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Tree-Ring Analysis of Timbers from the Abbey Barn, Boxley, Kent

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Summary

This large medieval stone-walled structure is thought to have been built as the *hospitum* to a Cistercian monastery, but has been used as an agricultural barn for generations. Dendrochronological dating was requested to establish the date of primary construction, to see whether a floored area was original to the building, date some of the doorways into the building, and date the changes evident in the roof at the east end of the building. Eighteen dated samples show that the floor and western scissor-truss roof are contemporaneous, with a single timber retaining complete sapwood with a felling date of winter AD 1382/3, suggesting a construction date within a few years either side of this date. This is later than the expected date for the roof. The timbers in the eastern roof appear to be re-used and a single timber yielded a felling date after AD 1273. None of the door lintels could be dated.

Keywords

Dendrochronology
Standing Building

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Introduction

The barn at the site of the old abbey at Boxley (NGR TQ 760 586; Fig 1) is a scheduled ancient monument, and a grade I listed building on the English Heritage Buildings at Risk Register (http://ehbar.cassium.com). Although referred to as a barn which has been in agricultural use for many years, it was originally part of the Cistercian abbey, possibly the *hospitum*, and may have had other uses as well. The walls of Kentish ragstone, almost a metre thick, are thought to be mostly mid-fourteenth-century, although they incorporate some earlier features. The majority of the roof, from the western end to the large doors in the north wall near the east end, is of scissor construction (Fig 2) with the rafters resting on an outer wallplate, and ashlar pieces bearing on an inner wallplate. The roof at the east end appears to be a later repair and has a different form (Fig 3) with king posts, and incorporates several re-used timbers.

Dendrochronological investigation of the building was requested by Peter Kendall, English Heritage Ancient Monument Inspector, in order to elucidate the history of construction of the building, and inform ongoing conservation plans. Several areas were of particular interest. The western scissor-truss roof, thought to be of late-thirteenth or early-fourteenth century date, was of great interest as this would effectively date the primary construction of the building. The eastern king-post roof, thought to be a later replacement following some damage in the historical period would perhaps date another phase of upkeep of the barn, or show the re-use of timbers from this or another building. The beams and joists of the floor were of interest to determine whether this is original to the building or a later insertion, and the door lintels above inserted doorways, and internal partition walls may also date other building phases.

Methodology

The site was visited on two occasions in March AD 2004. 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.

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 utilising 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 (1999a). Whilst one would normally reject sequences of less than 50 years or so, with the extensive sampling and borderline nature of the material here, it was decided that some shorter sequences might be worth analysing.

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 (1997a), 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).

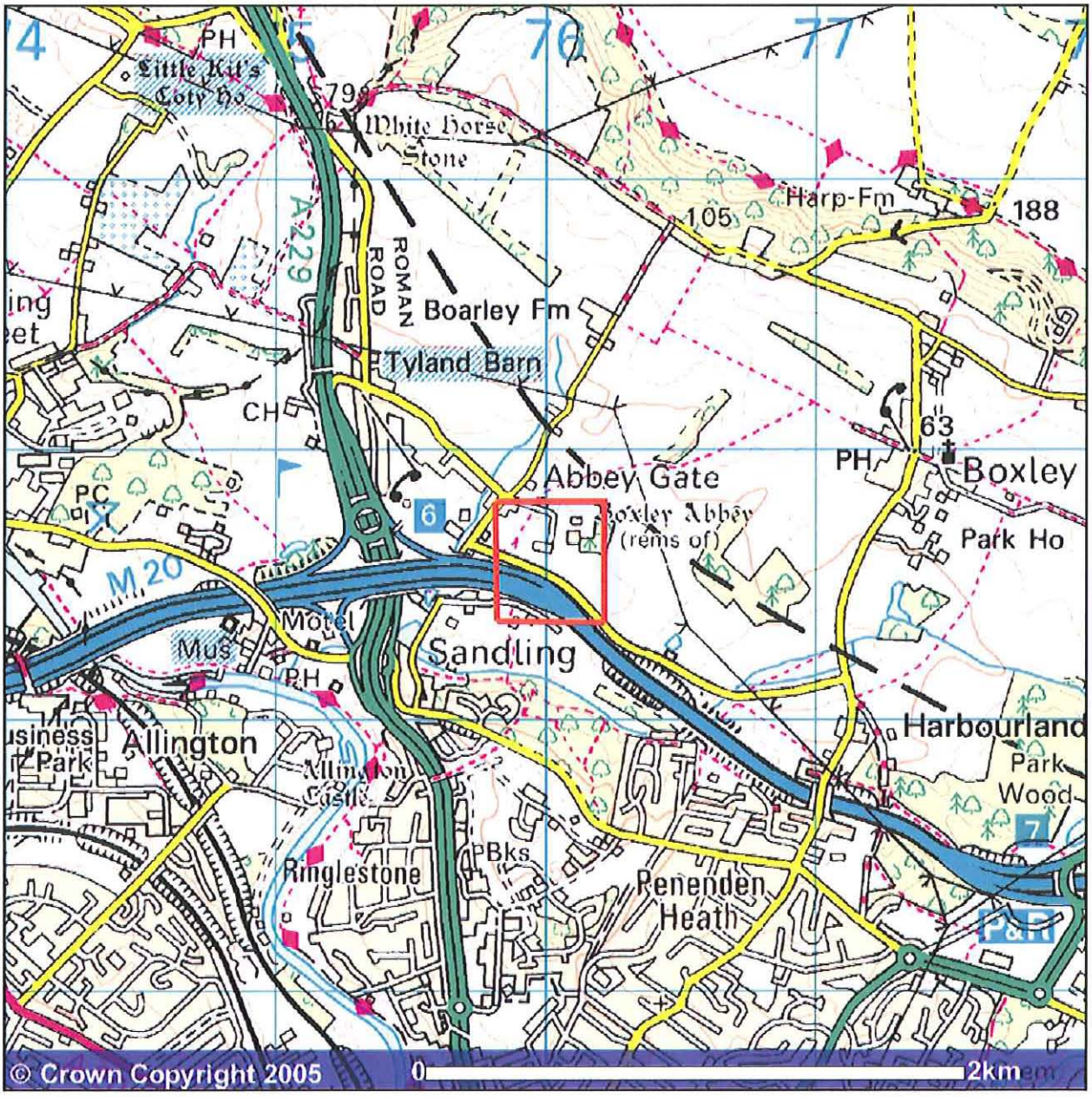

Figure 1: Map showing the location of the barn at Boxley Abbey, Kent (within square)

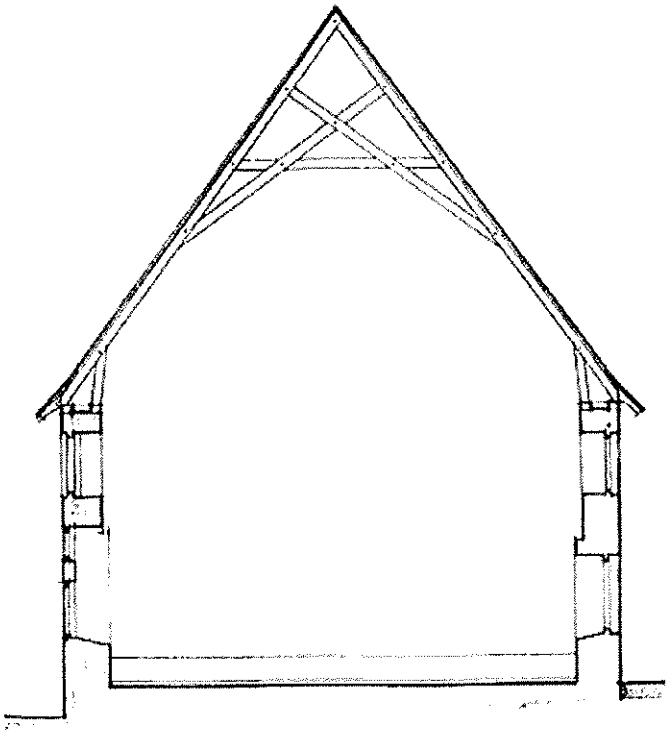

Figure 2: Form of the roof trusses in the western roof at Boxley Abbey barn

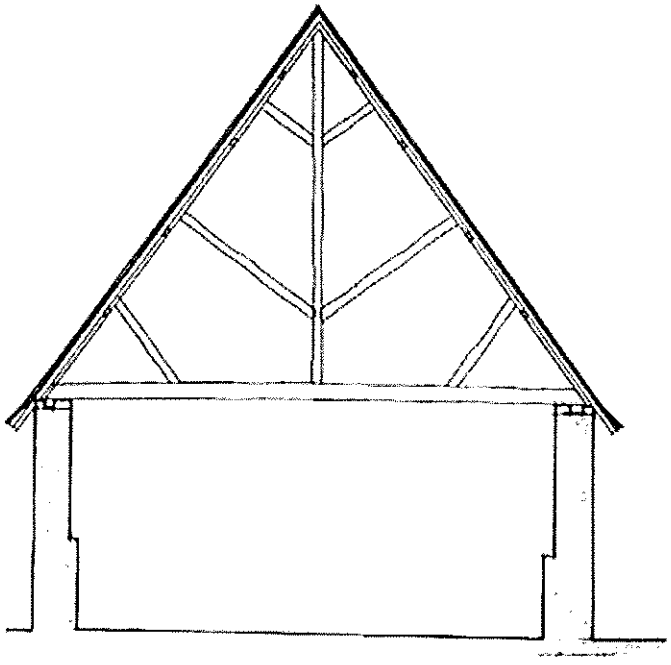

Figure 3: Form of the roof trusses in the eastern roof at Boxley Abbey barn

Results

After detailed inspection of the timbers, not all those of interest were considered as suitable for sampling. For example, many of the lintels over the doorways and the timbers of the internal partition wall were found to contain too few rings. Much of the timber in the eastern king-post roof was also rejected as the timbers had too few rings. Sampling was therefore dominated by timbers in the long western roof and the floor (Fig 4 and 5).

Whilst most of the timbers investigated were of oak, the third tie beam from the west end was coniferous. All the timbers sampled were of oak (*Quercus* spp.). Details of those timbers sampled are given in Table 1, along with other basic information about the samples. Two cores broke and both sections of these cores (BXB02 and BXB30) are shown separately before being combined into a single sequence, once it had been established by comparing plots with other sequences that no rings were missing. Three timbers had more than one core taken (shown as a and b in Table 1) in an attempt to get more information about the timber, particularly its sapwood complement.

Crossmatching was found between a large number of samples, as shown in Table 2, including one sequence with only 44 rings. It should be noted that this is an exceptional case, and only the strong visual matching with several other samples allowed this short sequence to be included. The internal partition walls also failed to provide timbers with sufficient number of rings to be sampled. Despite much effort, the sequences from samples BXB38 a and b, which contain bands of very narrow rings, could not be satisfactorily crossmatched either to each other, or to the dated sequences.

A 183-year long site chronology, ***BOXLEY***, was made from these crossmatching timbers, whose relative positions are shown in Figure 6. This sequence was dated by comparison with a large number of regional multi-site, and individual site chronologies, the best results being shown in Table 3.

Other non-matching timbers of sufficient length were tested individually against the reference material. One other timber, sample BXB23 from the eastern roof section gave consistent matches and good visual matches (Table 4) and was dated to the period AD 1200-64. The ring width data for both the site chronology and BXB23 are given in Tables 5 and 6 respectively. Many of the remaining samples were rather short and none could be reliably dated.

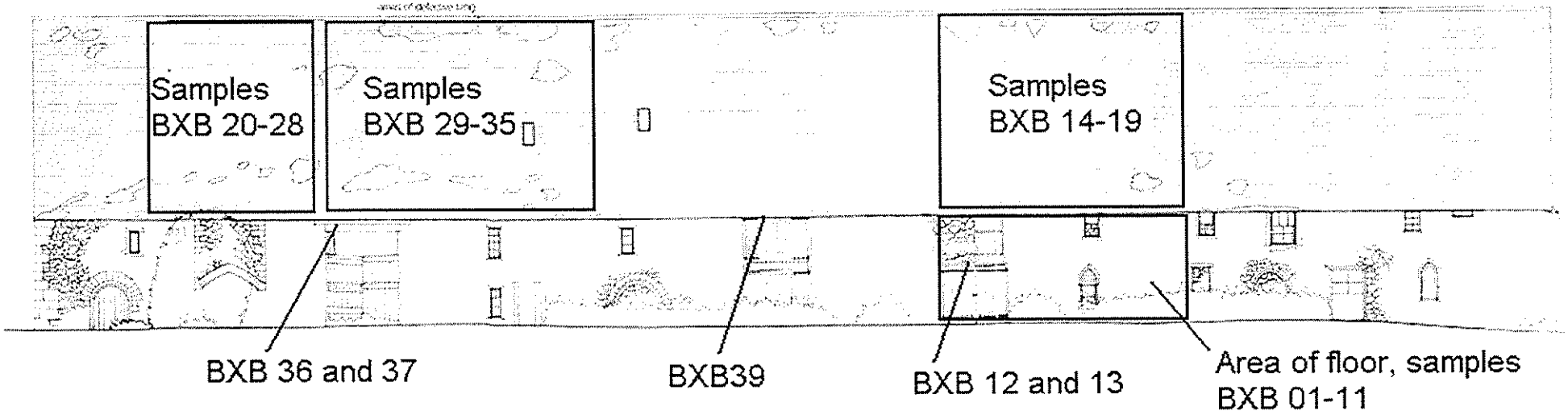

Figure 4: North elevation of the barn showing the areas sampled for dendrochronology

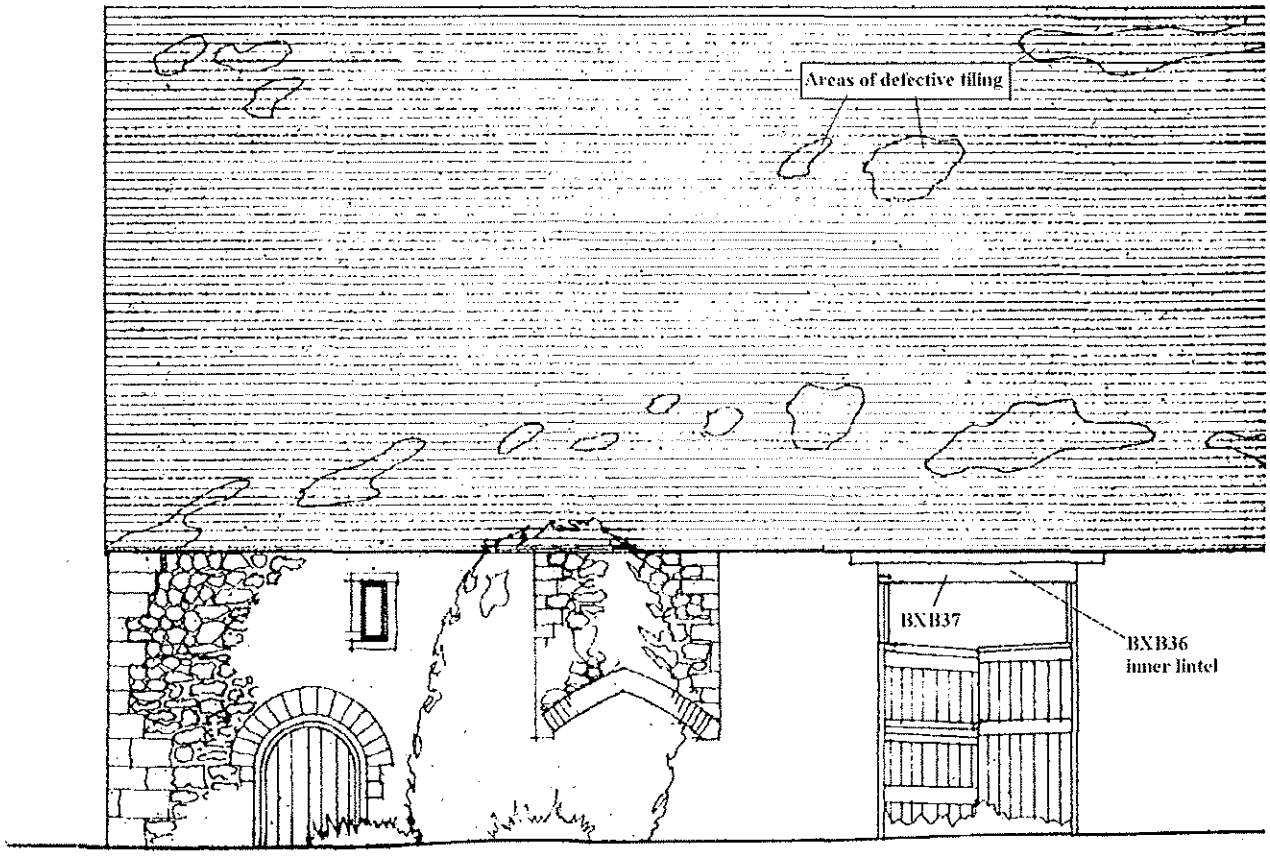

Figure 5: View of the east end of the barn, from the north, showing the position of the door lintels sampled. The eastern section of roof with the different form of construction is located from the east side of these doors to the east end of the barn. Adapted from an original drawing by Anthony Swaine

Table 1: Dated oak (*Quercus* spp.) timbers sampled from the Barn, Boxley Abbey, Kent

Sample number	Timber and position	No. of rings	Mean width (mm)	Mean sens (mm)	Dates AD spanning	H/S bdry AD	Sapwood complement	Felling seasons and dates/date ranges (AD)
Floor								
*BXB01	Central post to floor	133	1.13	0.27	1222 - 1354	1354	h/s + 19 sap	1373 - 95
BXB02i	*South brace to BXB01*	*31*	*1.29*	*0.25*	*1271 - 1301*	-	-	
BXB02ii	*South brace to BXB01*	*61*	*1.21*	*0.26*	*1302 - 1362*	*1362*	*h/s*	
*BXB02m	South brace to BXB01	92	1.23	0.26	1271 - 1362	1362	h/s	1371 - 1403
*BXB03	West floor beam	130	1.22	0.20	1236 - 1365	1363	2	1372 - 1404
*BXB04	Floor joist, 5th from wall	81	1.65	0.27	1283 - 1363	1362	1	1371 - 1403
BXB05	Floor joist, 8th from wall	71	1.53	0.23	unknown	-	4	unknown
BXB06a	*Floor beam*	125	1.83	0.22	1237 - 1361	1361	19C detached	
BXB06b	*Floor beam*	99	1.43	0.25	1284 - 1382	1361	21C	
*BXB06m	Floor beam	146	1.75	0.23	1237 - 1382	1361	21C	Winter 1382/3
BXB07a	*East post*	72	1.75	0.27	1266 - 1337	-	-	
BXB07b	*East post*	53	1.89	0.26	1285 - 1337	-	-	
*BXB07m	East post	72	1.82	0.27	1266 - 1337	-	-	after 1346
BXB08	North brace to east post	43	3.12	0.19	unknown	-	-	unknown
*BXB09	East floor beam	136	1.44	0.22	1228 - 1363	1363	h/s	1372 - 1404
*BXB10	Floor joist, 9th from wall	100	1.20	0.27	1260 - 1359	1359	h/s	1368 - 1400
*BXB11	West floor beam	62	2.65	0.24	1309 - 1370	1369	1	1378 - 1410
Door lintels								
BXB12	Inner door lintel	43	2.48	0.24	unknown	-	h/s	unknown
BXB13	Outer door lintel	<40	-	-	unknown	-	-	unknown
Western roof								
*BXB14	Tie beam	77	2.79	0.18	1297 - 1373	1361	13	1373 - 1402
*BXB15	Common rafter south	61	2.23	0.20	1299 - 1359	1359	h/s	1368 - 1400
*BXB16	Principal rafter south	75	1.58	0.28	1286 - 1360	1360	h/s	1369 - 1401
*BXB17	Common rafter south	58	2.49	0.23	1310 - 1367	-	-	after 1376
BXB18	Inner wallplate south	<40	-	-	unknown	-	-	unknown
BXB19	Principal rafter north	<40	-	-	unknown	-	-	unknown

continued overleaf

Sample number	Timber and position	No. of rings	Mean width (mm)	Mean sens (mm)	Dates AD spanning	H/S bdry AD	Sapwood complement	Felling seasons and dates/date ranges (AD)
Eastern roof section								
BXB20	South brace to king post	<40	-	-	unknown	-	-	unknown
BXB21	South lower purlin	<40	-	-	unknown	-	-	unknown
BXB22	West king post	<40	-	-	unknown	-	-	unknown
BXB23	West tie beam	65	1.84	0.23	1200 - 1264	-	-	after 1273
BXB24	3rd king post	<40	-	-	unknown	-	-	unknown
BXB25	Tie 3	105	1.22	0.21	unknown	-	-	unknown
BXB26	North brace, west truss	<40	-	-	unknown	-	-	unknown
BXB27	2nd purlin bay 1	108	0.99	0.29	unknown	-	-	unknown
BXB28	North strut truss 2	<40	-	-	unknown	-	-	unknown
Western roof								
*BXB29	Principal rafter 3 north	58	2.35	0.21	1307 - 64	1364	h/s	1373 - 1405
BXB30i	*Common rafter north*	43	1.61	0.25	unknown	-	-	
BXB30ii	*Common rafter north*	30	1.60	0.20	unknown	-	-	
BXB30m	Common rafter north	73	1.61	0.23	unknown	-	-	unknown
BXB31	Common rafter north	83	1.70	0.20	unknown	-	-	unknown
*BXB32	East principal rafter, north	58	3.62	0.25	1313 - 70	1370	h/s	1379 - 1411
BXB33	Common rafter north	<40	-	-	unknown	-	-	unknown
*BXB34	East principal rafter, south	54	3.58	0.21	1314 - 1367	1367	h/s	1376 - 1408
*BXB35	Common rafter south	84	1.87	0.13	1274 - 1357	1357	h/s	1366 - 98
BXB36	Inner north door lintel	<40	-	-	unknown	-	-	unknown
*BXB37	Outer north door lintel	113	1.63	0.26	1250 - 1362	1362	h/s	1371 - 1403
BXB38a	*Tie at partition*	145	0.71	0.16	unknown	-	-	unknown
BXB38b	*Tie at partition*	156	0.70	0.19	unknown	-	16	unknown
*BXB39	Outer wallplate	44	2.50	0.16	1319 - 62	1362	h/s	1371 - 1403

h/s = heartwood-sapwood boundary, C = complete sapwood, * = sample used in site chronology

t - values																		
SAMPLE	BXB02	BXB03	BXB04	BXB06	BXB07	BXB09	BXB10	BXB11	BXB14	BXB15	BXB16	BXB17	BXB29	BXB32	BXB34	BXB35	BXB37	BXB39
BXB01	7.8	5.9	4.4	7.7	7.1	9.0	5.5	-	-	-	-	-	-	-	-	-	7.0	-
BXB02		4.2	3.9	6.3	12.0	8.1	7.0	3.4	-	-	-	-	-	-	-	4.7	7.0	3.3
BXB03			-	5.6	3.6	5.3	5.3	3.4	-	-	-	-	-	-	3.8	-	-	-
BXB04				5.7	4.1	5.0	3.6	3.4	-	-	-	-	-	-	-	3.2	5.9	-
BXB06					4.8	11.5	6.1	5.4	4.0	3.3	-	-	-	3.7	3.5	3.2	8.2	-
BXB07						8.8	5.5	3.1	-	-	-	-	-	-	-	5.4	7.2	3.4
BXB09							6.6	4.6	3.6	-	-	-	-	-	-	3.7	7.7	4.4
BXB10								4.1	-	-	-	-	-	-	-	3.8	5.2	3.7
BXB11									6.2	5.9	3.1	5.0	3.4	3.2	3.6	-	3.8	5.1
BXB14										4.8	5.7	5.5	5.7	4.7	5.2	3.2	-	5.9
BXB15											5.0	4.2	5.1	5.6	5.7	-	4.1	3.6
BXB16												3.5	4.5	5.3	3.9	-	-	3.4
BXB17													-	3.9	-	3.6	-	4.7
BXB29														3.9	4.1	-	3.5	3.9
BXB32															7.9	-	3.7	3.6
BXB34																-	3.2	3.6
BXB35																	-	3.3
BXB37																		3.8

Table 2: Crossmatching between the dated samples from Boxley Barn, excluding BXB23, which only has a short overlap with other samples, and was dated independently. A (-) represents a *t*-value of 3.0 or less

Table 3: Dating evidence for the site chronology ***BOXLEY*** AD 1200 - 1382
Regional multi-site chronologies have the file name in **bold**; those sites shaded grey are ecclesiastical sites

	County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	*t-value:*
	Kent	Kent Master Chronology	*(Laxton and Litton 1989)*	**KENT88**	1158-1540	183	10.5
	Hampshire	Hampshire Master Chronology	*(Miles 2003)*	**HANTS02**	443-1972	183	9.1
	Oxfordshire	Oxford Master Chronology	*(Miles pers comm.)*	**OXON93**	632-1987	183	8.7
	London	London Master Chrocnology	*(Tyers pers comm.)*	**LONDON**	413-1728	183	8.7
	Bedfordshire	Toddington church	*(Bridge 2000)*	TODDNGTN	1226-1392	157	8.3
	Southern England	Southern England Master	*(Bridge 1988)*	**SENGLAND**	1083-1589	183	7.8
	Oxfordshire	New Inn, Oxford	*(Miles and Haddon-Reece 1996a)*	ZACHS	1164-1381	182	7.5
	Bedfordshire	Chicksands Priory	*(Howard et al 1998)*	CHKSPQ01	1200-1541	183	7.5
	Berkshire	Reading waterfront	*(Groves et al 1999)*	READING	1160-1407	183	7.3
	Kent	Manor Farm barn, Frindsbury	*(Arnold et al 2002)*	FRNDSBRY	1254-1403	129	7.3
	Southern England	Southern England Master	*(Hillam and Groves 1994b)*	**SOUTH**	406-1594	183	7.2
	Hertfordshire	Clothall Bury Barn	*(Arnold et al 2003)*	CLBASQ01	1253-1367	115	7.1
*	Oxfordshire	Queen's Head, Crowmarsh Gifford	*(Haddon-Reece et al 1989)*	QUEENS1	1203-1341	120	7.0
‡	Hampshire	Old Church House, Odiham	*(Miles and Haddon-Reece 1996b)*	OLDCHRCH	1177-1365	166	7.0
	Essex	Navestock Church	*(Tyers pers comm.)*	NAVSTCK1	1201-1355	155	7.0
*	Oxfordshire	Bayllols Manor, Harwell	*(Miles and Haddon-Reece unpubl)*	BAYLLOLS	1170-1370	171	6.7
	Kent	Borden Church	*(Litton et al 2000)*	BORDEN	1218-1333	116	6.5
‡	Hampshire	Rye Cottage, Mapledurwell	*(Miles and Worthington 1999)*	RYECOTT1	1317-1486	66	6.5
	Essex	15 High Street, Dunmow	*(Bridge 1999)*	DUNMOW	1312-1373	62	6.4
‡	Hampshire	Odiham Priory	*(Miles and Worthington 2000)*	ODIHMPRY	1207-1448	176	5.9

‡ Component of HANTS02, * Component of OXON93

Table 4: Dating evidence for the site chronology ***BXB23*** AD 1200 - 1264
Regional multi-site chronologies have the file name in **bold**

	County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	*t-value:*
*	Oxfordshire	Manor Farm, Stanton St John	*(Miles and Worthington 1998)*	STNSTJN1	1131-1304	65	5.5
	Northern England	Northern England Master	*(Hillam and Groves 1994a)*	**NORTH**	440-1742	65	5.5
	Southern England	Southern England Master	*(Hillam and Groves 1994b)*	**SOUTH**	406-1594	65	5.5
‡	Hampshire	Tudor House, East Meon	*(Miles et al 2003)*	EASTMEON	1172-1332	65	5.4
	Berkshire	Reading waterfront	*(Groves et al 1999)*	READING	1160-1407	65	5.4
	England	Ref75 Master Chronology	*(Fletcher 1977)*	**REF75**	845-1298	65	5.2
	Buckinghamshire	Pendyce House, Ivinghoe	*(Miles pers comm.)*	IVI	1175-1275	65	5.1
	Hertfordshire	Ashwell Church	*(Miles et al 2003)*	ASHWN1A	1184-1339	65	5.0
	Oxfordshire	Oxford Master Chronology	*(Miles pers comm.)*	**OXON93**	632-1987	65	4.9
	Suffolk	Abbas Hall	*(Bridge 2000)*	ABBAS1	1150-1289	65	4.9
	Berkshire	Oracle Site, Reading	*(Miles pers comm.)*	ORACLE1	1117-1293	65	4.8
	Wales	Welsh Master Chronology	*(Miles 1997b)*	**WALES97**	404-1981	65	4.7
	London	London Master Chrocnology	*(Tyers pers comm.)*	**LONDON**	413-1728	65	4.7
	Buckinghamshire	Bradwell Abbey	*(Bridge 1983)*	BRADWELL	1083-1279	65	4.6
	Essex	Navestock Church	*(Tyers pers comm.)*	NAVSTCK1	1201-1355	64	4.6
	Berkshire	Great Coxwell Barn	*(Siebenlist-Kerner et al 1978)*	COXWELL	1043-1267	65	4.6

‡ Component of HANTS02, * Component of OXON93

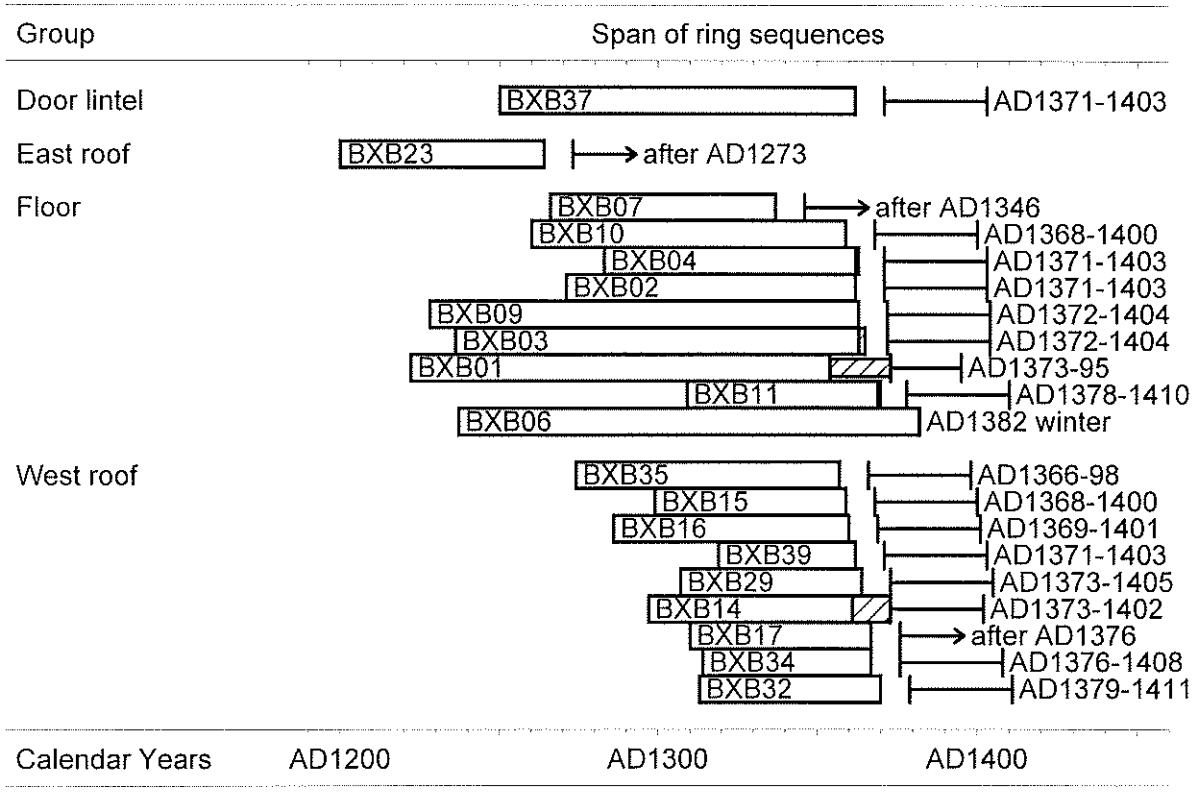

Figure 6: Bar diagram showing the relative positions of overlap of the dated timbers from Boxley Abbey Barn, along with their interpreted felling dates

Interpretation and Discussion

Only a single timber, a floor beam, retained complete sapwood to the bark, and this was from a tree felled in the winter AD 1382/3. The illustration (Fig 6) shows that many timbers had similar heartwood-sapwood boundary dates, and it would appear that the timbers from the western roof and the floor form a single batch felled at approximately the same time. In a project of this size, it is not uncommon to find timbers felled over a period of maybe three to four years, suggesting a construction date within a few years either side of this date. The date of the barn was expected to be late-13th or early-14th century, so this result makes the barn somewhat later than had previously been assumed.

It is of interest that, as has been noticed elsewhere by several workers, the wood in this ecclesiastical building matches best with other ecclesiastical sites (shaded in Table 3), suggesting that they are using similar sources of wood, perhaps managed in the same way, forming a different resource to those used by domestic dwellings.

Unfortunately the door lintels on the north side toward the western end of the barn did not date, although the outer door lintel over the carriage doors at the east end in the north side is part of this same dated group of timbers. This is effectively the outer wallplate, and it would have been possible to insert these large doors without necessarily disturbing this plate. The other lintels had insufficient rings to be dated, and so little can be said about the possible dates insertion of the doorways.

Many of the timbers in the eastern section of the roof could be seen to be re-used, many having empty mortices and peg holes which do not relate to their current positions. Most were either too fast-grown to be sampled in the first place, or yielded sequences too short to crossdate, although one or two longer sequences, for example in the tie beam, also failed to date. A single timber, BXB23 had no sapwood, but may be from an earlier date than the remaining dated timbers, or perhaps the sample merely represents the inner part of a rather older tree. The several doorways, particularly the high double doors not thought to be original to the building, and internal partition walls could not be dated because their timbers had too few rings.

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Table 5: Ring width data for the site chronology BOXLEY from AD 1200 -1382

ring widths (0.01mm)										no of trees									
180	210	146	170	123	139	153	137	210	288	1	1	1	1	1	1	1	1	1	1
203	242	180	205	219	197	263	198	175	164	1	1	1	1	1	1	1	1	1	1
178	193	127	270	270	212	358	276	265	346	1	1	2	2	2	2	2	2	3	3
278	237	224	227	159	189	131	246	203	237	3	3	3	3	3	3	4	5	5	5
244	156	136	203	145	140	144	151	103	175	5	5	5	5	5	5	5	5	5	5
170	145	155	171	199	195	162	233	226	215	6	6	6	6	6	6	6	6	6	6
243	219	234	163	193	194	211	161	158	186	7	7	7	7	7	6	7	7	7	7
185	178	150	209	186	109	146	191	150	139	7	8	8	8	9	9	9	9	9	9
189	177	165	143	144	169	181	165	177	236	9	9	9	10	10	10	11	11	11	11
239	207	250	246	184	191	190	192	178	177	11	11	11	11	11	11	11	12	12	13
212	190	174	134	141	151	159	213	213	185	13	13	13	13	13	13	13	14	14	15
183	147	192	190	239	260	175	158	154	200	16	16	16	17	18	18	18	18	18	19
201	212	205	232	219	163	163	227	228	232	19	19	19	19	19	19	19	19	19	19
183	135	115	189	239	242	206	176	167	223	19	19	19	19	19	19	19	19	18	18
210	187	214	148	140	180	178	163	161	161	18	18	18	18	18	18	18	18	18	18
168	210	150	200	199	153	130	126	121	151	18	18	18	17	17	17	17	17	16	16
151	163	148	210	235	188	189	209	229	227	14	13	13	10	8	7	6	6	4	4
209	146	182	125	86	97	119	184	203	167	4	2	2	2	1	1	1	1	1	1
125	144	114								1	1	1							

Table 6: Ring width data for sample BXB23, AD 1200 to 1264

ring widths (0.01mm)									
180	210	146	170	123	139	153	137	210	288
203	242	180	205	219	197	263	198	175	164
178	193	167	173	183	176	244	255	272	228
166	167	181	168	217	180	140	285	181	257
220	171	136	160	119	139	209	186	144	214
171	157	191	163	173	214	124	182	114	146
191	180	189	125	127					