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Tree-Ring Analysis of Timbers from Priory Barn, Little Wymondley, Hertfordshire

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Summary

Before this dendrochronological study was undertaken it was widely believed that the barn was of early to mid fifteenth-century construction, relating to the Augustinian priory known to have existed on the site. Radiocarbon measurements produced in the AD 1960s were at the time estimated to relate to probable historical ages of c AD 1265 and c AD 1625 or AD 1425. Re-used timbers found in the roof of the extant barn are of late fourteenth-century date (likely felling period **AD 1373-95**) and may relate to an earlier barn. The timbers for the present barn were found to have been cut in the winter of **AD 1540-1**, when the post-Dissolution estate was owned by James Nedeham (or Needham), Surveyor of the King's Works to Henry VIII. Amongst the sixteenth-century dated timbers were battens nailed to the main framing posts to which weather-boarding was attached, the common studs being set about 20mm in from the external face, making the weather-boarded panels flush, an interesting transition from vertically inset boards to fully external feather-edged weather-boarding. The north porch, although of different design to the south porch, was found to be broadly contemporaneous, although the timbers may have come from a different location to the remainder of timber used in this phase of building. The lean-to at the west end failed to date. The site chronologies formed, although relatively short, gave exceptionally strong crossmatching with the available reference material.

Keywords

Dendrochronology
Standing Building

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TREE-RING ANALYSIS OF TIMBERS FROM PRIORY BARN, LITTLE WYMONDLEY, HERTFORDSHIRE

Introduction

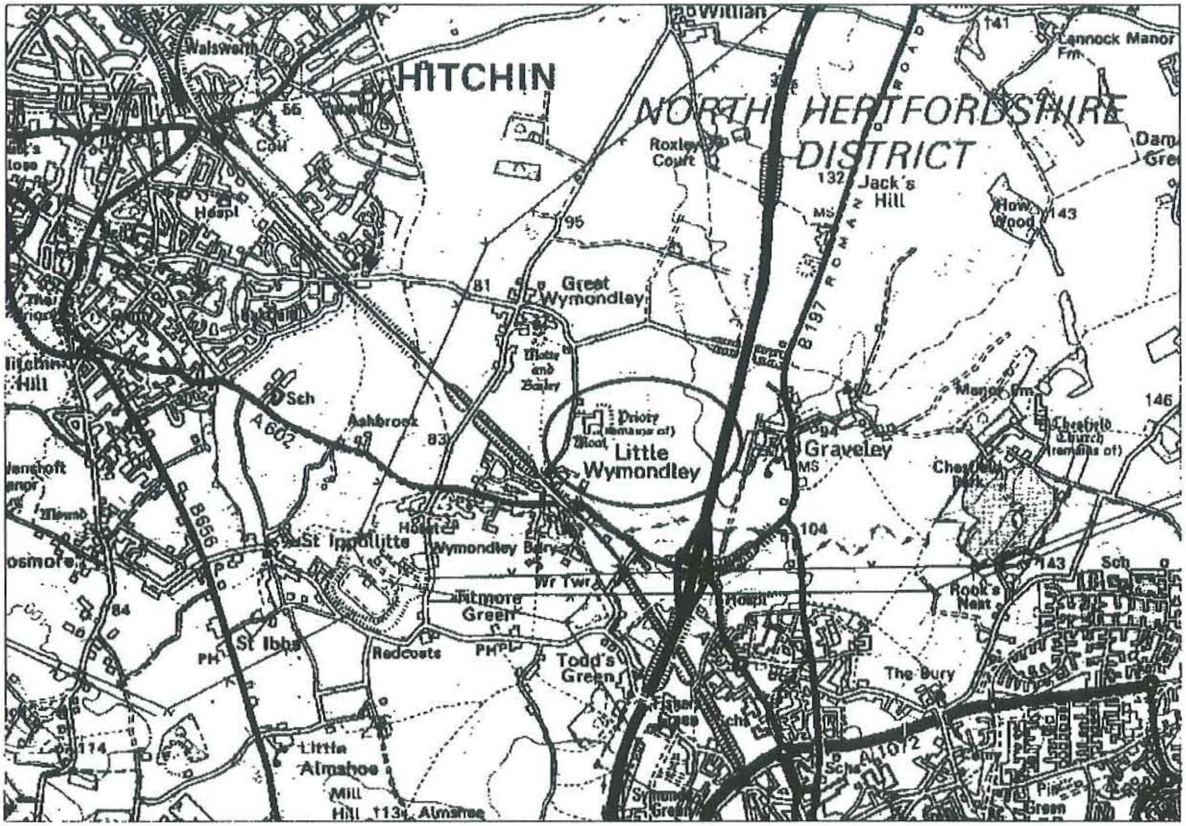
Priory Barn (NGR TL 218279; Fig 1) is a grade II* listed aisled-barn and Scheduled Ancient Monument. It is large, measuring 102 x 39 feet (approximately 31 x 12 m), divided into nine bays, and is symmetrical. Although the present barn appears to be all of one construction (except for the lean-to sections at either end), many timbers appear to have been re-used from an earlier structure. Many common rafters have mortices at their lower end, angled to suggest that they once had ashlar pieces inserted in them, and several of the principal rafters have mortices below the collar which do not relate to the current design. Some aisle ties also appear to be re-used, again having deep-brace mortices which do not relate to their present function.

The barn occupies the site of a former Augustinian priory, some remnants of which can be seen *in situ* in the adjacent farmhouse, which was converted into a dwelling house at the time of the Dissolution. The barn has long been considered by building historians to be of early to mid fifteenth-century origin, and indeed it is stylistically similar to the Manor Barn at Harmondsworth, Middlesex, previously dated by dendrochronology to after AD 1432 (Fletcher 1983), though subsequently dendrochronologically dated by Tyers and Hibberd (1993) who found that the timbers had been felled in the ?spring of AD 1426.

Radiocarbon measurements were produced on timbers from the barn in the AD 1960s. The sapwood from a post of Truss H gave a radiocarbon result of 670±60 BP (UCLA-1057) which at the time was estimated to relate to a probable historical age of *c* AD 1265, and that from a post of Truss G gave a result of 350±60 BP (UCLA-1058) which was estimated to relate to a probable historical age of either *c* AD 1475 or *c* AD 1625 (Berger and Libby 1967, 489). In the same paper sapwood from a post of the Harmondsworth barn produced a radiocarbon result of 555±60 BP which was estimated to relate to a probable historical age of *c* AD 1295 to 1415 (ibid, 489-90).

The barn has a side-purlin roof with two tiers of butt purlins. The upper purlins are carried on collars, the lower purlins are supported by inclined straight queen posts. Long curved braces from the arcade posts support heavy cambered tie beams. The main longitudinal timbers are joined with edge-halved scarf joints, having bridled butt joints in the lower third, with the upper third extending down into the middle third as a tenon where it is secured by in-line edge-pegs. This scarf joint is rare, as yet only recorded elsewhere in the north-west transept roof of Canterbury Cathedral and at the Harmondsworth barn (Hewett 1980,197). Those examples have been dated to the fifteenth century by documentary evidence and tree-ring dating respectively. It is used as well at Hemel Hempstead church in Hertfordshire to join the undated long spire rafter lengths together (Gibson pers comm). The exterior face of the posts of the east wall are heavily weathered, though the wall is now protected by an added lean-to, thought on stylistic grounds to be of nineteenth-century origin. The posts have battens nailed to them about 1" (*c* 25mm) in from the external face, to which feather-edged weather-boarding has been attached in flush panels. Some remaining boards of elm (*Ulmus* spp.) appear to be original. The external faces of the posts of the west wall do not show weathering, and thus there may always have been a lean-to at this end.

On-site discussion with Richard Bond and Adrian Gibson suggested that the north porch might be a later modification. This suggestion is based on the braces, which differ from those in the south porch, which appears integral to the rest of the barn.


HITCHIN
NORTH HERTFORDSHIRE DISTRICT
Walsworth
Roxley Court
Jack's Hill
Great Wymondley
Little Wymondley
Graveley
Priory (remains of)
Motte and Bailey
Ashbrook
Sch
A 602
B656
St Ippollitts
Wymondley Bury
Titmore Green
Todd's Green
Redcoats
St Ibbs
Little Almshoe
Mill Hill
The Bury
Rook's Nest
Chesfield Church (remains of)
Manor Fm
How Wood
Lannock Manor Fm
Willian
B197
A1072
Hospl
Wr Twr
Symonds Green

Dendrochronological dating was requested by Deborah Priddy (English Heritage) and Adrian Gibson in order to establish a building date for the barn and further the understanding of the development of late-medieval carpentry in the region, and to determine whether the west lean-to was contemporaneous with the primary construction of the barn.

Methodology

The site was visited twice, once during AD 1999, and once in AD 2000. It was apparent after the first visit that it would be desirable to sample timbers high in the roof, which was not possible on the first visit. In the period between the two visits, other interesting details were noticed, and additional areas were later sampled. Overall sampling was carried out to include a range of structural elements associated with the primary construction, incorporating the clearly re-used timbers in the present building, battens supporting the weather-boarding, the north porch area, and the west lean-to.

The timbers were assessed for their potential use in dendrochronological study. Oak timbers with more than 50 rings, traces of sapwood, and accessibility were the main considerations in the initial assessment. Those 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. On the second visit other important timbers were sampled which perhaps did not show as many rings as are normally looked for, in the hope that they might crossmatch with the working site chronology already well-developed by this stage.

The cores were prepared for measuring by sanding using an electric belt-sander with progressively finer grit papers down to 400 grit. Any further preparation necessary, eg where bands of narrow rings occurred, was done manually. Suitable samples had their tree-ring sequences measured to an accuracy of 0.01 mm using a specially constructed system utilizing a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC. The software used in measuring and subsequent analysis was written by Ian Tyers (1999).

Ring sequences were plotted to allow visual comparisons to be made between sequences on a light table. This activity also acts as a measure of quality control in identifying any errors in the measurements when the samples crossmatch. Statistical comparisons were made using Student's *t*-test (Baillie and Pilcher 1973; Munro 1984). The *t*-values quoted below were derived from the original CROS program (Baillie and Pilcher 1973). Those *t*-values in excess of 3.5 are taken to be indicative of acceptable matching positions provided that they are supported by satisfactory visual matches, and give consistent matching positions.

When crossmatching between samples is found, their ring-width sequences are meaned to form an internal 'working' site mean sequence. Other samples may then be incorporated after comparison with this 'working' master until a final site sequence is established, which is then compared with a number of reference chronologies (multi-site chronologies from a region) and dated individual site masters in an attempt to date it. Individual long series which are not included in the site mean(s) are also compared with the database to see if they can be dated.

The dates thus obtained represent the time of formation of the rings available on each sample. Interpretation of these dates then has to be undertaken to relate these findings to the construction date of the phase under investigation. An important aspect of this interpretation is the estimate of the number of sapwood rings missing. In this instance, the sapwood estimates are based on those proposed for this area by Miles (1997), in which 95% of samples are likely to have from 9 to 41 sapwood rings. Where bark is present on the sample the exact date of felling of the tree used may be determined.

The dates derived for the felling of the trees used in construction do not necessarily relate directly to the date of construction of the building. However, evidence suggests that, except in the re-use of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965).

Results

All the timbers sampled were oak (*Quercus* spp.). Details of the samples and their origins within the building are given in Table 1, and illustrated in Figures 2 - 5. A large number of series crossmatched with each other, initially forming three separate groups. The degree of crossmatching between each individual ring-width series within each of the two largest groups is shown in Tables 2 and 3. Some of the individual sequences match better against several combined series than against individuals. When a large number of timbers had been crossmatched into a well-replicated working site master, it was decided to try the shorter series such as LWY25, which at only 37 rings would not normally be analysed further. Visual crossmatching of these series (LWY 25, 26, and 27) was very good.

Two timbers from the north porch (LWY 14 and 15) matched each other well (t = 7.1 with 71 years of overlap) but gave significant matches against only one other individual timber (LWY03, t = 4.6 with 68 years of overlap). These two timbers were therefore combined into a single series (NPORCH) which was dated separately (Table 4). However, NPORCH was contemporaneous and matched well with a working master composed of the other primary timbers (t = 5.2, 80 years overlap) and, since they were part of the site, the two individual series (LWY 14 and 15) were incorporated into the second site chronology (see below). The relative positions of overlap of the dated timbers are shown in Figure 6. The dated series were combined to make two site chronologies, one representing the re-used timbers used as aisle ties and principal rafters (WYMONDLEY1) and the second from primary timbers (WYMONDLEY2). The chronologies were dated by comparison with a range of regional and site chronologies, the best results being shown in Tables 5 and 6.

Amongst the undated series, LWY29 (100 rings) and LWY31 (83 rings), both from the lean-to on the west end of the barn, crossmatched (t = 8.9 with 83 years of overlap), and were combined into a series named LWY2931M (Table 7). This did not give any consistent crossmatching with the reference material.

The ring-width data for the dated site series and LWY2931M are given in Table 7.

Interpretation and Discussion

A large number of timbers in the barn had complete sapwood out to the original bark surface. It is clear from the results that the trees producing the main structural timbers of the barn were cut in the winter of AD 1540-1, indicating an immediately post-Dissolution construction date. The good crossmatching of shorter series than are usually analysed against a well-replicated working site master chronology allowed some important non-structural timbers to be dated. The building incorporates a number of re-used timbers, which if taken as a single contemporaneous group, have a likely felling date of AD 1373-95. These re-used timbers may well represent material from an earlier structure built to serve the Augustinian priory. The timbers used in the north porch did not match most of the remaining timbers, although they have an estimated felling date range of AD 1531 – 53, making them of very similar date to the main batch of timbers. They date well against a range of chronologies, and probably represent timbers from a different

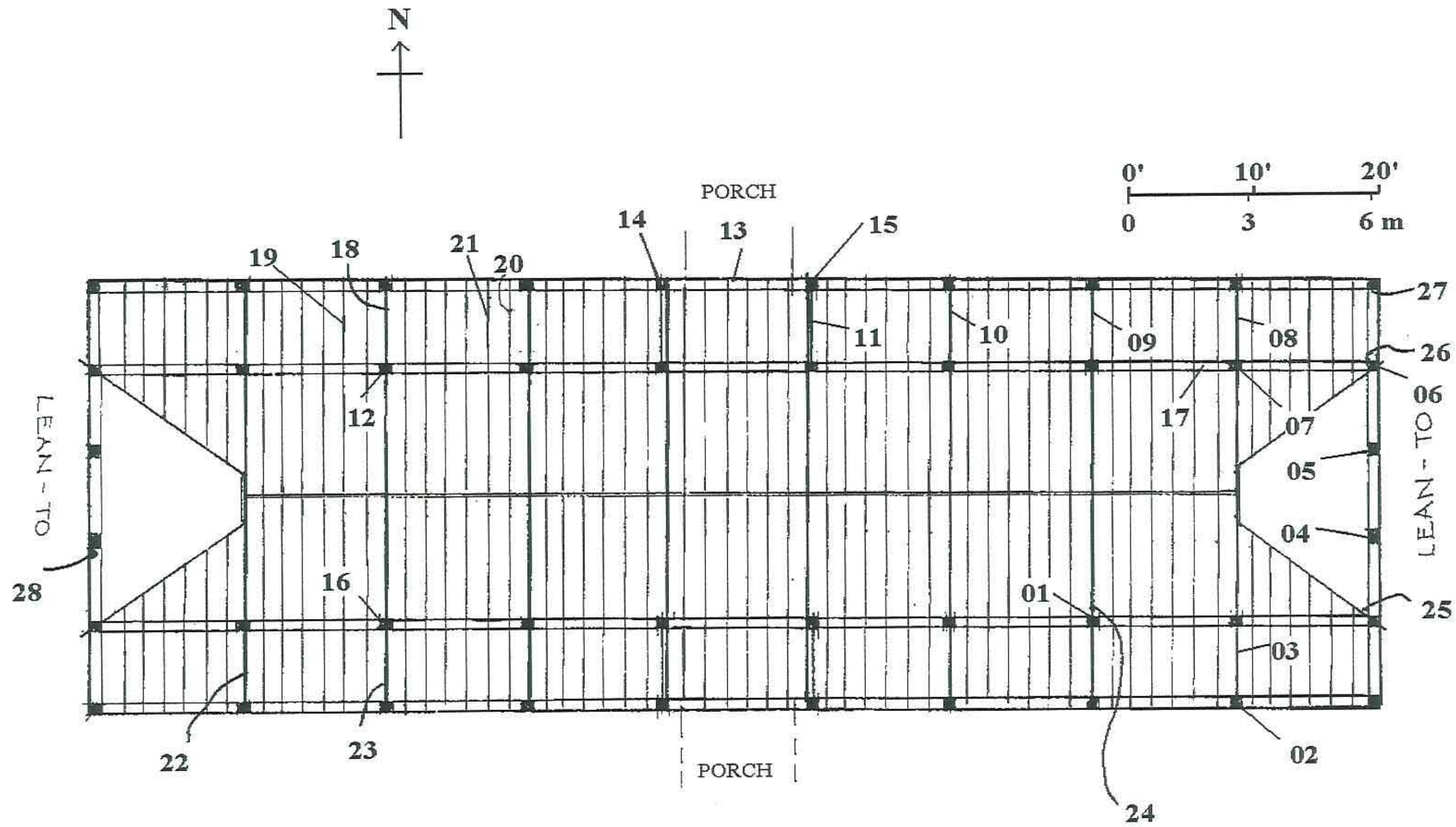


Figure 2: Plan of Priory Barn, Little Wymondley, showing the locations of samples taken for dendrochronology. Based on an original drawing by Adrian Gibson. Trusses are numbered from the west end

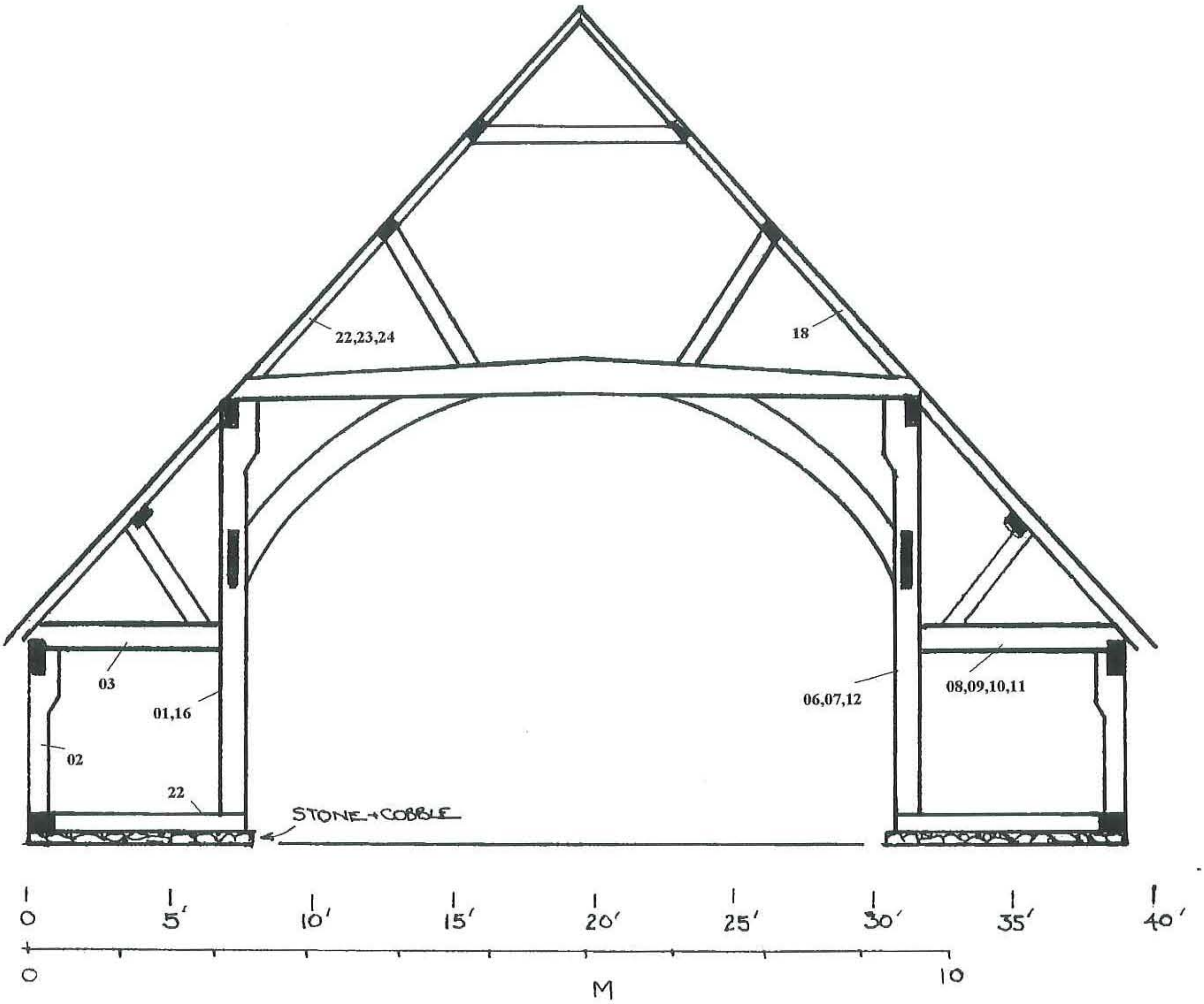


Figure 3: Cross section of a typical truss (viewed from the east), showing the timbers sampled for dendrochronology. Based on an original drawing by Adrian Gibson

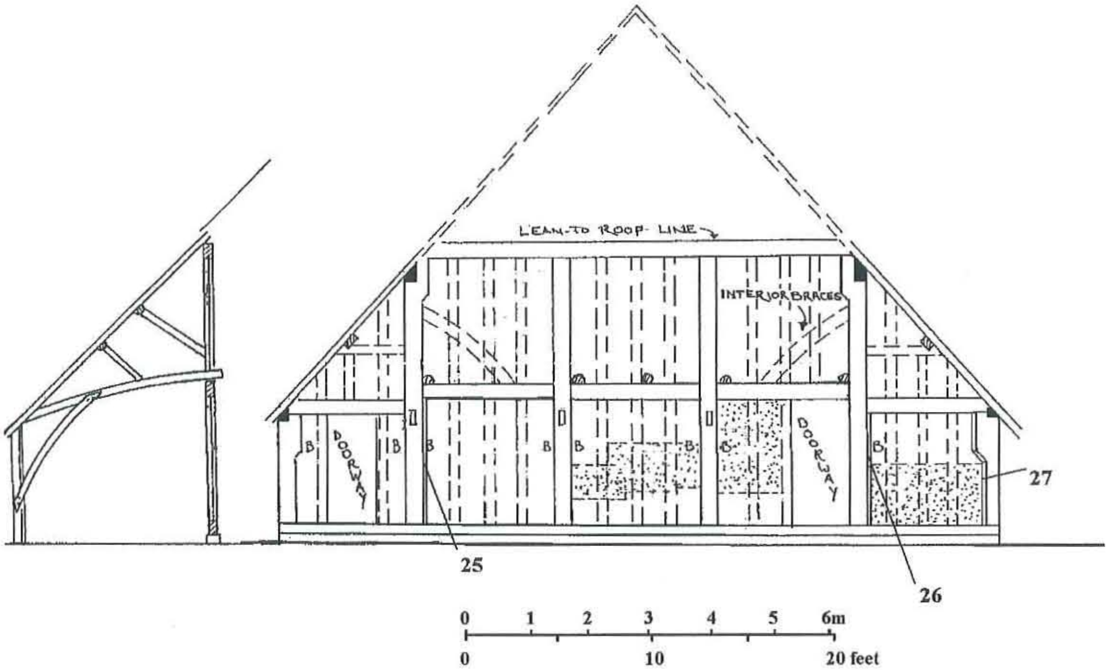


Figure 4: Drawing of the east end wall showing the location of the battens (B) supporting original weatherboarding (shaded). the numbers refer to the location of samples of the battens removed for dendrochronological analysis. The lean-to (left) is made from ash poles, nailed together, and is thought to be of nineteenth-century construction. Based on an original drawing by Adrian Gibson

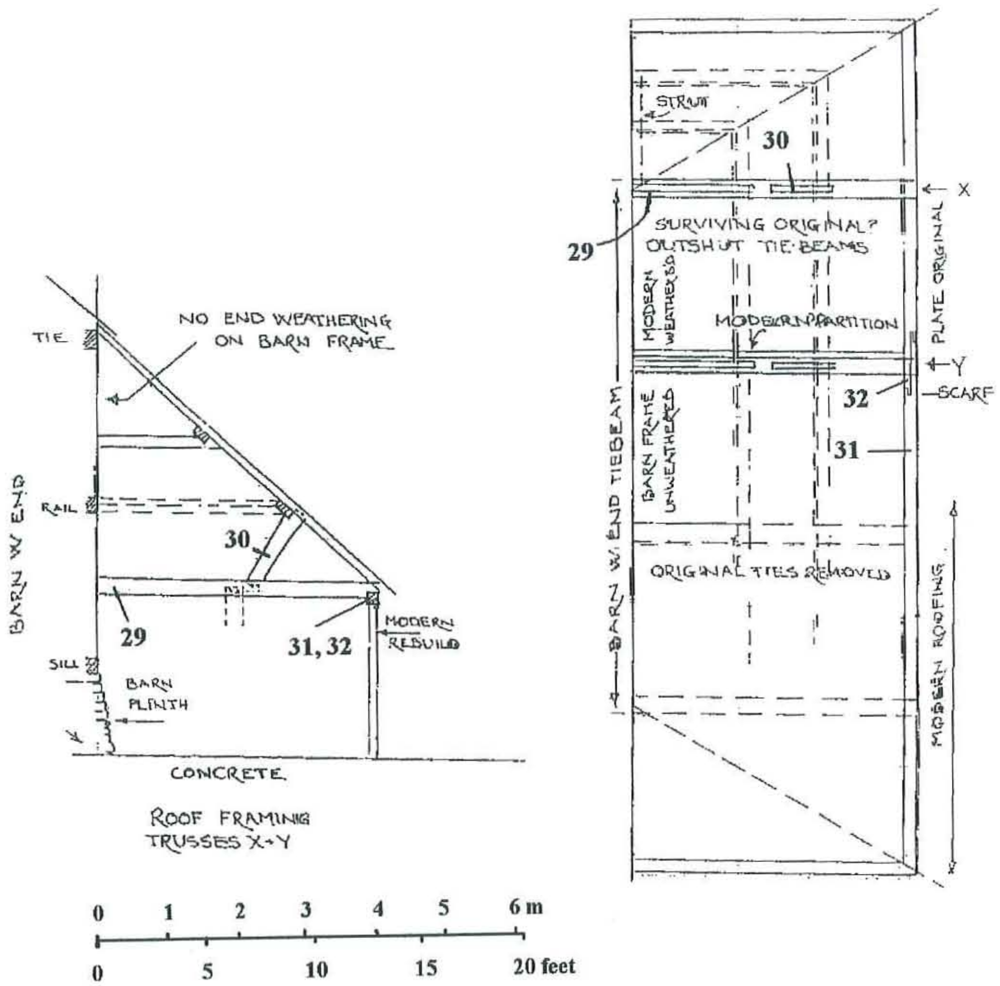


Figure 5: Sketch section and plan of the west-end lean-to of Priory Barn, Little Wymondley, showing the locations of samples taken for dendrochronology. Based on an original drawing by Adrian Gibson

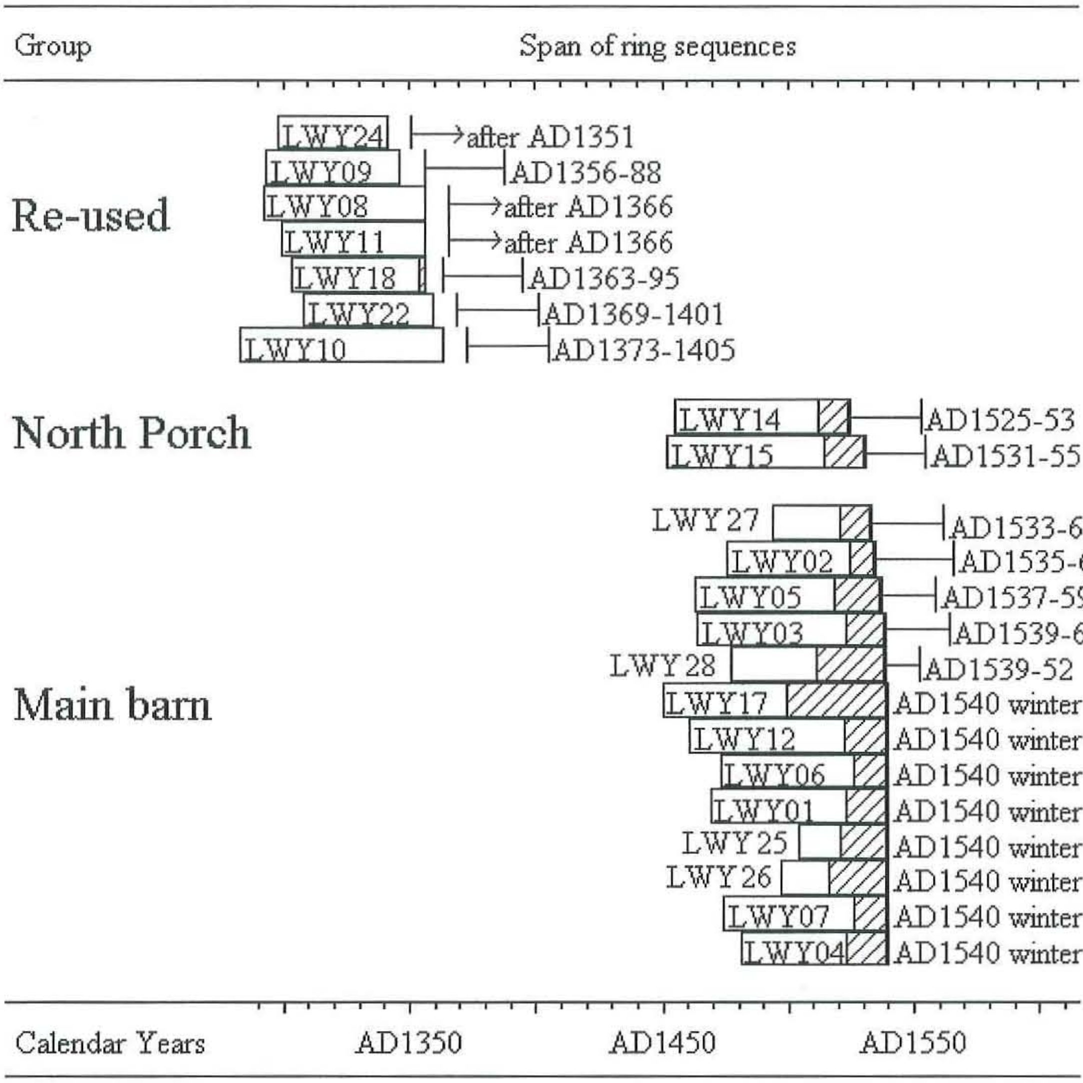


Figure 6: Bar chart showing the relative positions of overlap of the dated timbers at Priory Barn, Little Wymondley. The sapwood (hatched) and felling dates are also shown

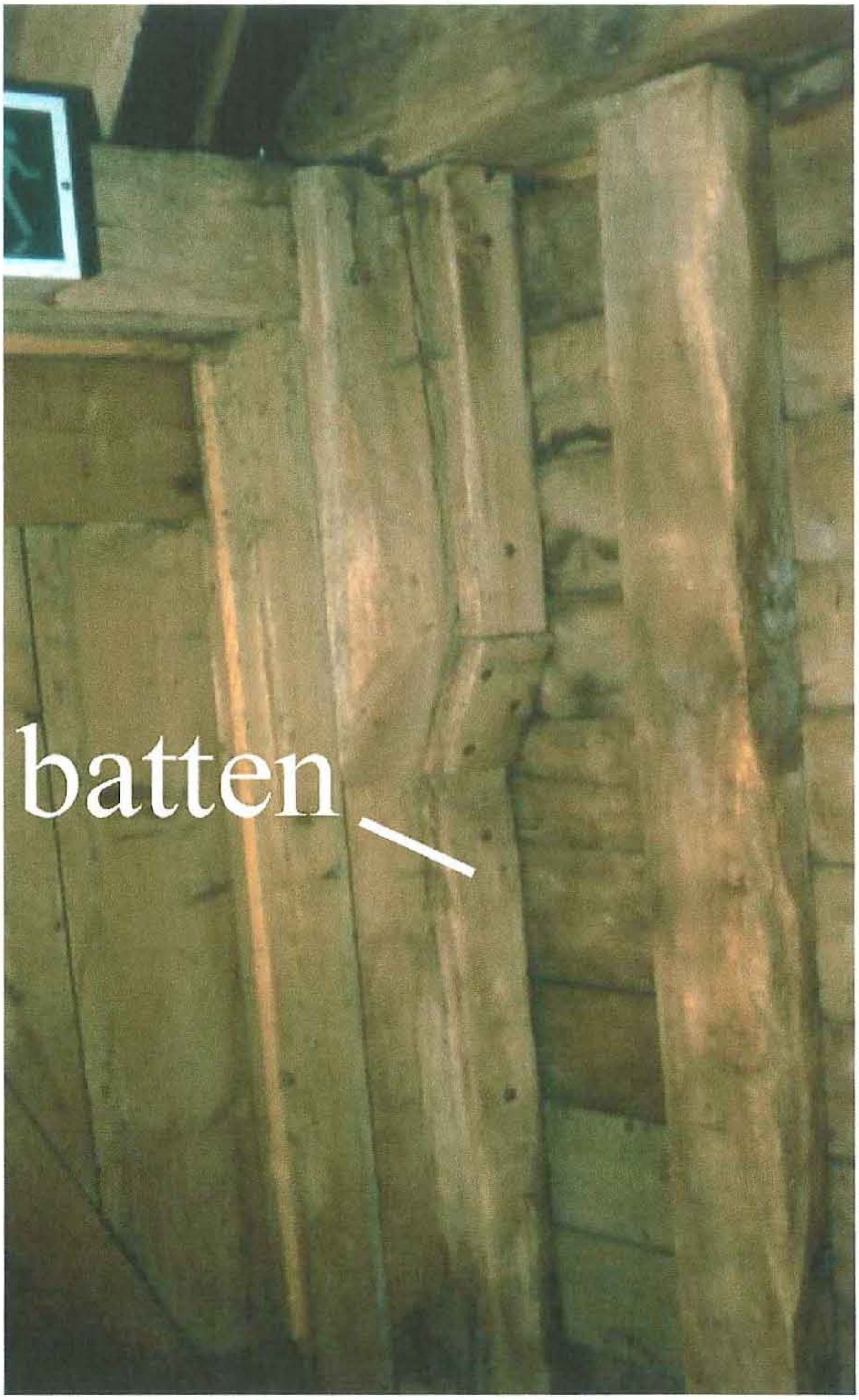


Figure 7: Photograph of the north-east corner showing the batten nailed to the main post, supporting the feather-edged weatherboarding (photo Adrian Gibson)

Table 1: Oak (*Quercus* spp.) timbers sampled from Priory Barn, Little Wymondley, Hertfordshire. h/s = heartwood-sapwood boundary

Sample number	Origin of core	Total no of years	Average growth rate (mm yr^{-1})	Sapwood details	Date of sequence AD	Felling date of timber AD
LWY01	Arcade post 8 south	72	2.34	17 complete	1469 - 1540	Winter 1540-1
LWY02	Aisle post 9 south	60	1.63	10	1476 - 1535	after 1535
LWY03	Aisle tie 9 south	76	1.72	16	1464 - 1539	after 1539
LWY04	East wall, south stud	60	2.39	17 complete	1481 - 1540	Winter 1540-1
LWY05	East wall, north stud	75	2.39	19	1463 - 1537	after 1537
LWY06	East wall, arcade post 10	68	2.14	14 complete	1473 - 1540	Winter 1540-1
LWY07	Arcade post 9 north	67	2.37	14 complete	1474 - 1540	Winter 1540-1
LWY08	Aisle tie 9 north (re-used)	66	2.52	-	1292 - 1357	after 1366
LWY09	Aisle tie 8 north (re-used)	55	1.80	h/s	1293 - 1347	1356-88
LWY10	Aisle tie 7 north (re-used)	82	2.19	h/s	1283 - 1364	1373 – 1405
LWY11	Aisle tie 7 north (re-used)	59	2.99	-	1299 - 1357	after 1366
LWY12	Arcade post 3 north	80	2.04	18 complete	1461 - 1540	Winter 1540-1
LWY13	Tie over north porch	24	not measured	h/s	undated	unknown
LWY14	West post to north porch	71	2.01	13	1455 - 1525	1525 – 53
LWY15	East porch to north porch	80	1.68	17	1452 - 1531	1531 - 55
LWY16	Sill 3 south	106	1.41	-	undated	unknown

Table 1 continued:

Sample number	Origin of core	Total no of years	Average growth rate (mm yr^{-1})	Sapwood details	Date of sequence AD	Felling date of timber AD
LWY17	Arcade plate, bay 8 north	91	1.86	41 complete	1450 - 1540	Winter 1540-1
LWY18	Principal rafter 3 north (re-used)	55	2.48	3	1303 - 1357	1363 – 95
LWY19	Common rafter 5, bay 2 north (re-used)	22	not measured	5	undated	unknown
LWY20	Common rafter 6, bay 3 north (re-used)	19	not measured	h/s	undated	unknown
LWY21	Common rafter 5, bay 3 north (re-used)	24	not measured	3	undated	unknown
LWY22	Principal rafter 2, south (re-used)	53	2.54	h/s	1308 - 1360	1369 – 1401
LWY23	Principal rafter 3, south (re-used)	26	4.55	2	undated	unknown
LWY24	Principal rafter 8, south (re-used)	45	2.68	-	1298 - 1342	after 1351
LWY25	East wall, batten 3	37	1.50	19 complete	1504 - 1540	Winter 1540-1
LWY26	East wall, batten 9	44	1.39	24 complete	1497 - 1540	Winter 1540-1
LWY27	East wall, batten 10	40	2.33	12	1494 - 1533	after 1533
LWY28	West wall, batten 4	63	1.03	28	1477 - 1539	1539 - 52
LWY29	West lean-to, south tie	100	1.59	2	undated	unknown
LWY30	West lean-to, south brace	71	1.26	26 complete	undated	unknown
LWY31	West lean-to, north wall-plate	83	2.15	h/s	undated	unknown
LWY32	West lean-to, south wall-plate	66	1.12	3	undated	unknown

Table 2: Crossmatching between the dated timbers in the site chronology WYMONDLEY1. (-) represents *t*-value less than 3.0

	t-value					
SAMPLE	**LWY09**	**LWY10**	**LWY11**	**LWY18**	**LWY22**	**LWY24**
LWY08	4.4	-	4.0	4.8	-	-
LWY09		3.1	5.0	-	3.6	3.1
LWY10			4.9	-	5.4	3.3
LWY11				3.8	4.0	4.1
LWY18					-	-
LWY22						-

Table 3: Crossmatching between the dated timbers in the site chronology WYMONDLEY2. (-) represents *t*-value less than 3.0. Does not include timbers LWY14 and LWY15 mentioned separately in the text, and included in WYMONDLEY2

	t-value											
SAMPLE	**LWY02**	**LWY03**	**LWY04**	**LWY05**	**LWY06**	**LWY07**	**LWY12**	**LWY17**	**LWY25**	**LWY26**	**LWY27**	**LWY28**
LWY01	3.3	5.4	3.2	3.4	6.6	3.7	3.7	4.0	-	3.3	3.2	3.2
LWY02		4.9	-	-	5.1	4.0	-	4.8	-	3.7	-	-
LWY03			5.4	-	7.9	6.2	5.2	3.9	3.4	4.1	3.0	3.4
LWY04				4.7	5.0	7.5	3.8	4.8	4.0	3.5	3.2	-
LWY05					3.8	3.8	3.0	4.2	3.7	-	-	-
LWY06						8.1	3.8	5.0	5.1	-	3.5	3.9
LWY07							4.4	6.3	3.6	3.8	3.2	-
LWY12								3.8	3.2	4.2	-	3.4
LWY17									-	-	-	-
LWY25										-	-	-
LWY26											-	-
LWY27												-

Table 4: Dating evidence for the site chronology NPORCH

	NPORCH AD 1452 - 1531	
Dated reference or site master chronology	*t*-value	Overlap (yrs)
Feb2000 (Bridge unpubl)	6.1	80
London1175 (Tyers pers comm)	6.0	80
Oxon93 (Miles pers comm)	5.1	80
Kent (Laxton and Litton 1989)	4.8	80
Magdalen Laver, Essex (Tyers and Boswijk 1998)	6.3	80
Windsor Castle, Berkshire (Hillam and Groves 1996)	6.0	80
Mary Rose 'refit' (Bridge and Dobbs 1996)	5.9	80
Hill Hall, Essex (Bridge 1999a)	5.7	80
Bruce Castle, London (Bridge 1998a)	5.4	80
Boyes Croft, Essex (Bridge 1999b)	5.2	61

Table 5: Dating of the oak site chronology WYMONDLEY 1

	WYMONDLEY 1 AD 1283 - 1364	
Dated reference or site master chronology	*t*-value	Overlap (yrs)
London1175 (Tyers pers comm)	8.2	82
Hants97 (Miles pers comm)	7.4	82
Kent88 (Laxton and Litton 1989)	5.2	82
Newdigate1, Surrey (Bridge 1998a)	7.0	82
Croxley, Hertfordshire (Bridge 2000)	5.5	66
Shrewsbury Abbey, Shropshire (Nayling 1999)	5.3	82
Kempley3, Gloucestershire (Miles *et al* 1999)	5.1	57
King Street, Odiham, Hampshire (Miles and Haddon-Reece 1996)	5.1	82
Eastbury, Essex (Tyers 1997)	5.0	82

Table 6: Dating of the oak site chronology WYMONDLEY2

	WYMONDLEY 2 AD 1450 - 1540	
Dated reference or site master chronology	*t*-value	Overlap (yrs)
Oxon93 (Miles pers comm)	8.1	91
London1175 (Tyers pers comm)	8.0	91
East Midlands (Laxton and Litton 1988)	6.5	91
Windsor Castle, Berkshire (Hillam and Groves 1996)	10.3	91
Chicksands Priory, Bedfordshire (Howard *et al* 1998)	10.0	91
Magdalen Laver, Essex (Tyers and Boswijk 1998)	9.8	85
Gosfield, Essex (Bridge 1998c)	8.6	86
Wimpole, Cambridgeshire (Bridge (1998d)	8.2	72
Hill Hall, Essex (Bridge 1999a)	7.9	91

locality. The design of the north porch was noted as being different to the rest of the barn and it may have been executed by different craftsmen after the remainder of the barn had been completed, as a very early modification.

Having established this unexpected late post-Dissolution date for the present barn, records for the period showed that the site passed into the ownership of James Nedeham (or Needham) in AD 1537. Nedeham was Surveyor of the King's Works under Henry VIII, and as such, it is not surprising that he built such a fine barn with the best quality wood and carpentry of the day.

The battens nailed to the posts, and supporting the feather-edged weather-boarding panels which lay flush with the external faces of the posts at the east end of the barn (Fig 7), were also found to have been cut from trees felled at the same time as the remainder of the main timbers of the barn. This probably represents the earliest dated feather-edged weather-boarding yet known, and is an interesting transition from the vertical boards set in grooves to the weather-boarding nailed over the posts that is common today.

The west lean-to timbers used similar carpentry to the main barn, and coupled with the lack of weathering on the outside of the posts of the west-end wall, it was thought that the lean-to might be contemporaneous with the main barn. None of the ring-width series from timbers in the lean-to crossmatched with other barn timbers however. Neither did they date against other reference material. This suggests that the timbers are from a different source to the main barn, and may also be from a different period of time. During sampling in the lean-to it was noticed that the scarf in the west-end wallplate was face-halved and bladed, which would suggest a date later than the main barn. This however would not explain the lack of weathering to the main timbers of the barn, so if of later origin, it may have replaced an original lean-to.

Current interpretation of radiocarbon measurements

It is now possible to reinterpret the radiocarbon measurements from the barn undertaken in the AD 1960s using new approaches to calibration and high-precision calibration data. The sapwood from a post of Truss H produced a radiocarbon date of cal AD 1270-1430 including an allowance of 15 years to the bark of the tree (UCLA-1057; 670±6O BP) and that from a post of Truss G gave a radiocarbon date of cal AD 1460-1680, including an allowance of 25 years (UCLA-1058; 350±60 BP; Stuiver *et al* 1998; Stuiver and Reimer 1986). This would be consistent with the post of Truss H belonging to the group of re-used fourteenth-century timbers identified by this analysis, and the post from Truss G being part of the newly felled timber of AD 1540-I. A post for the barn at Harmondsworth also provided two radiocarbon determinations, which when the relative sequence of the samples and an allowance of 15 years to the bark of the tree are included, provide a posterior probability density for the post of *cal AD 1310-1460* (UCLA-1050; 670±6O BP; UCLA-1051; 555+60 BP Buck *et al* 1996; Bronk Ramsey 1995; Stuiver *et al* 1998). This is consistent with felling dates of ?spring AD 1426 produced by dendrochronology for this structure (Tyers and Hibberd 1993).

It is not clear which trusses the letters G and H refer to, but logically, given the results of the present study and assuming that the posts were numbered in alphabetical order from one end, the implication is that one of the west-most posts associated with the truss in which the principal rafter was sampled (LWY22, Fig 2) was made from a timber re-used from the AD 1373-95 group. It may be worth closer study of these two posts to ascertain whether there is any indication of this.

Acknowledgements

I would like to thank Adrian Gibson for his practical help, encouragement, and detailed discussion about the building. He also supplied the drawings used as the basis of many of the figures presented in this report, and made valuable comments on an earlier draft of this report. Richard Bond (English Heritage) also discussed the building on-site and continued to take an interest in the results as they emerged. The owner, Mr John Hope, kindly allowed access to the barn. I am indebted to Alex Bayliss (English Heritage) for her assistance in providing the modern radiocarbon interpretations and her comments on a draft of this report. This work was funded by English Heritage.

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Table 7: Ring-width data for chronologies WYMONDLEY1, WYMONDLEY2, NPORCH, and the undated series LWY2931M

Year	ring widths (0.01mm)										no of samples									
WYMONDLEY1																				
AD1283			332	221	234	215	201	154	249	233			1	1	1	1	1	1	1	1
	257	409	313	363	292	281	308	280	288	299	1	2	3	3	3	3	3	4	5	5
AD1301	348	373	220	240	263	209	293	365	314	240	5	5	6	6	6	6	6	7	7	7
	232	284	236	289	309	312	301	293	293	276	7	7	7	7	7	7	7	7	7	7
	294	285	278	211	179	166	204	239	236	171	7	7	7	7	7	7	7	7	7	7
	162	198	241	265	265	222	192	188	227	210	7	7	7	7	7	7	7	7	7	7
	194	181	184	225	300	235	212	256	237	197	7	7	6	6	6	6	6	5	5	5
AD1351	273	192	226	184	141	144	165	119	166	175	5	5	5	5	5	5	5	2	2	2
	135	185	223	188							1	1	1	1						
WYMONDLEY2 (includes LWY 14 and 15)																				
AD1450										256										1
AD1451	278	213	236	290	278	309	248	219	228	209	1	2	2	2	3	3	3	3	3	3
	203	205	249	173	227	240	173	222	284	300	4	4	5	6	6	6	6	6	7	7
	252	285	238	290	356	237	240	233	319	290	7	7	8	9	9	10	10	10	10	10
	303	300	287	293	237	222	296	235	220	237	11	11	11	11	11	11	11	11	11	11
	160	164	189	235	212	285	230	161	192	165	11	11	11	12	12	12	13	13	13	13
AD1501	169	183	166	182	172	155	148	128	132	148	13	13	13	14	14	14	14	14	14	14
	168	171	158	136	144	156	99	141	181	161	14	14	14	14	14	14	14	14	14	14
	154	179	156	202	150	197	185	187	159	164	14	14	14	14	14	13	13	13	13	13
	223	159	175	156	248	197	195	176	210	182	13	12	12	11	11	10	10	9	9	8
NPORCH																				
AD1452		198	190	257	270	305	240	225	215	192		1	1	1	2	2	2	2	2	2
	195	177	190	166	254	230	178	236	227	253	2	2	2	2	2	2	2	2	2	2
	187	193	190	206	286	241	225	205	230	235	2	2	2	2	2	2	2	2	2	2
	226	210	200	263	217	191	235	175	153	187	2	2	2	2	2	2	2	2	2	2
	112	115	130	152	180	215	189	142	168	143	2	2	2	2	2	2	2	2	2	2
AD1501	154	157	132	194	182	175	186	151	157	146	2	2	2	2	2	2	2	2	2	2
	152	104	118	130	146	139	101	122	106	115	2	2	2	2	2	2	2	2	2	2
	180	215	160	174	129	167	154	166	124	122	2	2	2	2	2	1	1	1	1	1
	149										1									

Table 7 continued:

Year	ring widths (0.01mm)										no of samples
LWY2931M											
1	189	317	537	458	490	382	523	510	504	270	
	309	278	330	294	276	269	282	309	277	407	
	375	332	379	343	380	331	312	330	316	310	
	89	109	142	212	137	125	150	236	290	276	
	119	85	97	118	152	151	200	205	191	202	
51	191	76	60	58	52	63	80	97	103	64	
	66	78	73	85	117	138	72	57	64	50	
	55	83	68	77	65	95	64	69	55	59	
	82	73	80	64	68	73	62	43	68	55	
	62	73	67	60	57	62	77	96	80	97	