



1 High Street, Stratford-upon-Avon, Warwickshire

Tree-ring Analysis of Oak Timbers

Martin Bridge and Cathy Tyers



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Summary

Ring-width series from seven oak timbers were cross-matched and dated. The dated sample from one timber retained complete sapwood, indicating a felling date for the tree from which this timber was derived in the summer of AD 1441. Another dated sample had only lost a couple of millimetres from the outer part of the complete sapwood present on the timber and had a last measured ring formed in AD 1438. The other five dated samples all produce similar felling date ranges. These seven dated timbers are from three levels in the building, and it is likely that the present building was constructed in late AD 1441, or within a year or two after this date, using timber of local origin.

Contributors

Martin Bridge and Cathy Tyers

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Front cover image

1 High Street, Stratford-upon-Avon, Warwickshire [Photograph Martin Bridge]

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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-century 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 \(stratfordsociety.co.uk\)](http://stratfordsociety.co.uk)), which has itself led to the development of the *StratFire* project ([StratFire Project \(stratfordsociety.co.uk\)](http://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.”

1 High Street

The Grade II*-listed 1 High Street (List Entry Number [1187808](#)) sits on the junction of the east side of High Street and the south side of Bridge Street (Fig 1).

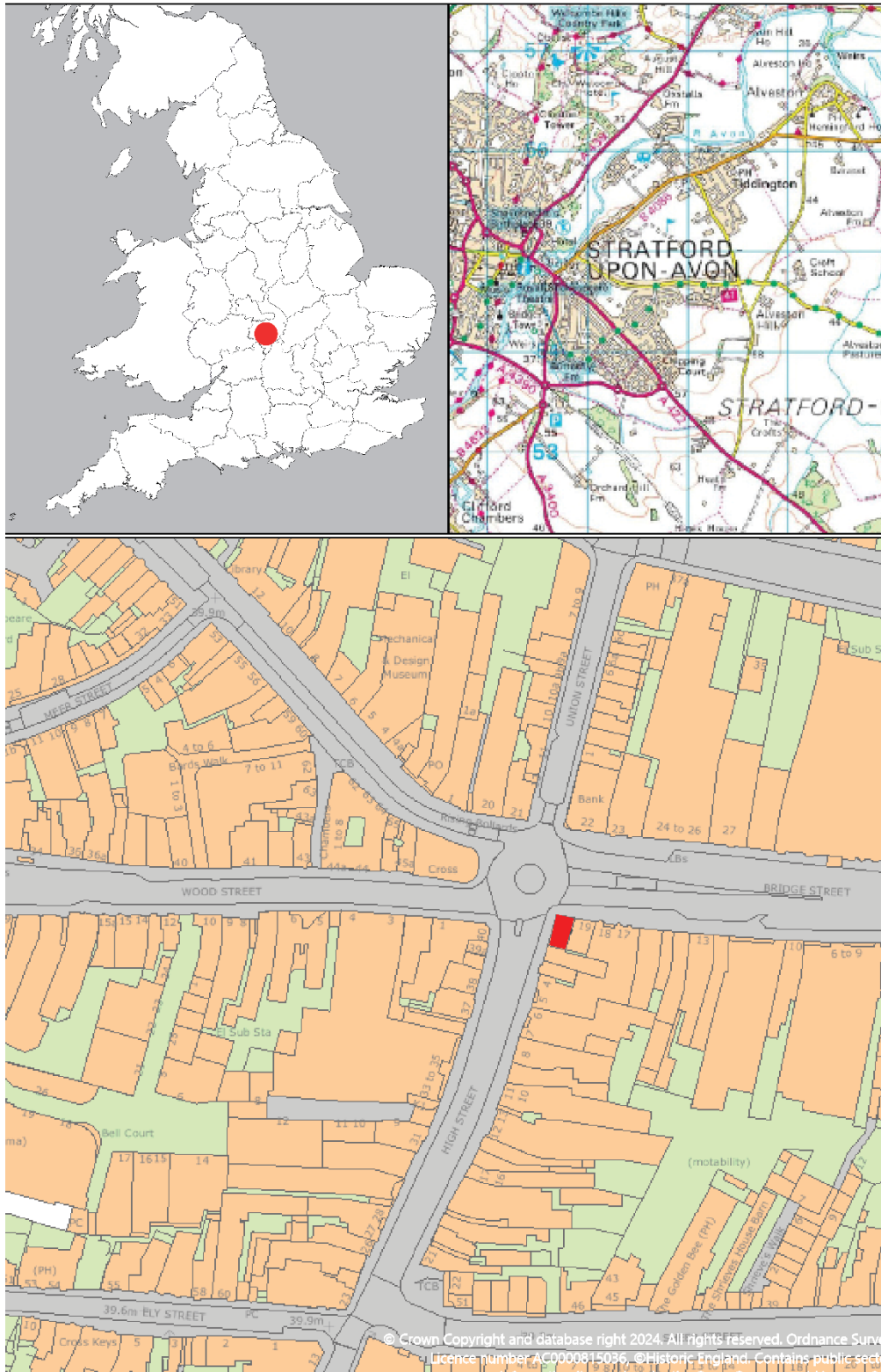


Figure 1: Maps to show the location of 1 High Street, Stratford-upon-Avon, Warwickshire. Top left on map of England; top right on map at scale 1:50,000, bottom on street map at scale 1:1,500. [© Crown Copyright and database right 2024. All rights reserved. Ordnance Survey Licence number 100024900].

The building is listed as dating to c. AD 1600, although documentary research has shown that, by AD 1422/3, the plot of land on the corner of High St. and Bridge St. was held by the Guild of the Holy Cross, when it paid £15 to a carpenter for building a house on the site (Bearman 2024). The building, as recorded (Tyler 2024), comprises a two-bay range of three storeys above an earlier basement, beneath a pitched roof aligned parallel to High Street, hipped to the north elevation. Originally fully timber-framed, the exterior elevations have been subject to sequential remodelling, most recently in 1923, although extensive timberwork survives internally in the form of studwork, external and interior partition walls, ceilings and a clasped-purlin roof structure. Dragon beams recorded at ground- and first-floor levels indicate that the building was originally fully jettied to both northern and southern façades. The upper floor level of the northern bay has been historically raised, re-using the primary timbers, when the timber-framed exterior walls were removed and underbuilt, although the date of this remodelling is unclear. This range was, from an early date, sub-divided into two tenements, as recorded in Guild rental records, while it is known to have been historically conjoined with No. 19 Bridge Street to the east, with interconnecting doorways blocked up as late as 1923.

Methodology

An initial assessment of the timbers for dendrochronological potential sought accessible timbers with more than 50 rings and, where possible, traces of sapwood, although slightly shorter sequences are sometimes sampled if little other material is available. Initial assessment suggested that most timbers were considered marginal in terms of the number of rings available. Those timbers judged to be potentially most suitable were cored in May 2024, 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 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 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 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 (i.e. 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* (tpq) 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 for oak 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

Details of the samples taken, all oak (*Quercus* spp), are shown in Table 1, with their location in the building illustrated in Figures 2–5. One sample (strh06) had too few rings to be considered for further analysis. The ring-width measurements for the measured samples are given in Appendix 1.

Sample strh02 was in two parts (i and ii), but cross-matching with the other measured series showed that no rings were missing and the two measured series from the inner and outer rings were, therefore, combined into a single sequence. Sample strh05 was similarly in two parts, but in this case the inner rings (strh05i) could not be cross-matched with the other samples. The measured series from seven timbers were cross-matched and a 109-year long site chronology was constructed. Cross-matching is shown in Table 2, and the relative positions of overlap of the dated samples are shown in Figure 6. This site chronology was compared to an extensive range of reference chronologies and was dated as spanning the period AD 1332–1440, the strongest matches being shown in Table 3.

The remaining sample, strh04, did not cross-match the other samples, neither did it date individually when compared to the reference chronologies. This ring series did not appear to have any anatomical anomalies that would hinder successful dating, and it is thus, one of the percentage of samples that fail to date in spite of their apparent suitability.

Table 1: Details of samples taken from 1 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)
Attic							
strh01	Collar, truss 2	62	1360–1421	h/s +14NM	1.57	0.22	1435–62
strh02i	Tiebeam, truss 2, inner rings	46	1332–1377		1.48	0.16	
strh02ii	Tiebeam, truss 2, outer rings	36	1378–1413	h/s	1.24	0.18	
strh02	02i and 02ii combined	82	1332–1413	h/s	1.37	0.17	1422–54
strh03	West stud between collar and tie-beam, T2	58	1363–1420	9 +17NM	1.49	0.16	1437–52
Second floor							
strh04	Tiebeam, truss 1	49	-	-	1.40	0.22	-
strh05i	East purlin, bay 1-2, inner rings	29	-	-	2.98	0.16	
strh05ii	East purlin, bay 1-2, outer rings	60	1361–1420	8	1.15	0.19	1421–53
strh06	East common rafter, 5 th north of T1	<10	-		NM	-	-
strh07	Tiebeam, truss 3	80	1341–1420	5 + 12NM	1.66	0.20	1432–56
First-floor							
strh08	North-south joist from dragon beam	77	1362–1438	22 + 2NM	0.97	0.25	1440–45
strh09	East wall, girding beam supporting floor	100	1341–1440	24½C	1.27	0.20	summer 1441

Key: h/s = heartwood/sapwood boundary; ½C = complete sapwood, felled the following summer; NM = not measured

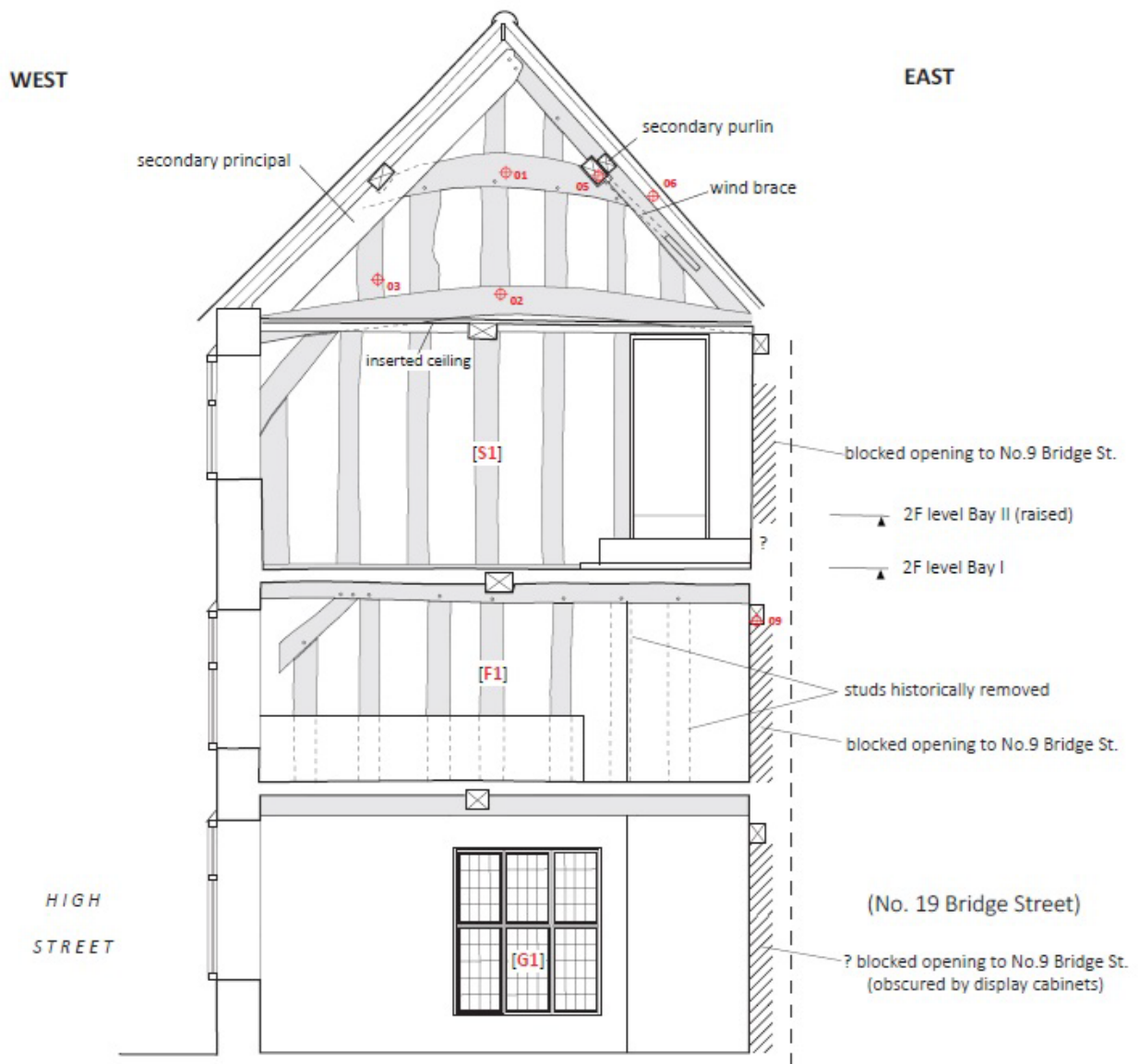


Figure 2: Section through truss two (T2) without the cellar, showing the locations of some of the samples taken for dendrochronology [adapted from an original drawing by Ric Tyler]



Figure 3: Section through truss one (T1) showing the location of sample 07 [adapted from an original drawing by Ric Tyler]

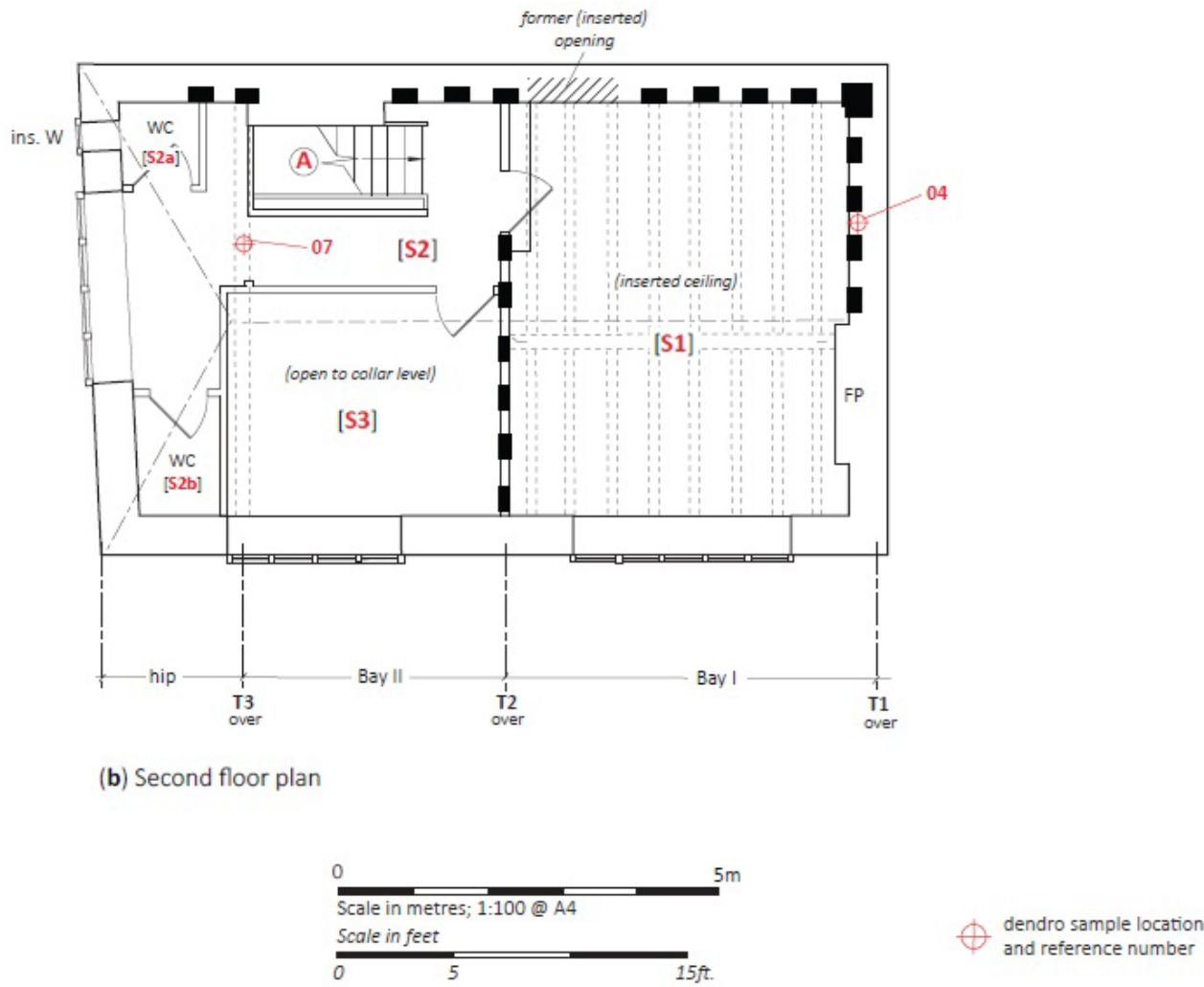


Figure 4: Second-floor plan showing the location of two samples taken for dendrochronology [adapted from an original drawing by Ric Tyler]

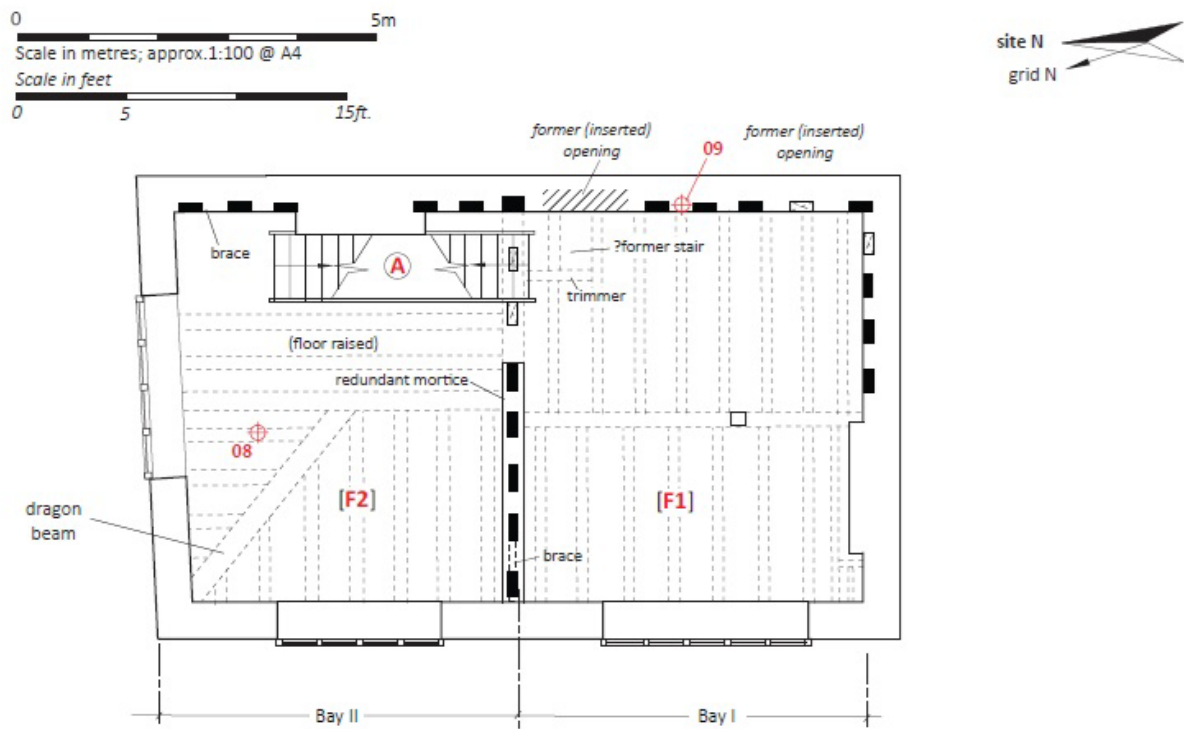


Figure 5: First-floor plan showing the location of two samples taken for dendrochronology [adapted from an original drawing by Ric Tyler]

Table 2: Cross-matching between the dated series from 1 High Street, Stratford-upon-Avon (*t*-values above 3.5 are significant)

Sample No.	<i>t</i> -values					
	strh02	strh03	strh05ii	strh07	strh08	strh09
strh01	3.1	4.0	3.0	2.5	6.0	3.9
strh02		5.6	2.9	7.9	4.9	6.0
strh03			3.3	3.4	2.8	4.3
strh05ii				2.9	2.3	4.0
strh07					2.1	4.4
strh08						4.3

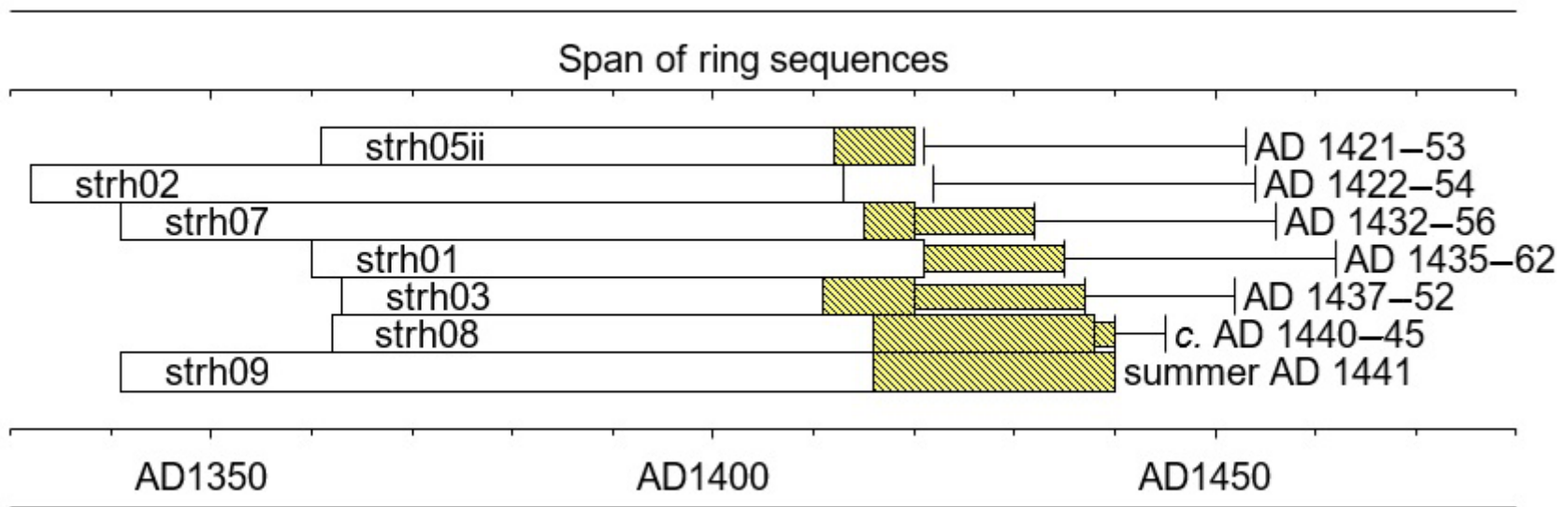


Figure 6: Bar diagram showing the relative positions of overlap of the dated timbers from 1 High Street, Stratford-upon-Avon. White sections represent heartwood rings, yellow hatched bars represent sapwood rings, with narrow sections representing additional unmeasured rings

Table 3: Strongest matches for site series SRTHt7, dated AD 1332–1440

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	t-value
Warwickshire	High Street, Henley-in-Arden	Miles and Worthington 2002	HIARDEN2	1293–1439	108	13.0
Worcestershire	The Raven Hotel, Droitwich	Bridge and Miles 2022	RAVENT15	1280–1535	109	11.7
Worcestershire	The Commandery, Worcester	Arnold et al. 2006	WORDSQ01	1284–1473	109	10.4
West Midlands	Primrose Hill, King's Norton	Arnold and Howard 2008a	KGNBSQ01	1354–1593	87	9.3
Devon	Panelling, Sydenham House	Arnold et al. 2015	SYDPSQ01	1266–1629	109	9.2
West Midlands	Halesowen Abbey	Arnold and Howard 2008b	HLNASQ01	1310–1535	109	8.9
Worcestershire	Upwich salt making site	Groves and Hillam 1997	UPWICH2	946–1415	84	8.9
Gloucestershire	10 Church Street, Tewkesbury	Arnold et al. 2023	TWKBSQ01	1265–1467	109	8.9
Worcestershire	St Nicholas' Church, Warndon	Tyers 1998	WARNDON1	1348–1424	77	8.8
Herefordshire	Cradley Village Hall	Miles and Worthington 2004	CRADLEY	1347–1530	94	8.7

Interpretation and Discussion

The seven dated timbers are from the three levels of the building sampled and appear to form a coherent group, most likely all felled at the same time (Table 1 and Fig 6). One sample, strh09, has provided a felling date of summer AD 1441. Whilst another sample, strh08, was noted at the time of sampling as to having lost a couple of millimetres from the complete sapwood during coring, and has thus been allotted a 5-year likely felling date range.

It appears that construction is likely to have taken place late in AD 1441, or within a year or two after this date. This is of interest as it is about 20 years after the written records show a carpenter being paid for work on the site, and so this construction event may represent a more substantial building replacing an earlier one. The primary structure can however be seen to significantly pre-date, and to have survived, the major fires of the late-sixteenth century as well as the slightly later one of the early-seventeenth century.

The cross-matching of the site chronology with reference chronologies (Table 2) indicates that the timber used was likely of relatively local origin.

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Appendix

Ring width values (0.01mm) for the sequences measured

strh01

186	139	103	226	186	140	162	191	133	197
157	142	164	118	220	146	148	161	170	190
143	169	137	127	114	177	208	208	175	153
122	109	101	109	100	81	127	136	170	201
206	158	148	219	197	182	231	150	202	184
163	132	152	117	124	86	117	151	178	108
207	184								

strh02i

108	139	146	169	128	115	122	155	129	144
144	176	128	215	175	146	146	133	115	126
103	113	139	142	117	154	142	208	126	143
205	209	197	122	149	152	134	172	154	138
134	159	149	162	162	163				

strh02ii

140	187	143	118	146	104	113	117	137	147
117	148	113	127	117	102	82	71	98	76
80	107	119	127	113	132	135	90	129	100
156	190	137	140	144	145				

strh03

167	169	120	132	154	175	230	186	165	107
109	99	125	152	149	196	184	169	139	168
139	162	188	271	262	215	205	179	232	164
132	135	84	125	102	104	122	121	122	129
178	164	160	176	148	180	211	130	101	115
119	90	87	88	102	111	83	98		

strh04

259	192	144	158	98	123	147	200	181	138
125	99	114	139	115	151	121	131	97	155
136	173	99	118	118	120	185	110	139	111
157	152	132	124	148	125	117	180	164	113
150	121	100	130	158	202	137	134	119	

strh05i

396	364	336	327	310	275	274	292	228	254
207	205	209	154	135	234	302	213	393	379
324	394	389	435	310	272	367	330	337	

strh05ii

105	159	187	159	117	134	108	136	169	113
80	76	69	73	105	85	114	117	106	117
119	101	74	82	123	160	184	139	133	108
138	100	102	120	106	145	123	113	130	157
118	98	136	172	131	129	125	101	127	107
129	99	88	73	89	67	86	74	100	85

strh07

186	269	332	207	276	271	245	273	202	186
271	179	198	226	213	215	242	228	253	151
186	215	236	231	167	218	163	152	220	199
160	142	127	146	143	153	190	185	258	165
127	147	100	140	118	155	137	127	166	116
136	98	78	78	98	106	108	132	143	149
112	102	90	127	86	123	100	138	160	150
125	161	122	121	135	103	120	157	121	203

strh08

266	258	227	147	240	171	132	130	82	60
96	53	88	78	89	106	86	104	117	61
86	60	63	79	86	94	73	62	64	38
74	53	61	40	90	70	71	79	101	69
74	106	102	83	98	72	112	127	77	96
102	82	86	61	82	99	100	74	126	106
118	94	90	74	52	77	99	88	80	97
124	81	73	124	148	90	81			

strh09

242	190	248	167	277	230	222	291	231	126
192	142	172	233	181	164	195	157	150	119
128	174	200	153	123	139	169	190	182	145
85	96	86	116	127	145	154	136	171	138
104	103	86	103	136	177	166	149	117	142
148	112	170	155	94	121	111	107	99	126
96	83	93	95	78	111	70	88	115	86
86	86	73	77	68	72	58	89	72	98
106	103	125	114	105	73	70	101	97	103
73	119	76	66	56	54	62	70	73	90



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