Research Report Series xx-2023

GARRICK INN
25 HIGH STREET
STRATFORD-UPON-AVON
WARWICKSHIRE

Tree-ring analysis of oak and elm timbers

Martin Bridge and Cathy Tyers

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SUMMARY
Only a limited number of those timbers of interest were considered potentially suitable for dendrochronological analysis, or other scientific dating techniques. Nevertheless, three oak timbers from the first-floor front range were dated, giving a likely felling date range spanning the late-sixteenth to early-seventeenth centuries, in line with the expected date of *c* AD 1596. An oak beam in the cellar exhibited bands of narrow rings and could not be dated, and timbers in the stair range which projects south into the neighbouring property were found to be of elm.

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ARCHIVE LOCATION
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HISTORIC ENVIRONMENT RECORD
Warwickshire Historic Environment Record
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INTRODUCTION

This building was investigated as part of the *StratFire* project, a project proposed by the Stratford-upon-Avon Society and subsequently supported by Historic England.

The project focusses on the impact of two major fires in the late-sixteenth century in AD 1594 and AD 1595, as well as taking into account another major fire in AD 1614. Bearman (2000) investigated the two late-sixteenth fires in detail using documentary sources. Subsequently the Stratford-upon-Avon Society have been highlighting the architectural heritage along the main thoroughfare through on-going volunteer-led research (Historic Spine (stratfordsociety.co.uk)) which has itself led to the development of the *StratFire* project (StratFire Project (stratfordsociety.co.uk)) which combines detailed archival research with comprehensive building recording and analysis, as well as dendrochronology. The project summary, as per the final agreed project design (Historic England Project number 8452) is as follows:

"The aim of this project, by means of high-level building recording and analysis, detailed archival research and dendrochronology, is to establish, following Stratford-upon-Avon's town fires of 1594 and 1595, the chronology, extent and nature of the reconstruction of buildings along High Street and Chapel Street, the epicentre of one or both of these fires. Post-fire documentary sources record damage to certain buildings, and architectural appraisal indicates that several timber-framed buildings surviving today date from the post-fire period. However, more needs to be established concerning the scale, nature and speed of this rebuilding, and the impact of the fires, both on the economic well-being of the town and the fortunes of the families most seriously affected. For many buildings there is simply no documentary evidence to draw on. Moreover, even when documentary evidence exists, it is either confusing or only establishes a date by which rebuilding had taken place. Conversely, it may record fire damage to properties that, from surviving architectural features, appear not to have been entirely rebuilt. High-level building analysis and dendrochronological investigation will resolve much of this uncertainty, provide a sound base for the interpretation of the documentary evidence, and throw definitive light on a crucial episode in the evolution of the architectural and cultural heritage of this internationally renowned town."

Garrick Inn, 25 High Street

The Grade II* listed Garrick Inn (LEN 1187814) sits on the west side of the High Street, near the junction with Chapel Street, Ely Street, and Sheep Street (Fig 1). It is thought to date to *c* AD 1596, following the fires in the town, but the front was heavily restored in AD 1912 after the removal of a later brick front. The front range on to the street is thought to be the oldest section of the building (Bearman 2000; Tyler 2022 unpubl) and is of two bays parallel to the street (Fig 2), and three storeys, the upper floors each jettied on brackets. To the west is

another, probably later range, beyond which (further to the west) lie more modern extensions. A stair range on the south side projects into the next door property (Fig 2).

METHODOLOGY

An assessment of the timbers for dendrochronological study sought accessible timbers, preferably with more than 50 rings and, where possible, traces of sapwood, although shorter sequences are sometimes 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.

The cores were polished on a belt sander using 80 to 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 process of qualified statistical comparison by computer, supported by visual checks. 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 series. This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one 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*-values in the range 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 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.

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. 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* or felled-after date.

A review of the geographical distribution of dated sapwood data from historic 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). 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

Limited sampling was undertaken, as most of the timbers of interest that were accessible were assessed as having too few rings, even for radiocarbon and/or oxygen isotope analysis. No timbers were deemed suitable for sampling in the roof but four oak (*Quercus* spp) samples were taken from the front range first-floor room, one from the cellar below, and two from the stair range to the south (Figs 2 and 3), although these latter two were found to be of elm (*Ulmus* spp) and no further samples were taken in that area. Details of the samples are given in Table 1.

One oak sample had too few rings for secure dating purposes and was not further analysed, and only one of the elm timbers was measured to allow assessment as to whether it might be useful for different scientific dating techniques. The oak beam in the cellar (gar07) yielded a 107-year long ring series, but this was found to contain several bands of very narrow rings, and it neither cross-matched the other series from this site, nor could it be dated securely when compared to the reference chronologies. Sample gar01 fractured into two pieces, each of which was measured separately, but the break was thought to be clean, and when the two sections were combined as if nothing was missing, the 45-year sequence, retaining 7 sapwood rings, dated to the period AD 1543–87 (Table 2a). Two other timbers yielded dates, the north-south beams either side of the central east-west beam in the first-floor ceiling. These matched each other (t = 4.9 with 54 years overlap), and were combined into a single 166-year long sequence (gar43m), which was subsequently dated to the period AD 1391–1556 (Table 2b). As there was only a very short overlap between the two sequences, they are not presented as a single site master, though when tested a site master using all three timbers did give slightly stronger matches. The relative positions of overlap of the three dated timbers are shown in Figure 4. The ring-width measurements for all measured samples are given in Appendix 1.

INTERPRETATION AND DISCUSSION

Only one of the three dated timbers (gar01) from the first-floor ceiling had any sapwood, although the northern beam (gar04) was recorded during sampling as likely to be close to the heartwood-sapwood boundary. Using the 9–41 sapwood ring estimate (Miles 1997), felling is likely to have taken place in the period AD 1589–1621.

In order to attempt to further refine the estimated felling date range for this group of timbers, and for comparative purposes within the *StratFire* project, the single sample with sapwood (gar01) was assessed for its suitability with respect to using the methodology developed by Miles (2005) and implemented in OxCal v4.4 (Bronk Ramsey 2009; Miles 2006). Following the methodology set out by Millard (2002), Bayesian statistical models are used to provide individual sapwood estimates for samples using the variables of the number of heartwood rings present, the mean ring-width of those heartwood rings, the heartwood-sapwood boundary date, and the number of any surviving sapwood rings (including those that can only be counted, not measured, or those lost on sampling). Miles (2005) suggests several such models, of which the one that applies to the timbers in this case is that for 'England & Wales AD'. This model is based on data from timbers throughout this area, although there is a bias towards data from the densely-dated counties Shropshire, Somerset, Hampshire, Oxfordshire, and Kent. This model is considered appropriate geographically for historic timbers from buildings in Warwickshire, as well as being compatible with the growth characteristics of this particular sample.

Using the above methodology, as implemented in OxCal 4.4 (2023), a sapwood estimate was produced for the only dated series with sapwood, gar01, which indicates that felling occurred in AD 1588–1610 (95.4% probability; gar01 Sapwood; Fig 5). This, as well as the empirically based estimated felling date range, agrees well with the presumed date of construction around AD 1596, following a major fire in the area.

The matches obtained with reference chronologies (Tables 2a and 2b), mostly from the surrounding counties, suggest the timber used was most likely derived from relatively locally-grown trees.

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FIGURES

Maps to be inserted

Figure 1:

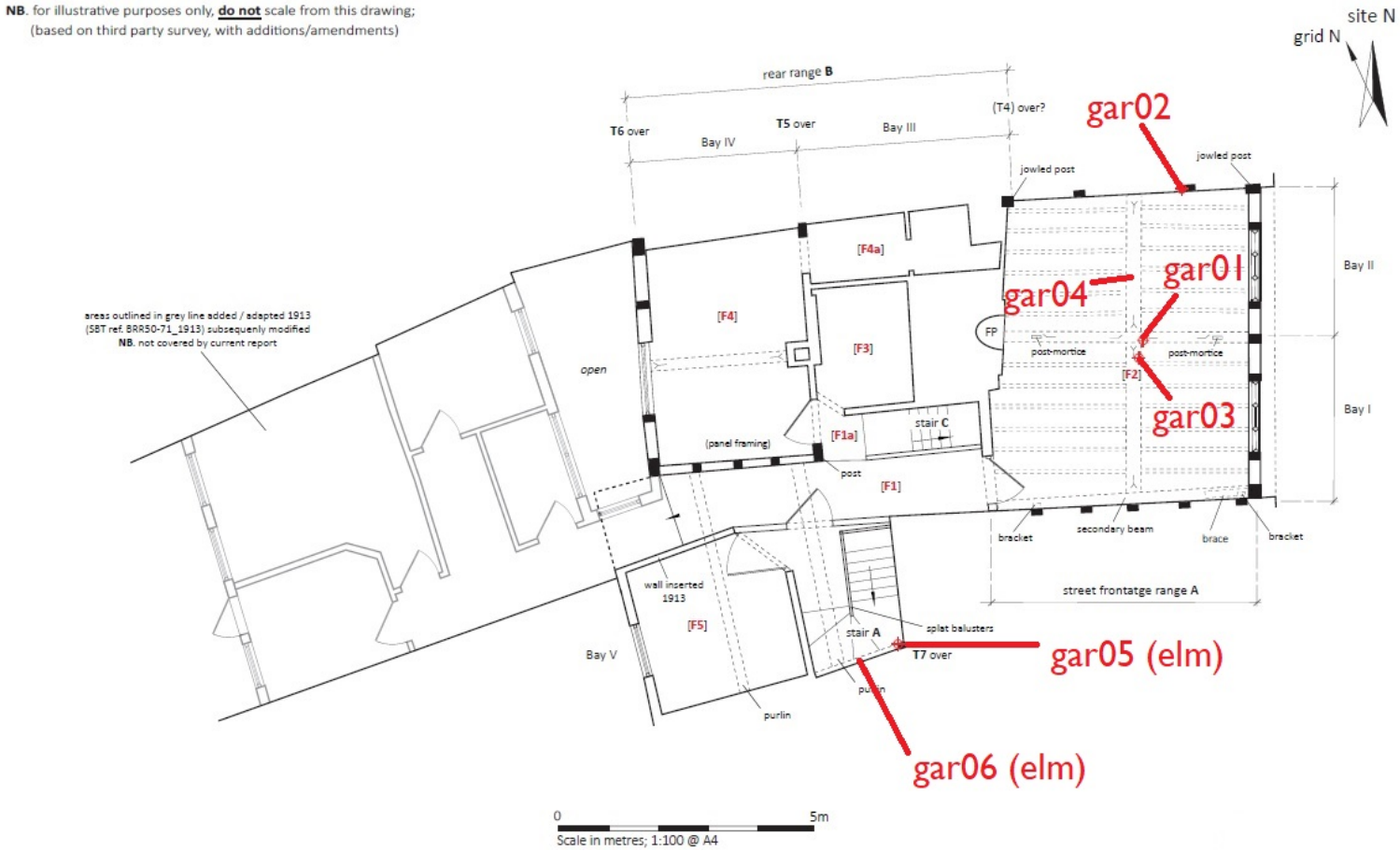

Figure 2: First-floor plan showing the approximate positions of timbers sampled for dendrochronology (adapted from an original drawing by Ric Tyler 2022)

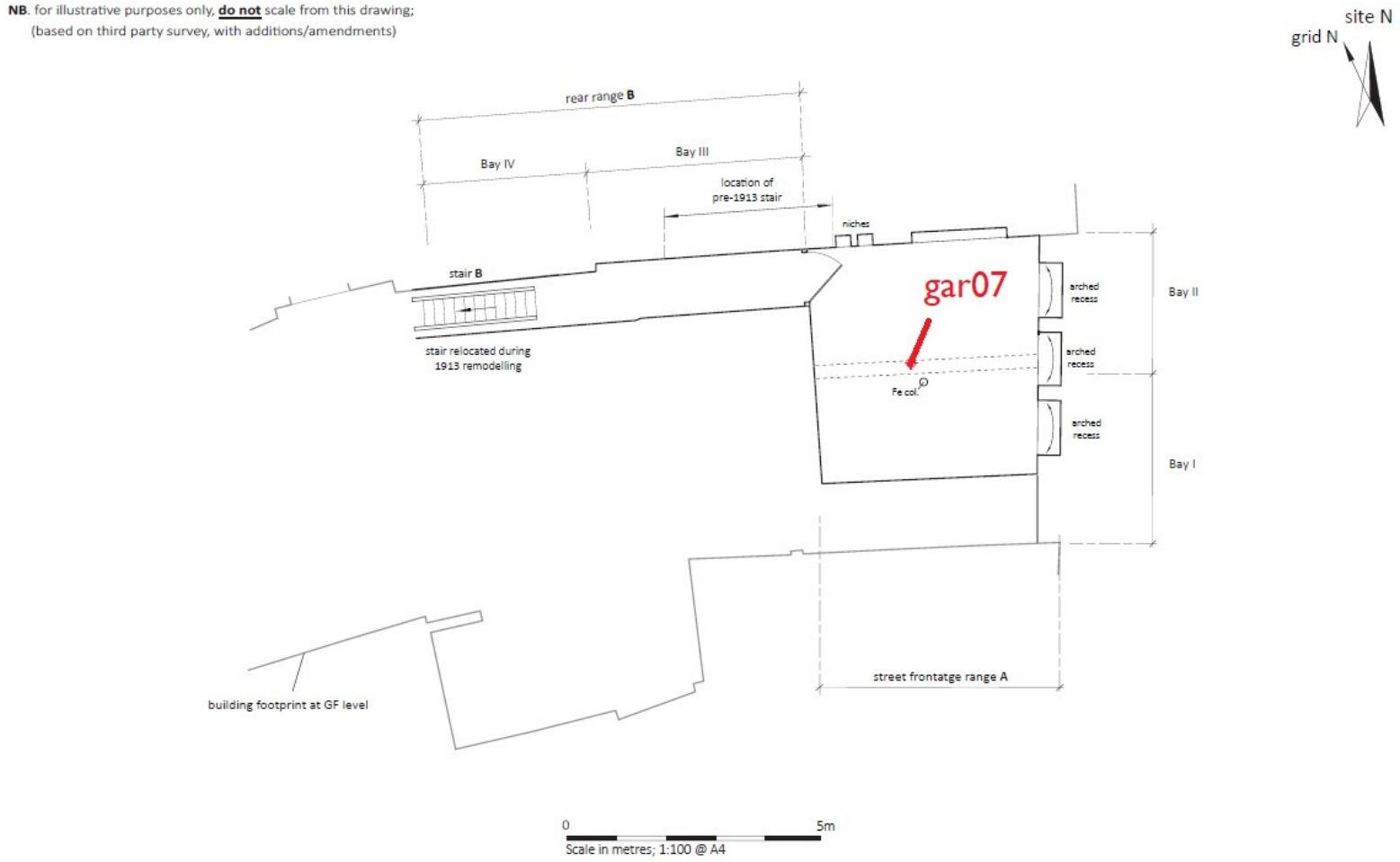

Figure 3: Cellar plan showing the approximate positions of timbers sampled for dendrochronology (adapted from an original drawing by Ric Tyler 2022)

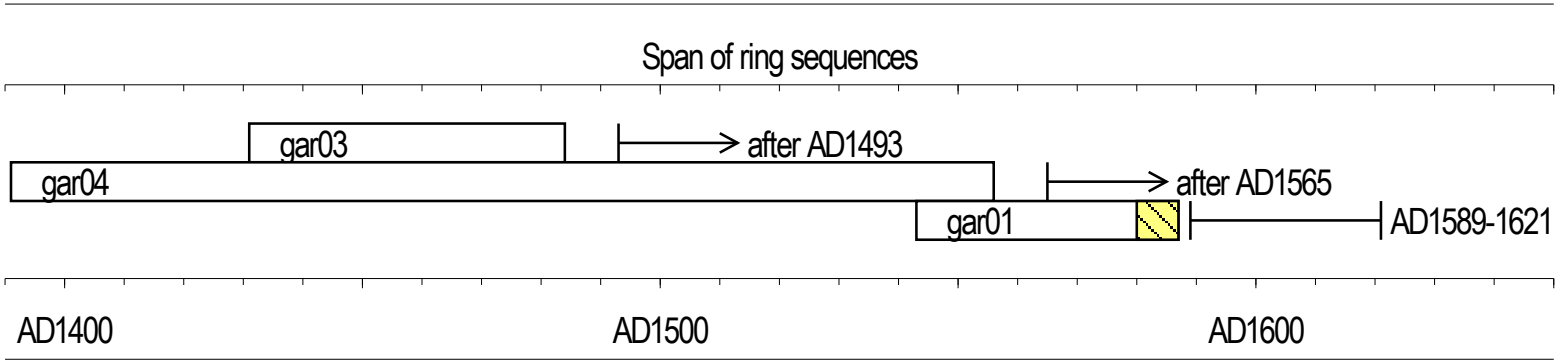

Figure 4: Bar diagram showing the relative positions of overlap of the dated ring sequences and their individual likely felling dates/date ranges. White bars represent measured heartwood rings; yellow hatched sections represent measured sapwood rings

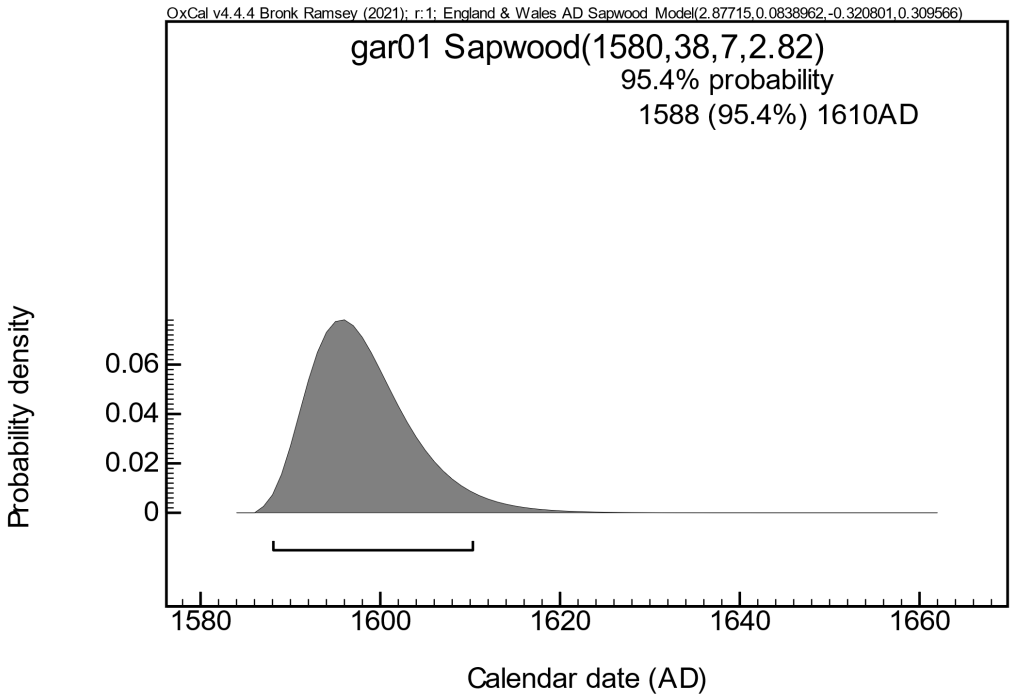

Figure 5: Probability distribution for the estimated felling of the first-floor main east-west ceiling beam, gar01. The 95.4% probability range is indicated

TABLES

Table 1. Details of samples taken from the Garrick Inn, 25 High Street, Stratford-upon-Avon

Sample No	Location	Number of rings	Date of sequence (AD)	Sapwood	Mean ring width (mm)	Mean sensitivity	Felling date range (AD)
Front range							
gar01	1st floor – main E-W ceiling beam	45	1543–87	7	2.82	0.19	1589–1621
gar01i	*ditto* (inner rings)	26	1543–68	-	2.73	0.21	-
gar01ii	*ditto* (outer rings)	19	1569–87	7	2.94	0.16	-
gar02	1st floor – east stud in north wall	NM (19)	-	(7)	5.30	0.19	-
gar03	1st floor – south ceiling beam	54	1431–84	-	1.84	0.16	after 1493
gar04	1st floor – north ceiling beam	166	1391–1556	-	1.55	0.20	after 1565
gar07	Main E-W beam in cellar	107	-	23C	1.46	0.22	-
Stair bay							
gar05	SE corner post (ELM)	NM (25)	-	-	-	-	-
gar06	Tiebeam (T6) (ELM)	37	-	-	2.08	0.29	-

Key: h/s = heartwood/sapwood boundary; NM = not measured but ring count given in brackets

Table 2a. Dating evidence for the site sequence gar01, AD 1543–87

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	*t*-value
Berkshire	Cloth Hall, Newbury	Tyers 2009	NEWCLOTH	1488–1624	45	7.4
London	Real Tennis Court, Hampton Court	Bridge and Miles 2016	HMPTN3	1498–1635	45	6.8
Oxfordshire	Bodleian Library, Oxford	Miles and Worthington 1999	BDLEIAN3	1395–1610	45	6.7
Gloucestershire	Estcourt Grange, Tetbury	Bridge and Miles 2022	ESTCRTGt9	1379–1610	45	6.6
Buckinghamshire	Pitstone Windmill	Miles *et al* 2004	PITSTN2	1489–1669	45	6.6
Derbyshire	Bretby Hall	Howard *et al* 1999	BRETALL	1494–1805	45	6.6
Oxfordshire	Fellow's Quad, Merton College, Oxford	Miles and Worthington 2006	MERTON2	1442–1608	45	6.5
Oxfordshire	Laudian Library, St John's College, Oxford	Miles *et al* 2021	LAUDIAN3	1511–1633	45	6.5
Staffordshire	Sinai Park	Tyers 1997	SINAI	1227–1750	45	6.5
Grtr Manchester	30–31 Market Place, Stockport	Tyers 1999	MPS2T20	1402–1618	45	6.5

Table 2b. Dating evidence for the site chronology gar43m, AD 1391–1556

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	*t*-value
Warwickshire	Gorcott Hall	Nayling 2006	GORC_T17	1385–1531	141	8.9
Warwickshire	Kingsbury Hall	Arnold *et al* 2006	KNGHSQ01	1391–1564	166	8.1
West Midlands	Primrose Hill, King's Norton	Arnold and Howard 2008	KGNBSQ01	1354–1593	166	8.1
Worcestershire	Hartlebury Castle	Tyers 2008	HARTLEBY	1235–1745	166	7.8
Shropshire	Bush Cottage, Stottesdon	Miles and Bridge 2013	BUSHCOTT	1369–1547	157	7.7
Worcestershire	Star Yard, Droitwich	Tyers 2017	DRSTYRD	1404–1620	153	7.4
London	Westminster School	Miles *et al* 2008	LIDDELLS	1346–1540	150	7.3

London	Henry VIII Alterations, Hampton Court	Miles and Bridge 2013	HMPTNCT6	1351–1533	143	7.3
Shropshire	Ightfield Hall Barn, Whitchurch	Groves 1997	IGHTFELD	1341–1566	166	7.2
Gloucestershire	26 Westgate Street, Gloucester	Howard *et al* 1998	GLOBSQ01	1399–1622	158	7.2

APPENDIX 1

Ring width values (0.01mm) for the sequences measured

gar01i

118	129	173	129	111	132	225	254	380	293
319	354	438	267	247	343	403	416	365	434
280	283	210	256	226	303				

gar01ii

307	345	302	257	311	325	320	317	291	227
258	353	282	197	335	353	316	263	226	

gar01

118	129	173	129	111	132	225	254	380	293
319	354	438	267	247	343	403	416	365	434
280	283	210	256	226	303	307	345	302	257
311	325	320	317	291	227	258	353	282	197
335	353	316	263	226					

gar03

202	267	171	174	154	172	149	130	165	200
160	154	170	283	192	170	147	156	164	156
192	198	170	267	203	174	151	167	155	169
150	197	238	187	193	188	233	226	271	221
208	202	205	189	299	213	118	109	152	153
148	147	156	139						

gar04

291	207	181	184	155	282	266	220	220	231
349	199	278	331	300	275	192	231	252	236
244	283	259	203	189	152	175	244	175	274
246	205	240	288	332	174	223	198	195	199
224	371	213	229	149	138	131	68	91	127
174	155	199	219	180	153	191	230	195	265
350	216	201	217	261	189	170	215	181	193
149	190	253	118	112	88	100	105	91	112
109	107	109	130	166	131	77	55	49	51
61	71	77	63	61	71	105	147	175	192
187	132	157	158	145	218	149	137	126	116
133	87	65	67	73	73	65	96	108	105
134	185	150	151	161	190	195	203	137	75
85	99	70	68	79	123	128	159	141	109
149	99	60	65	53	65	82	85	116	157
125	85	84	87	70	62	51	58	57	67
49	62	68	85	92	98				

gar05

363	356	513	344	282	293	129	208	311	196
248	65	55	56	75	93	200	256	197	143
211	194	209	203	288					

gar06

123	109	142	194	207	252	408	511	385	269
173	245	204	154	119	101	55	92	55	66
82	147	107	170	175	132	296	544	343	272
322	312	227	195	191	141	171			

gar07

264	320	346	285	304	334	333	368	307	372
320	302	306	305	308	216	307	236	73	55
67	81	97	85	104	125	133	172	157	162
142	169	168	208	157	150	100	40	30	32
25	59	79	58	84	96	94	91	121	105
138	117	122	141	85	146	223	168	144	200
176	195	201	165	157	114	90	138	152	166
154	176	163	142	186	245	263	221	150	111
81	123	162	161	208	141	201	47	30	28
30	33	44	47	41	39	53	41	51	60
27	32	51	43	43	52	42			

APPENDIX 2

OxCal Code (Figure 5)

```
Options()
 {
  Resolution=1;
 };
 Plot()
 {
  Sapwood_Model("EnglandWales", 2.877146, 0.0838962, -0.3208009,
0.3095663);
  Sapwood("gar01", 1580, 38, 7, 2.82);
 };
```