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MANOR FARM BARN, WINTERBORNE CLENSTON, DORSET
TREE-RING ANALYSIS OF OAK TIMBERS

SCIENTIFIC DATING REPORT

Martin Bridge

INTERVENTION
AND ANALYSIS

ENGLISH HERITAGE

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SUMMARY

The timberwork in this barn includes an ornate reused roof of fifteenth-century style mounted on newer hammer beams, with one truss of cruck construction clearly representing a style different to that of the main roof. The hammer beams and associated supporting frame for the roof are thought to represent the date of construction of the barn itself.

Five timbers from the reused roof were dated and appear to represent a single group of timbers felled within a brief period. The likely range in which felling of these timbers occurred was AD 1474–1506. However the information recorded about lost sapwood on one timber at the time of coring suggests a felling date around AD 1487.

The hammer beams and the east tie beam appear to have been felled at the same time as the timbers in the cruck truss, and thus a likely felling date range for these timbers was found to be AD 1528–49. However, a single timber retained complete sapwood but lost between 1mm and 2mm from the outside on coring. The core had a last measured ring formed in AD 1535, and must therefore have been felled within a few years of this date, meaning that the barn was most likely constructed in the early phase of the Dissolution of monasteries.

A single brace was dated as having come from a tree most likely felled in the period AD 1504–36. Its earlier heartwood-sapwood boundary date suggests it could be a reused or stockpiled timber.

CONTRIBUTORS

Dr M C Bridge

ACKNOWLEDGEMENTS

The original fieldwork was requested by Phil McMahon, English Heritage Inspector of Ancient Monuments and commissioned by Dr John Meadows, then of the English Heritage Scientific Dating Team, who made useful comments on an earlier draft of this report. Subsequent fieldwork was commissioned by Dr Peter Marshall following a request by Shane Gould, English Heritage Inspector of Ancient Monuments. I thank Peter Marshall and Cathy Tyers, both of the English Heritage Scientific Dating Team, for their comments on this report. The keyholder, Barry West, was most helpful in facilitating access.

ARCHIVE LOCATION

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DATE OF INVESTIGATION

2007; 2012

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INTRODUCTION

Manor Farm Barn (Figs 1 and 2) is a Scheduled Monument and Grade I listed building that is on the English Heritage Heritage at Risk register. The majority of the roof, which is stylistically dated to the fifteenth century, appears to have been taken from a nearby monastic building, the most likely candidate being Milton Abbey, only about 4km to the west (Fig 1). The hammer beams on which the roof now sits appear to be later in origin, and one truss is of cruck construction, unlike all the others. It is thought that these newer timbers may date the construction of the barn itself, which is tentatively placed in the mid-sixteenth century. The building was undergoing repairs in 2007, and dendrochronological dating was requested by Phil McMahon, English Heritage Inspector of Ancient Monuments, to try to establish the construction date of the old reused roof, which may give more information as to its origin, and of the construction of the barn itself. In 2012 further work was requested by Shane Gould, English Heritage Inspector of Ancient Monuments, in an attempt to try to refine the information gained previously. This report covers the work undertaken in both 2007 and 2012.

METHODOLOGY

The site was assessed in February, and sampled in April, 2007. A subsequent visit was made in March 2012 to take additional samples that would potentially refine the dating evidence. In the initial assessment, accessible oak timbers with more than 50 rings and traces of sapwood were sought, although slightly shorter sequences are sometimes sampled if little other material is available. Those building timbers judged to be potentially useful were cored using a 15mm auger attached to an electric drill. The cores were glued to wooden laths, 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 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.

Figure 1: Map showing the general location of Manor Farm Barn (in box) and the proximity of Milton Abbas (south-west).

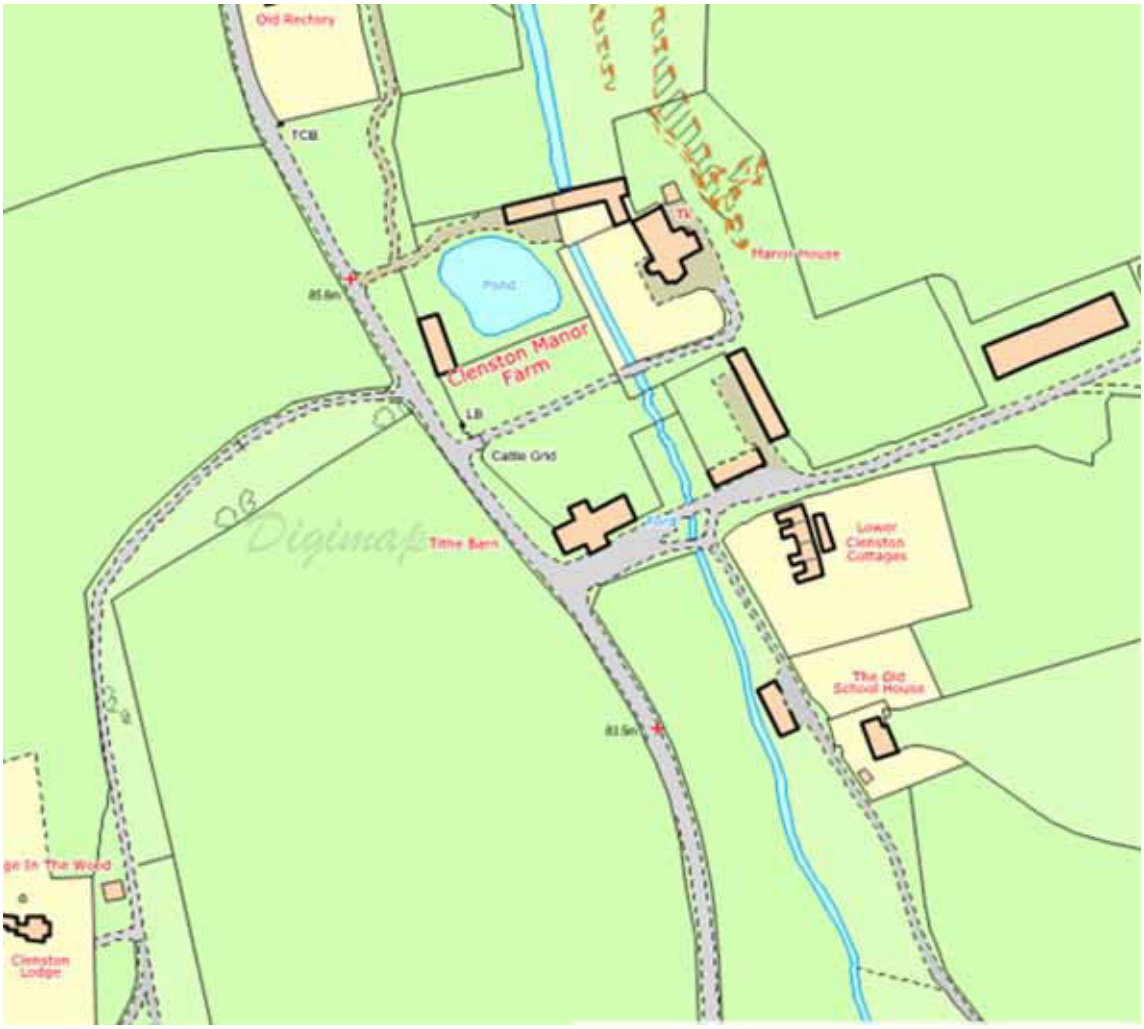

Figure 2: Map showing the location of Manor Farm Barn (centre) within its immediate environs. © Crown Copyright and database right 2014. All rights reserved. Ordnance Survey Licence number 100024900

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 of 5, 6, and higher, and for these to be well replicated with 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* (tpq) or felled-after date.

A review of the geographical distribution of dated sapwood data from historic timbers has shown that a sapwood estimate (95% confidence interval) 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. However, evidence suggests that, except in the reuse of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965; Miles 2005).

RESULTS

All timbers sampled were of oak (*Quercus* spp). Details of the samples are given in Table 1, and the positions of the samples are illustrated in Figures 3–7. Detailed drawings were only available for trusses 2, 3, and 6. One would normally expect to sample around eight or more timbers to represent each phase, however some phases here had fewer timbers sampled because of access problems and Health and Safety considerations. Many timbers were accessible via an internal scaffold which gave reasonable access to the easternmost trusses, but other trusses were only accessible by ladder.

One sample, wtc07, contained too few rings to be considered for further analysis and it was not measured. On the first sampling visit in 2007, three timbers had two samples each taken from them in order to try to extract maximum information from the timber. In each case the first and second cores matched each other well both visually and statistically, and the series were combined to produce three new series to represent the respective timbers.

wtc02a v wtc02b, t= 17.3
wtc03a v wtc03b, t= 7.0
wtc15a v wtc15b, t= 18.9

On the second sampling visit in 2012, three of the timbers were re-sampled in an attempt to refine the dating evidence by retaining the sapwood. The original and duplicate series matched well and three new series were therefore produced for subsequent analysis.

wtc08 vwtc20, t= 7.1, new series wtc2008 produced
wtc03 vwtc21, t= 12.9, new series wtc2103 produced
wtc13 vwtc22, t= 21.1, new series wtc2113 produced

Cross-matching was then carried out between all the measured timbers, initially within the expected groups at the time of sampling. The results are shown in Tables 2a–c. The cross-matching levels were rather lower than expected for long series of rings, and therefore the series were dated independently for corroborating evidence of the cross-matches found. The best results for each individual dated timber against reference material are given in Table 3. Some of the statistical matching was lower than expected given the relatively good visual matching shown for example between the hammer beams and the east-end tie beam, illustrated in Figure 8.

Sixteen timbers were successfully dated, and these were combined into a single site sequence, WINTCLN, which was dated to the period AD 1339–1535, the strongest matches being given in Table 4. A bar diagram showing the relative positions of overlap of these timbers in the groups in which they were sampled, and the interpreted felling dates for each timber is shown in Figure 9.

INTERPRETATION AND DISCUSSION

The relatively low statistical cross-matching found between most of the samples could result from the timbers coming from different sources, or maybe the result of management practices on individual trees – there is some suggestion for example of regularity in the declines in growth shown by some plots in Figure 8. Nevertheless, individual timbers matched well against the reference data, and the resulting site chronology dates well against relatively local data – the tendency to match with Hampshire chronologies probably reflecting the distribution of available chronologies more than a particular affinity with chronologies to the east of the site.

The reused timbers from the ornate roof form a single group of timbers probably felled within a short period. The mean heartwood/sapwood boundary date for this group is AD 1465, giving a likely felling date range of AD 1474–1506. One sample, wtc08, had complete sapwood at the point of sampling the timber, which was lost on coring. The missing sapwood was recorded as being 31mm deep which, at an average ring width of 1.93mm, estimates the number of missing sapwood rings as 16, giving a likely felling date of cAD 1487.

Although the hammer beams, east tie, and truss 6 were treated as different potential phases, it is apparent from their dates (most easily seen in Figure 9) that these timbers form a single group, probably all felled within a brief period, and probably associated with

the construction of the barn. The likely felling date range derived from the mean heartwood/sapwood boundary date of AD 1508, is AD 1517–49. This range can however be modified in the light of the sample wtc22 which lost a maximum of 2mm to the bark surface on coring. Adding a generous number of rings in this lost outer portion of sapwood allows a likely felling date range of c AD 1536–9 to be derived for this timber. This would imply that the hammer-beam roof supporting the reused ornate roof was constructed in the early years of the Dissolution, which is generally accepted to have started in AD 1536 for the lesser monasteries. This roof was also thought to represent the construction date of the barn itself, and so implies a construction date for the whole barn of around AD 1536–9.

One timber, wtc10, a brace apparently added to truss 2 and not part of the original construction of the barn, was most likely felled in the period AD 1504–36. If this timber had a larger number of sapwood rings than usual then it could be part of the second group of timbers used in construction of the barn, but its earlier heartwood/sapwood boundary date suggests that it may have been a reused or stockpiled timber. This timber is of different dimensions to an equivalent timber on truss 3, further supporting the idea that it is not part of the same group as the other timbers.

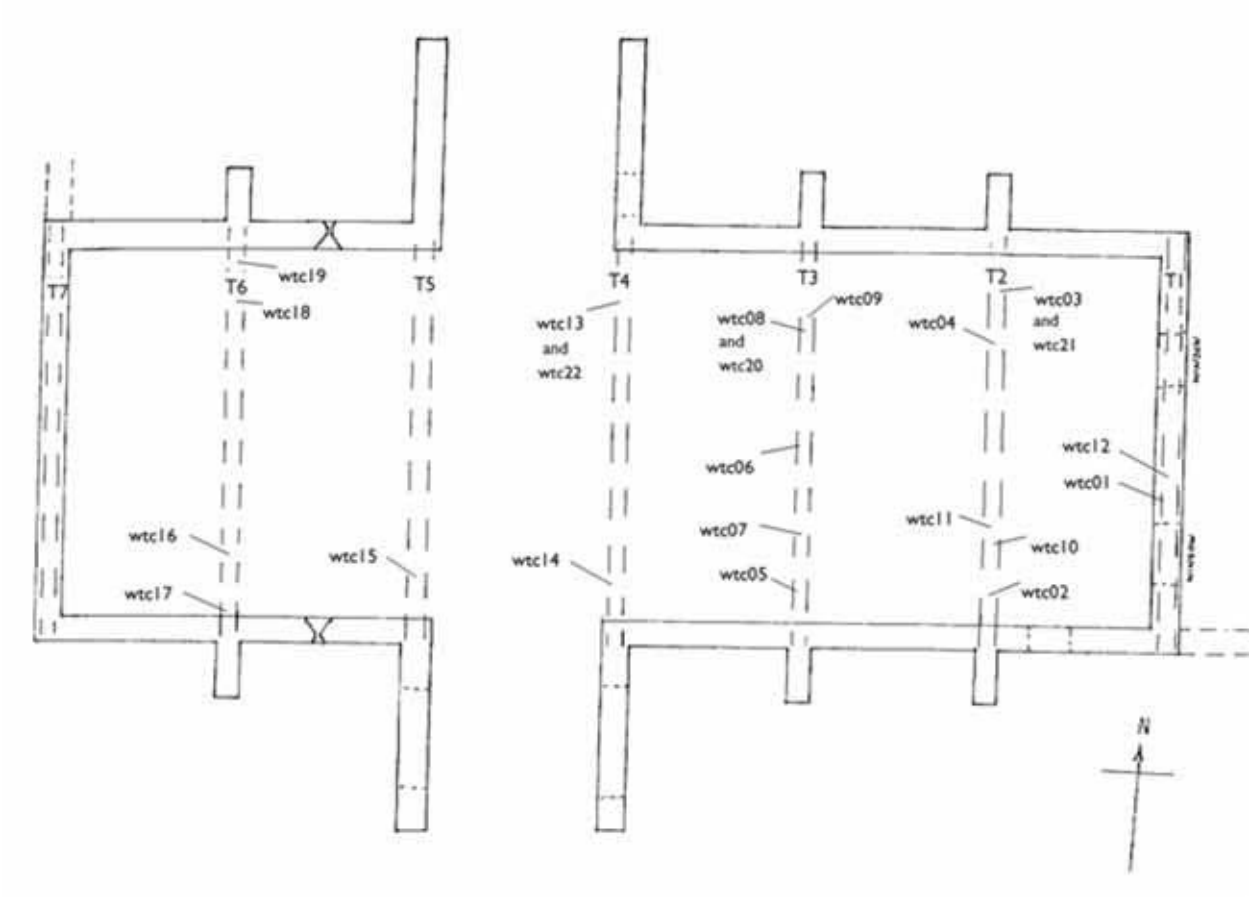

Figure 3: Plan of the tithe barn at Winterborne Clenston, showing the approximate position of samples taken for dendrochronology, based on an original drawing by P Brerner

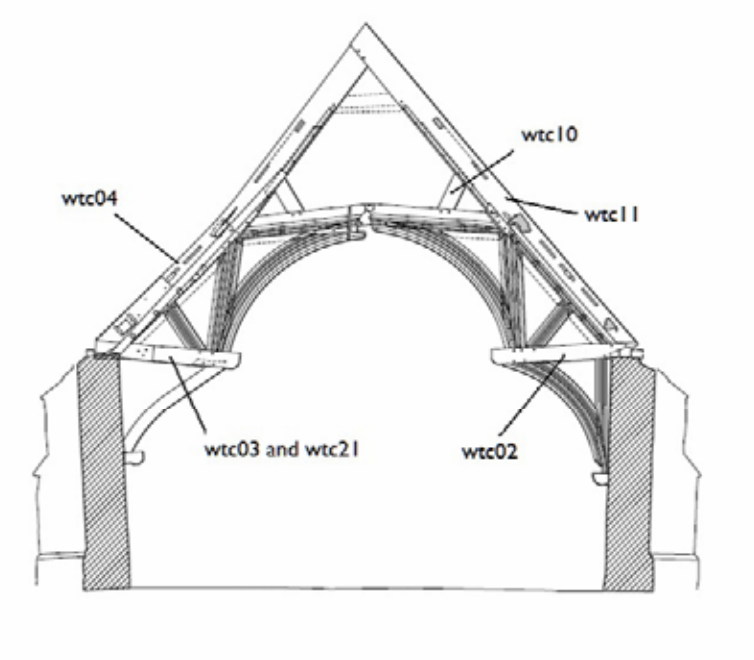

Figure 4: Drawing of truss 2, looking east, with sampled timbers indicated, adapted from an original by Nigel Fradgley

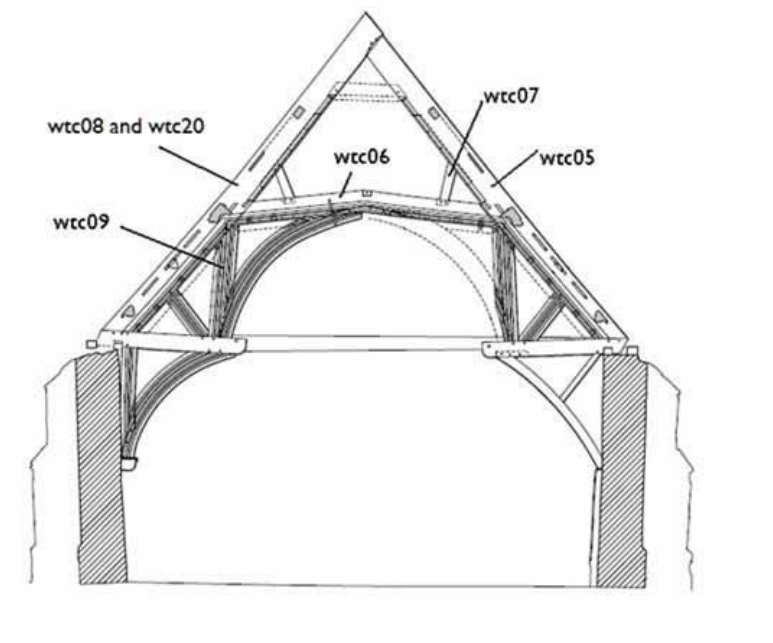

Figure 5: Drawing of truss 3, looking east, with sampled timbers indicated, adapted from an original by Nigel Fradgley

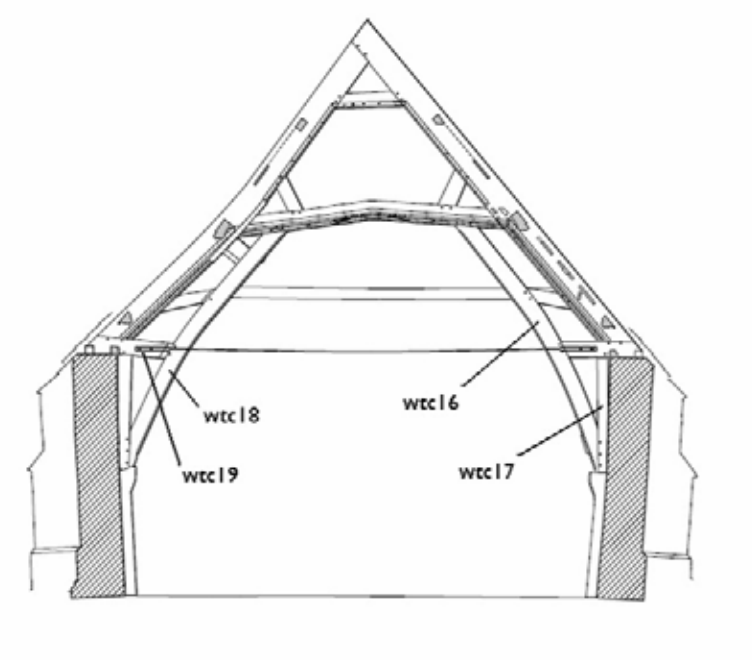

Figure 6: Drawing of truss 6, looking east, with sampled timbers indicated, adapted from an original by Nigel Fradgley

Figure 7: Photograph, looking north-east, showing the north-west side of truss 4, with the hammer beam sampled twice indicated (Martin Bridge)

Table 1: Details of oak (Quercus spp) timbers sampled from Manor Farm Barn, Winterborne Clenston, Dorset. Trusses are numbered from the east end. Key: HW = heartwood; Mean sens = mean sensitivity; H/S = heartwood/sapwood boundary; C = complete sapwood

Sample number	Timber and position	No of rings	Mean HW ring width (mm)	Mean overall ring width (mm)	Mean sens (mm)	Dates AD spanning	H/S bdry AD	Sapwood complement	Likely felling date ranges (AD)
wtc01	East end tie (tie 1)	94	1.84	1.84	0.15	1417–1510	1510	H/S	1519–51
wtc02a	South hammer beam, truss 2	74	1.73	1.73	0.23	1412–85	-	-	
wtc02b	ditto	55	1.56	1.56	0.25	1453–1507	1507	H/S	
wtc02	**Mean of 02a and 02b**	**96**	**1.74**	**1.74**	**0.22**	**1412–1507**	**1507**	**H/S**	**1516–48**
wtc03a	North hammer beam, truss 2	58	2.37	2.37	0.19	1439–96	-	-	
wtc03b	ditto	56	1.83	1.79	0.20	1451–1506	1501	5	
wtc21	ditto	37	1.85	1.85	0.17	1458–94	-	-	
wtc2103	**Mean of 03a, 03b, and 21**	**68**	**2.30**	**2.23**	**0.18**	**1439–1506**	**1501**	**5**	**1510–42**
wtc04	North principal rafter, truss 2	68	2.57	2.57	0.20	1394–1461	1461	H/S	1470–1502
wtc05	South principal rafter, truss 3	75	2.22	2.18	0.20	1401–75	1470	5	1479–1511
wtc06	Collar, truss 3	53	3.08	3.08	0.18	undated	-	H/S?	unknown
wtc07	Added brace, truss 3	<40	NM	NM	-	-	-	-	unknown
wtc08	North principal rafter, truss 3	97	1.93	1.93	0.18	1375–1471	1471	H/S + 31mmC	c1487
wtc20	ditto	80	1.92	1.92	0.20	1382–1461	-	-	
wtc2008	Mean of 08 and 20	97	1.92	1.92	0.17	1375–1471	1471	H/S + 31mmC	c1487
wtc09	North hammer post, truss 3	72	1.71	1.69	0.19	1398-1469	1468	1	1477–1509
wtc10	South brace, truss 2	84	1.75	1.75	0.24	1412–95	1495	H/S	1504–1536
wtc11	South principal rafter, truss 2	43	3.91	3.91	0.18	undated	-	H/S	unknown
wtc12	South principal rafter, truss 1	119	1.69	1.69	0.17	1339–1457	1455	2	1464–96
wtc13	North hammer beam, truss 4	60	1.57	1.57	0.21	1450–1509	1509	H/S + 20NM	1529–50
wtc22	ditto	93	1.57	1.64	0.22	1443–1535	1510	25 + <2mmC	c1536–9
wtc2213	**Mean of 13 and 22**	**93**	**1.57**	**1.64**	**0.22**	**1443–1535**	**1510**	**25 + <2mmC**	**c1536–9**
wtc14	South hammer beam, truss 4	101	1.59	1.59	0.24	1404–1504	1503	1	1512–44
wtc15a	South hammer beam, truss 5	49	1.97	1.97	0.28	1465–1513	1513	H/S	
wtc15b	ditto	60	2.82	2.82	0.17	1430–89	-	-	
wtc15	Mean of 15a and 15b	84	2.46	2.46	0.21	1430–1513	1513	H/S	1522–54

Table 1 continued.

Sample number	Timber and position	No of rings	Mean HW ring width (mm)	Mean overall ring width (mm)	Mean sens (mm)	Dates AD Spanning	H/S bdry AD	Sapwood complement	Likely felling date ranges (AD)
wtc16	South cruck, truss 6	58	2.89	2.85	0.24	1454–1511	1509	2	1518–50
wtc17	South post, truss 6	83	2.20	2.19	0.19	1433–1515	1513	2	1522–54
wtc18	North cruck, truss 6	43	3.88	3.79	0.23	1467–1509	1507	2	1516–48
wtc19	North cruck spur, truss 6	103	1.36	1.34	0.18	1406–1508	1505	3	1514–46

Table 2a: Cross-matching between dated samples from the upper levels of the roof, values above 3.5 are statistically significant

	t-values			
Sample no	wtc05	wtc2008	wtc09	wtc12
wtc04	6.6	3.4	3.4	3.0
wtc05		3.3	4.6	3.7
wtc2008			4.2	3.8
wtc09				4.5

Table 2b: Cross-matching between the timbers of the hammer beams and east tie beam, values above 3.5 are statistically significant

	t-values				
Sample no	wtc02	wtc2103	wtc2213	wtc14	wtc15
wtc01	3.1	5.9	2.8	1.8	2.8
wtc02		2.1	1.9	4.1	1.8
wtc2103			3.5	3.3	3.7
wtc2213				7.9	3.3
wtc14					2.8

*Table 2c: Cross-matching between the timbers from Truss 6, along with the lone brace to truss 2, positions marked * have too small an overlap to justify calculating a t value*

t-values				
Sample no	wtc16	wtc17	wtc18	wtc19
wtc10	4.0	4.5	*	3.8
wtc16		4.1	*	3.5
wtc17			*	3.2
wtc18				*

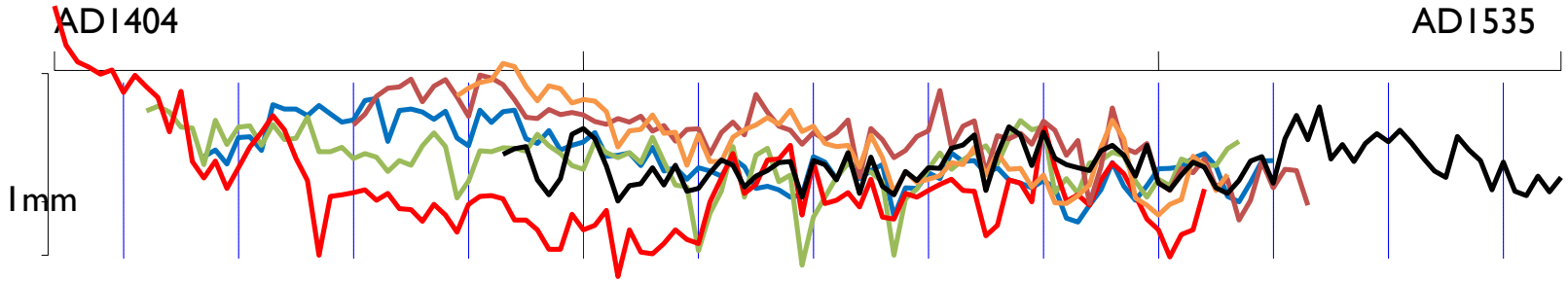

Figure 8: Plots of the ring width series from the hammer beams and the east end tie showing their overall similarities. The x axis is time in years, divided into decades by the vertical dotted lines, the y axis is the ring width in mm plotted on a logarithmic scale

Table 3: Highest matches for each individual dated series

Sample no	Last year AD	t-value	No of years overlap	Chronology name	Short reference
wtc01	1510	6.9	94	WGATE1	(Tyers and Wilson 2000)
		6.8	94	NUFF	(Haddon-Reece etal1989)
wtc02	1507	5.4	96	WCCLOSE3	(Miles etal2003)
		5.3	96	TFDEANE	(Miles etal2005)
wtc2103	1506	6.5	68	HANTS02	(Miles 2003)
		6.2	68	KNWESQ01	(Howard etal2006)
wtc2213	1509	6.0	93	OVERTON7	(Miles etal2005)
		5.6	93	CLRENDN7	(Miles etal2004)
wtc14	1504	6.9	96	BREMORE1	(Miles and Haddon-Reece 1996)
		5.7	101	CL_QMF2	(Tyers and Groves 1999)
wtc15	1513	7.7	84	SYDMNTN1	(Miles etal2005)
		6.0	61	HEMINGTN	(Miles and Worthington 2002)
wtc16	1511	7.3	58	HFCASQ01	(Arnold etal2003)
		7.1	58	KNWESQ01	(Howard etal2006)
wtc17	1515	6.1	83	HANTS02	(Miles 2003)
		5.8	83	ACTON	(Haddon-Reece and Miles 1994)
wtc18	1509	5.7	43	BRRYCTFM	(Miles etal2003)
		4.9	43	SKYERSFM	(Miles etal2004)
wtc19	1508	5.6	103	WHANNEY	(Miles etal2005)
		5.6	99	OVERTON2	(Miles and Haddon-Reece 1994)
wtc04	1461	5.8	68	BLCKCANN	(Miles etal2004)
		6.5	68	OVERTON5	(Miles and Worthington 2002)
wtc05	1475	7.0	75	LHM2	(Miles and Worthington 1999)
		6.2	75	SYDMNTN1	(Miles etal2005)
wtc2008	1471	5.8	84	HOLYWELL	(Miles etal2010)
		5.7	97	GROVEFM	(Miles and Worthington 1998)
wtc09	1469	6.6	72	SYDMNTN1	(Miles etal2005)
		5.7	72	DITTON4	(Miles etal2004)
wtc12	1457	6.3	85	BURCLER2	(Miles etal2005)
		5.3	119	VYNECOTT	(Miles and Worthington 2000)
wtc10	1495	8.3	84	SOMRST04	(Miles 2004)
		6.6	84	EXMED	(Mills 1988)

Table 4: Highest matches for a site chronology WINTCLEN, AD 1339–1535, produced by combining all the dated timbers

County/ region:	Chronology name:	Short publication reference:	File name:	Spanning: (yrs AD)	Overlap (yrs)	t-value
Hampshire	Hampshire master	(Miles 2003)	HANTS02	443–1972	197	10.2
Hampshire	Sydmonton Court, Kingsclere	(Miles etal2005)	SYDMNTN1	1383-1529	147	9.4
Hampshire Ω	St Olaf's Pond Cottage, Wonston	(Miles and Worthington 1997)	STOLAFS	1376-1535	160	8.3
Hampshire	10 The Close, Winchester	(Miles etal2003)	WCCLOSE3	1388-1528	141	8.0
Hampshire	St Mary and St Ethelflaeda, Romsey	(Hillam and Groves 1994)	ROMSEY	1362-1496	135	8.0
Somerset	Somerset Master Chronology	(Miles 2004)	SOMRST04	770-1979	197	8.0
Wiltshire	Salisbury Cathedral	(Miles etal2005)	SARUM11	1409-1541	127	7.7
Hampshire Ω	Huntingford Cottage, Headley	(Miles and Worthington 2002)	HUNTNFRD	1420-1565	116	7.6
Hampshire Ω	Mottisfont Abbey	(Miles 1996)	MOTISFNT	1388-1538	148	7.5
Somerset	Taunton Castle	(Miles and Bridge 2010)	TAUNTCA	1380-1479	100	7.4

Ω = constituent of HANTS02

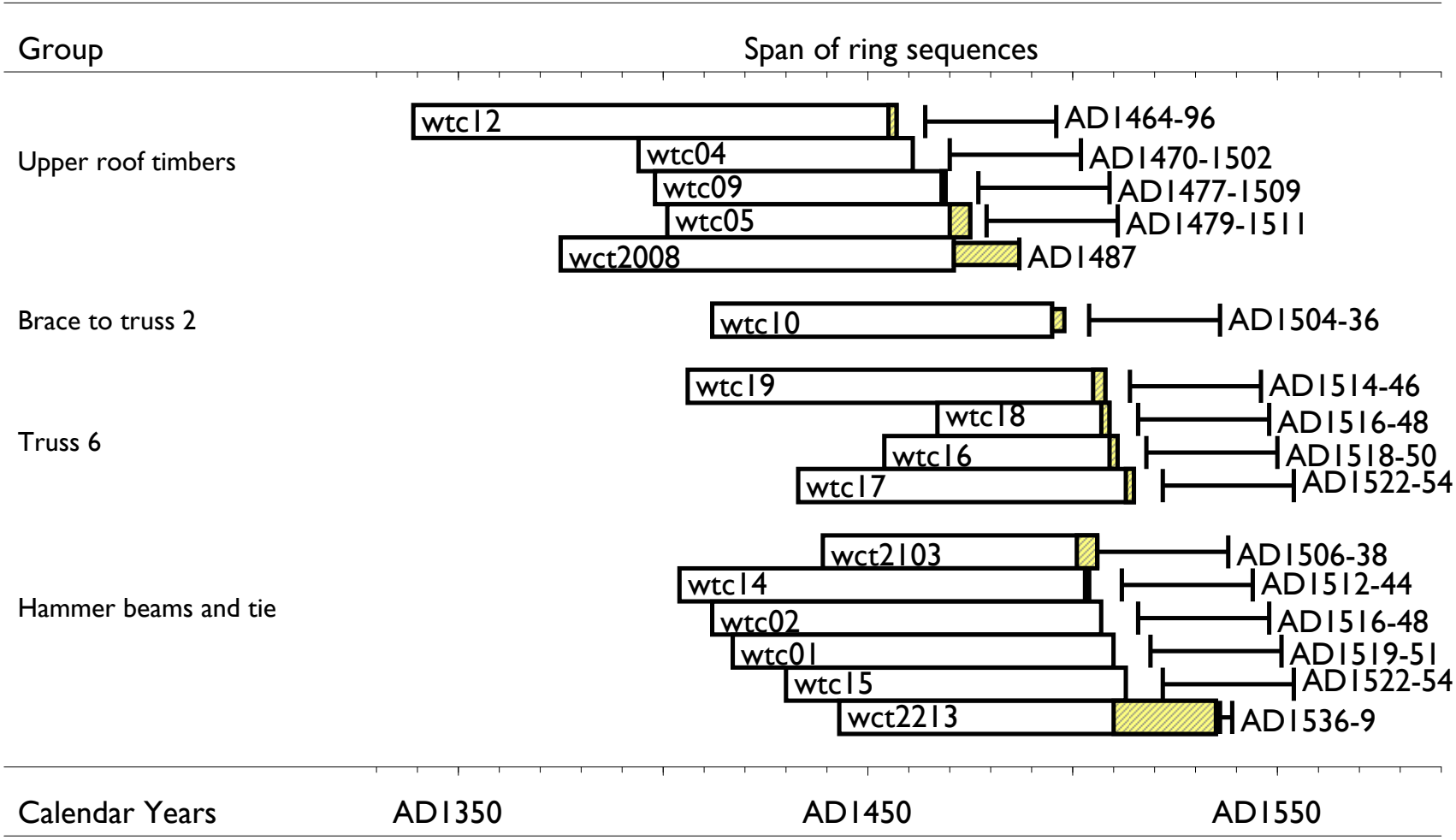

Figure 9: Bar diagram showing the relative positions of overlap of the dated timbers and their likely felling date ranges. White bars represent heartwood rings, yellow hatched bars sapwood, and narrow sections represent unmeasured additional sapwood rings

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APPENDIX

Ring width values (0.01mm) for the sequences measured

wtc01

174	189	159	220	222	188	329	312	312	288
326	294	266	273	347	355	210	307	312	301
275	304	219	199	308	265	302	308	217	205
240	189	200	208	234	175	177	182	156	195
146	152	132	152	146	137	171	154	118	121
116	106	109	174	163	133	165	133	147	158
84	119	118	143	133	182	164	166	142	152
131	126	119	130	119	82	78	96	116	162
121	102	122	150	151	154	171	181	155	107
100	127	165	166						

wtc02

305	323	301	250	247	158	272	202	250	254
200	258	215	218	283	185	185	195	170	181
173	145	166	157	199	233	197	105	129	187
185	194	193	186	229	199	181	156	149	209
183	172	183	162	221	164	123	120	55	87
114	197	106	177	193	128	139	46	83	106
135	160	153	144	128	52	104	117	150	182
149	167	184	199	159	217	271	242	251	112
133	111	161	166	184	176	129	106	132	122
169	160	157	156	192	210				

wtc03

366	403	432	445	546	525	412	345	414	401
336	351	344	303	196	239	243	290	232	249
158	219	163	165	217	241	255	283	249	308
223	234	180	180	169	132	197	145	103	144
121	132	134	163	163	191	131	176	141	152
122	144	104	111	114	132	195	272	217	105
96	85	97	103	175	156	115	140		

wtc04

247	313	428	328	242	283	373	402	302	317
327	259	343	330	401	252	226	202	337	370
278	291	166	168	274	183	310	281	186	283
297	274	224	162	277	176	217	240	286	247
207	212	252	435	281	230	220	231	215	159
147	232	183	230	289	260	249	265	235	193
243	209	219	206	200	184	178	189		

wtc05

374	306	250	271	238	321	303	377	275	251
181	238	319	288	253	167	234	289	149	210
256	238	285	236	196	166	164	288	236	189
237	273	203	205	257	287	393	271	211	196
179	188	205	141	249	173	229	232	229	152

182 198 145 149 150 179 207 162 222 240
148 138 194 122 134 170 182 155 173 217
205 209 180 124 137

wtc06
893 1177 903 325 307 271 312 364 338 322
265 456 393 438 263 169 161 168 260 221
257 246 253 208 148 206 203 274 350 400
369 246 269 265 271 230 214 208 223 279
203 267 242 206 242 286 249 248 255 210
208 306 299

wtc08
253 190 179 209 224 289 286 197 226 230
247 290 228 297 213 261 202 199 239 201
213 214 180 189 249 321 270 233 156 236
217 234 262 245 320 255 180 243 256 227
185 169 128 264 197 203 153 207 260 219
167 161 156 224 165 157 156 159 130 138
168 183 248 138 101 163 135 176 186 179
157 151 166 136 167 116 193 140 186 170
126 125 123 158 139 136 124 137 153 133
135 144 159 150 153 188 185

wtc09
468 468 394 263 242 269 310 339 294 286
230 312 183 137 166 206 272 233 158 182
351 208 211 177 189 224 252 211 155 103
187 166 134 142 129 130 119 141 128 146
133 85 90 84 75 84 76 95 107 113
100 103 105 116 95 138 142 116 157 121
96 104 83 89 80 117 91 103 124 82
104 79

wtc10
82 94 114 104 81 84 96 68 105 81
55 147 135 122 105 68 102 90 79 106
113 127 68 207 318 298 231 255 216 275
207 281 266 234 379 321 211 232 255 232
197 247 317 283 259 294 235 189 228 167
178 254 135 131 211 217 186 171 197 177
194 193 184 263 134 62 110 117 129 142
150 101 148 176 143 166 146 159 201 167
196 121 172 197

wtc11
494 536 550 527 553 627 398 483 490 294
564 266 326 335 359 363 307 297 376 501
529 407 506 451 416 355 271 233 360 252
364 321 331 390 333 348 323 285 356 386
340 354 248

wtc12

374	489	401	420	312	265	247	234	229	282
313	230	279	217	215	232	175	200	198	169
209	213	267	168	174	149	138	152	113	125
138	205	138	125	178	147	191	224	129	145
194	159	169	143	148	143	214	258	174	200
143	152	156	148	161	143	165	152	147	148
161	227	248	171	160	150	159	183	206	138
138	139	118	152	193	159	146	102	99	133
110	85	124	142	193	198	142	95	83	105
121	88	120	139	126	109	128	110	91	108
94	112	122	153	123	91	100	118	139	132
116	109	141	111	139	151	150	134	133	

wtc13

246	208	145	101	128	132	156	122	151	111
110	137	162	157	126	134	146	164	166	107
168	162	131	185	118	177	120	100	139	122
154	154	194	207	229	115	175	257	236	158
240	187	154	143	145	167	200	187	147	205
130	117	141	163	158	122	111	125	164	176

wtc14

1103	683	556	522	479	504	383	472	410	360
236	388	164	134	165	118	152	196	235	288
242	171	130	52	107	109	112	116	102	111
92	91	79	97	85	69	97	107	108	104
80	80	71	56	56	86	71	75	90	40
71	54	53	60	71	63	60	100	134	181
111	124	167	169	200	85	163	98	102	112
94	132	83	81	111	106	115	124	132	115
114	66	75	131	126	100	266	154	101	109
96	131	161	141	108	81	71	51	67	71
117									

wtc15

257	293	365	403	409	450	341	413	448	362
285	473	457	421	351	282	278	310	291	299
290	268	259	278	266	286	238	255	211	243
245	180	234	266	227	373	300	253	241	203
234	214	234	273	135	246	214	172	188	223
239	392	195	253	270	142	225	217	232	203
269	241	177	212	98	154	316	194	183	205
127	115	151	143	170	120	132	80	102	164
119	149	147	96						

wtc16

459	340	415	390	446	286	436	320	302	381
235	324	470	442	543	297	325	267	236	251
308	371	329	207	297	468	384	365	292	418
531	357	268	270	233	186	268	148	187	197
246	260	373	288	148	178	130	107	137	185
190	215	116	93	133	143	151	167		

wtc17

357	278	321	385	351	256	228	241	245	194
223	238	211	184	242	163	216	174	173	179
186	197	171	194	138	174	201	241	191	178
237	183	262	264	237	203	253	195	247	188
186	207	235	188	107	243	249	212	327	294
255	258	188	296	312	266	243	259	175	188
170	214	253	362	235	193	174	202	162	200
189	180	194	129	148	184	240	177	163	184
144	206	224							

wtc18

701	721	531	453	364	442	537	537	606	523
283	411	561	479	392	490	427	380	223	247
285	242	267	266	226	206	391	290	284	465
400	248	265	242	275	326	377	357	612	256
331	173	187							

wtc19

465	516	348	307	399	352	236	259	213	212
171	117	271	224	275	197	191	239	220	198
134	145	178	199	153	156	135	149	161	169
149	189	151	83	65	98	97	95	99	97
119	109	79	88	82	76	96	69	84	67
87	85	74	68	62	71	68	80	62	68
72	74	52	43	79	85	95	86	77	74
41	37	57	82	86	92	97	88	91	101
108	94	86	98	78	65	64	69	118	117
182	151	141	172	101	119	160	166	157	168
68	57	72							

wct20

197	218	187	227	303	235	318	260	223	204
161	245	199	253	204	185	221	241	215	251
247	152	235	203	248	232	275	403	347	253
351	211	151	119	125	124	217	152	207	156
164	194	185	152	149	127	154	128	126	147
185	128	162	186	191	269	161	111	136	157
125	208	200	144	142	157	168	150	147	181
117	163	168	204	192	153	171	130	128	148

wct21

222	156	236	166	163	225	243	260	280	269
308	251	272	230	215	232	174	255	200	122
146	133	132	143	162	154	199	147	188	158
150	118	134	95	86	102	114			

wct22

179	192	197	131	109	133	229	247	226	166
101	116	118	148	124	163	118	127	150	172
157	114	141	148	161	163	105	164	154	132
181	104	169	122	118	151	138	151	149	193
196	225	116	185	245	218	155	231	155	163

161	150	208	200	168	127	195	123	116	138
163	149	117	112	135	167	173	126	217	289
214	321	169	202	164	205	231	209	241	206
172	146	135	223	189	166	116	163	114	108
137	113	135							






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