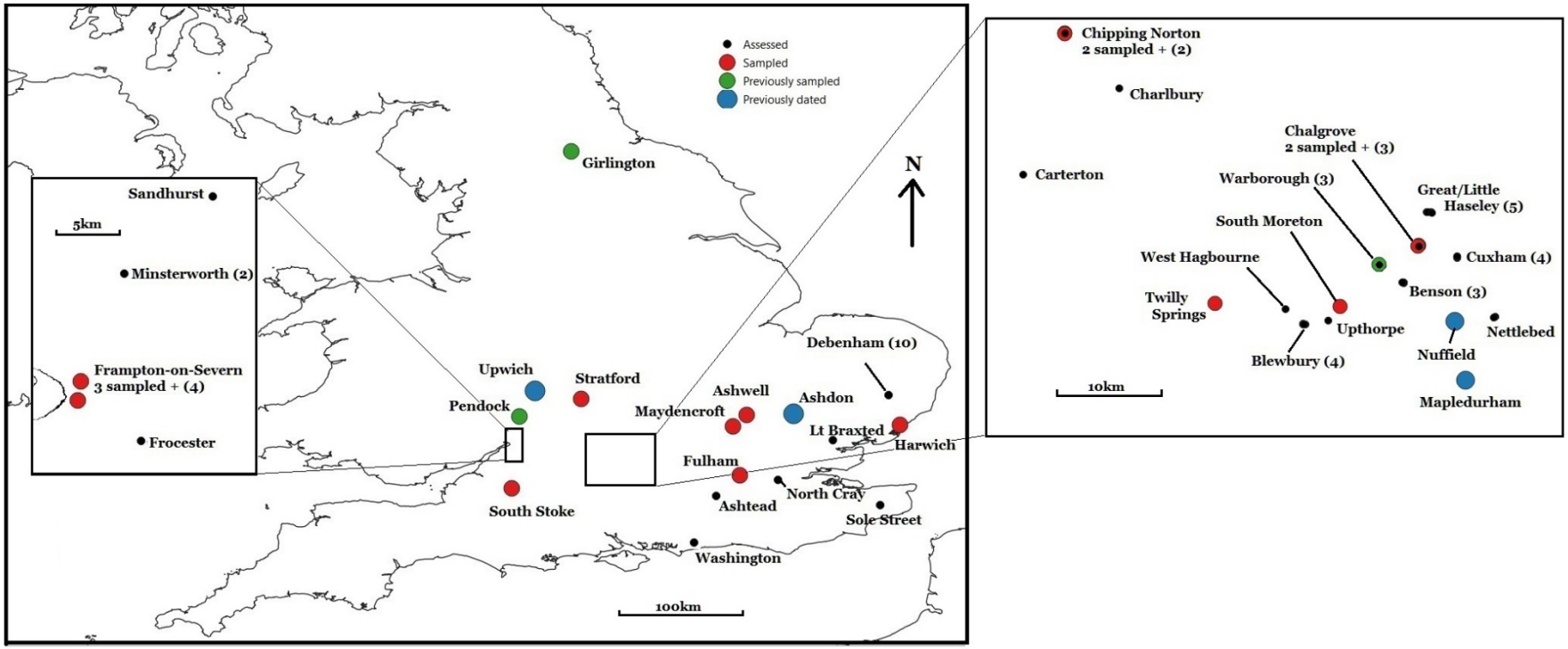

Figure 1: Map showing the distribution of sites sampled, some of which were dated, prior to the start of this project, and sites assessed and sampled properties for this project. Numbers in brackets after a place name represent the number of properties assessed in that location

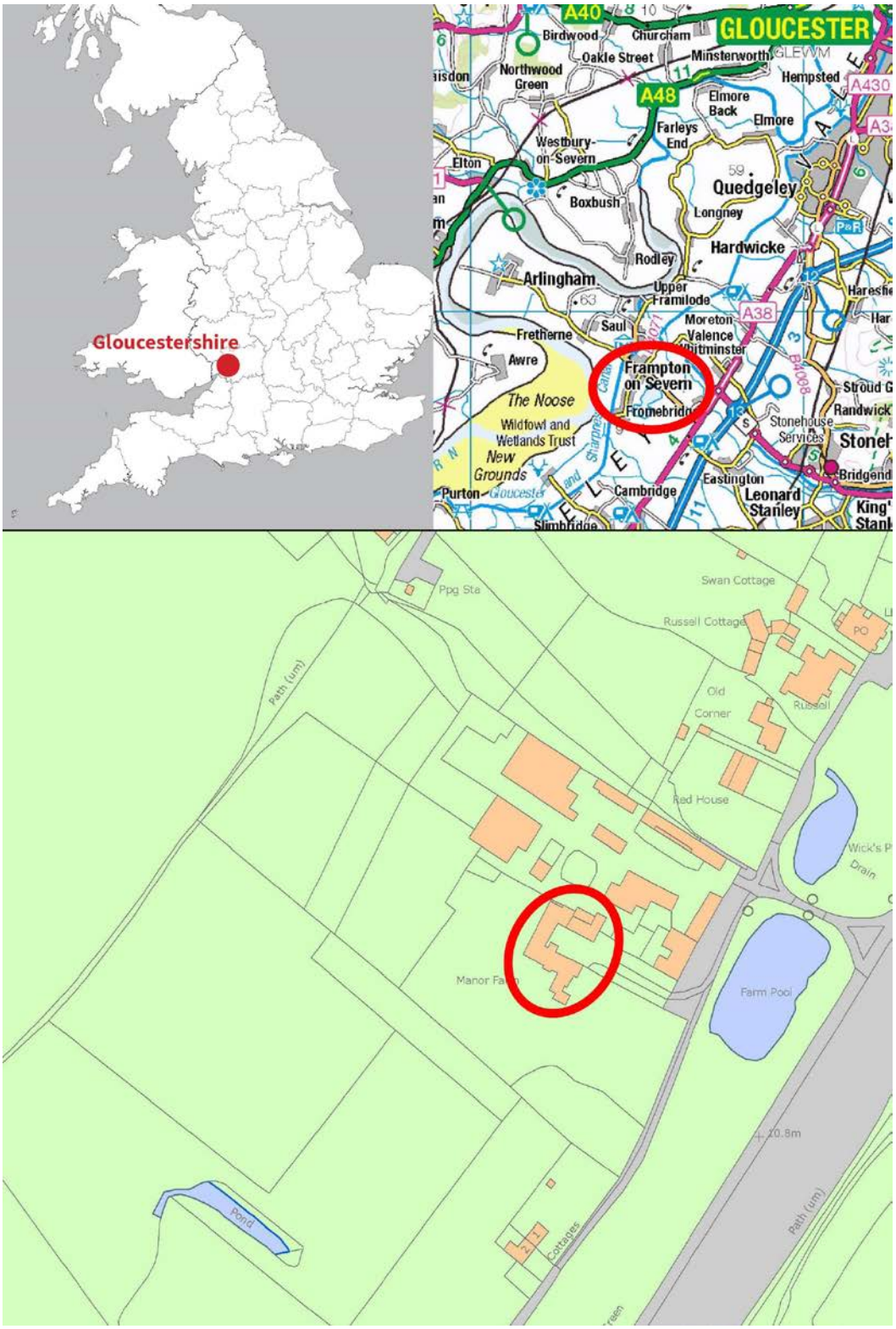

Figure 2: Maps to show location of the Manor House in Frampton-on-Severn in Gloucestershire, marked in red. Scale: top right 1:150000; bottom 1:2000. © Crown Copyright and database right 2020. All rights reserved. Ordnance Survey Licence number 100024900. © British Crown and SeaZone Solutions Ltd 2020. All rights reserved. Licence number 102006.006. © Historic England

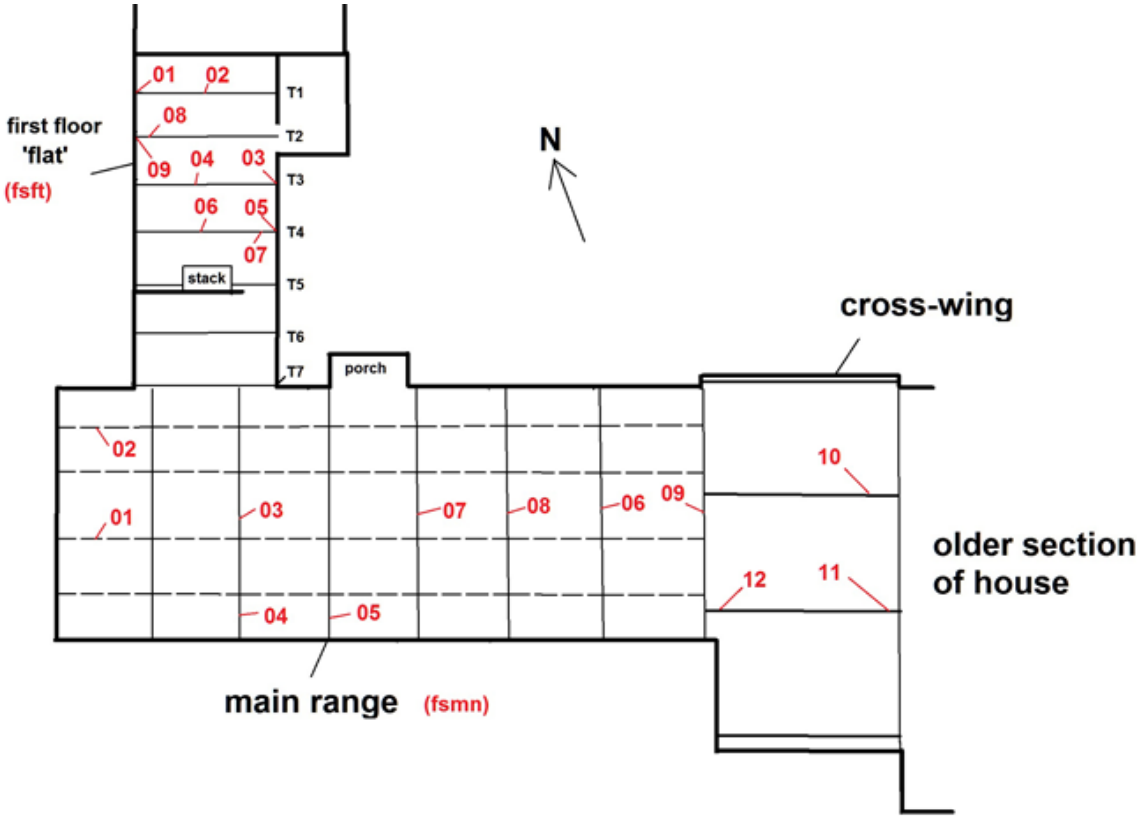

Figure 3: Sketch plan of the Manor House indicating the positions of timbers sampled

Figure 4: View within the flat, looking south-east, showing some of the timbers sampled (photograph Martin Bridge)

Figure 5: View of the roof to the main range of the manor, looking east, showing the general form of the trusses (photograph Martin Bridge)

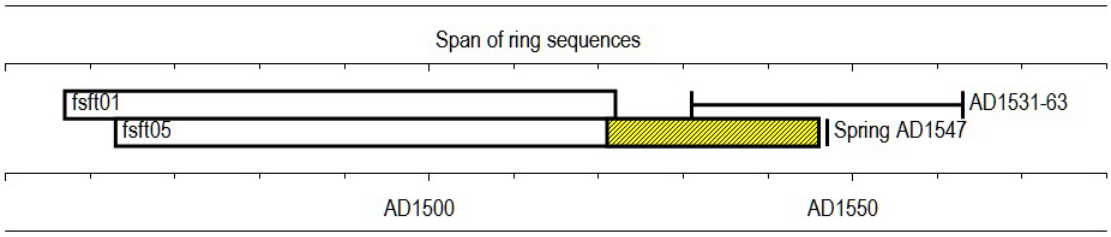

Figure 6: Bar diagram showing the relative positions of the dated oak samples from the north range of the manor house (the flat). White bars represent heartwood rings, while the yellow hatched bar represents sapwood

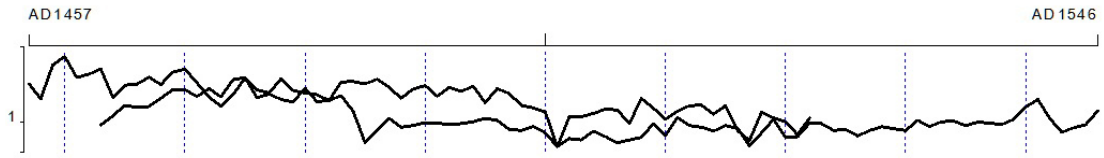

Figure 7: Plots of the two dated oak sequences fsft01 and fsft05 from the north range showing similarities in growth. The y-axis is ring width (mm) on a logarithmic scale

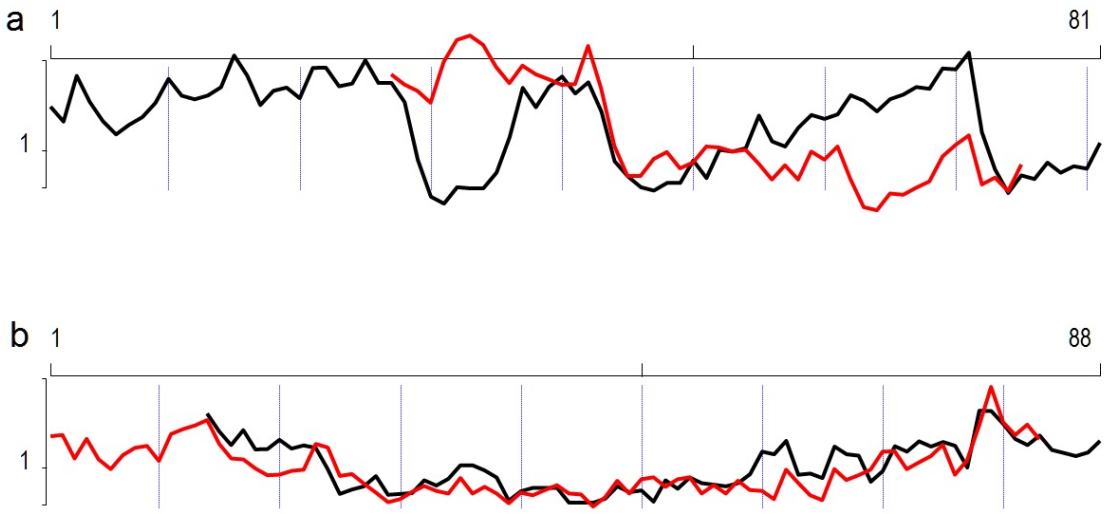

Figure 8: Plots of potentially matching elm sequences a) fsmn04 [red] plotted with fsmn10 [black], and b) fsmn03 [black] plotted with fsmn09 [red]. The y-axis is ring width (mm) on a logarithmic scale

APPENDIX

Ring width values (0.01mm) for the sequences measured

fsmn01

230	175	108	55	62	117	174	163	111	123
137	156	124	78	74	130	165	235	343	458
184	105	280	410	405	308	398	604	408	322
301	309	356	293	346	378	370	437	83	58
46	62	68	78	77	113	106	129	160	176
333	138	44	47	54	59	97	103	118	173
192	77	52	52	66	58	84			

fsmn03

257	188	148	192	137	138	162	139	147	141
97	63	68	72	86	62	63	64	80	73
82	104	104	95	84	56	66	70	70	70
54	54	54	58	72	65	67	55	80	69
84	76	74	72	76	89	132	126	159	88
90	83	144	126	123	78	94	145	132	158
144	156	146	100	270	268	213	164	148	175
136	129	122	130	159					

fsmn04

213	164	365	231	165	131	155	177	227	346
258	242	259	299	521	366	219	281	297	247
420	421	304	319	479	322	322	230	84	44
39	52	51	51	67	125	296	211	301	361
268	326	195	82	63	52	49	56	56	83
61	100	97	103	182	116	106	147	184	172
186	260	236	196	243	263	300	291	415	409
548	136	71	47	64	60	80	67	75	72
113									

fsmn06

414	356	383	434	347	226	152	294	338	532
288	368	346	577	755	241	262	371	266	233
219	252	191	192	395	333	365	359	111	119
116	109	118	123	141					

fsmn07

149	161	209	175	197	276	87	90	104	85
134	78	88	75	78	108	95	113	113	136
194	133	129	163	312	264	206	153	117	163
178	238	260	279	133	119	117	126	140	171
240	171	143	128	77	73	111	85	97	127
114	107	108	117	73	76	55	50	61	73
71	69	62	71	73	85	96	76	92	116
101	100								

fsmn09

174	178	118	166	116	98	125	142	147	113
181	197	210	231	152	118	116	99	88	89
95	97	152	143	87	90	76	65	55	58
66	73	67	64	84	64	72	64	54	65
62	68	74	64	63	51	60	80	64	82
85	72	82	85	64	74	64	80	68	67
58	97	77	62	57	98	81	88	97	133
134	98	110	123	150	89	114	209	412	222
178	213	165							

fsmn10

378	317	283	230	471	690	746	634	429	324
441	379	347	315	319	622	294	108	64	64
86	97	73	81	107	105	98	101	79	60
77	60	98	85	107	60	37	35	47	46
52	58	90	110	130	55	62	49	78	

fsmn11

299	231	245	198	249	160	178	125	62	55
58	51	94	67	108	72	95	84	86	96
105	179	124	113	107	83	87	280	400	311
209	204	131	186	166	179	218	184	136	183
104	105	53	74	88	82	70	64	83	87
56	50	44	70	84	79	96	106	101	132
118	224	139	84	50	50	61	62	83	66
38	42	50	54	62	85	123	141	251	226
342	179	215	241	226	144	50	36	49	54
54	46	46	55	57	66	59			

fsft01 (OAK)

223	162	332	394	254	272	304	167	216	220
256	219	284	303	226	168	139	176	251	195
183	247	193	183	177	156	231	233	222	244
206	164	199	214	171	206	190	211	149	201
181	141	134	122	59	111	111	119	130	128
96	163	133	105	125	140	142	117	140	83
67	122	108	100	76	108				

fsft02

285	286	199	297	118	88	80	96	101	125
136	153	225	282	116	87	86	98	154	120
108	132	207	171	128	164	230	151	90	71
74	81	94	134	97	150				

fsft05 (OAK)

93	113	141	135	138	164	197	196	170	201
169	242	254	166	179	160	151	202	152	157
173	125	64	83	107	89	92	98	97	94
96	100	107	103	85	83	90	79	59	70
68	82	73	64	68	72	96	75	109	92
89	82	92	87	60	79	105	72	73	97
96	83	85	74	83	90	86	83	103	90

100 101 92 99 97 94 105 136 160 107
80 88 94 126

fsft06
104 132 155 278 239 275 228 79 336 316
474 575 497 586 600 653 767 544 334 213
285 242 151 76 34 44 41 40 40 60
54 74 84 91 248 250 212 160 131 164
294 212 187 395 394 239 160 224 145 121
139 147 142

fsft07
880 869 842 846 776 726 389 381 424 524
556 117 67 61 97 219 313 281 345 262
305 346 399 493 603 609 716 810 673 516

fsft09
301 220 298 267 295 218 462 310 127 155
103 132 170 152 231 222 178 184 136 164
180 159 137 166 164 193 216 144 132 165
188 133 133 139 147 163 110 104 89 139
96 100 111 96 91 120 108 210 178 189
141 133 103 143 132 142 151 132 128 117
88 87 150 107 102 126 131 130 179 148
118 108 111 61 74 112 136 124 130 176
159 178 205 205 162 162 141 139 88 119
135 144

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