

Ancient Monuments Laboratory
Report 21/96

TREE-RING ANALYSIS OF OAK
TIMBERS FROM THE ROOF OF 3-3A
VICARS' COURT, LINCOLN

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COURT, LINCOLN

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Summary

Tree-ring analysis provided a felling date range of 1289-1334 for the remains of the original medieval roof at 3-3A Vicars' Court, which is situated within Lincoln Cathedral Close. A similar felling date range was obtained for the reused medieval timbers which were inserted from another building when 3-3A was re-roofed in the seventeenth century. The primary timbers for the new roof were felled in 1663/4 or just after.

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INTRODUCTION

This document is a technical archive report on the tree-ring analysis of the roof timbers from 3-3A Vicars' Court. It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. As part of a multifaceted and multidisciplinary study of the building, elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the building. The conclusions presented here may therefore have to be modified in the light of subsequent work.

Vicars' Court is formed from four ranges of buildings arranged round a grassed quadrangle immediately to the south of Lincoln Cathedral. Nos 3 and 3A (NGR: SK979729) are part of the south range. Following extensive repairs to the building, grant-aided by English Heritage, dendrochronological analysis was requested by Malcolm Cooper of the East Midlands Team to support the archaeological survey carried out by Lindsey Archaeological Services. A short description of the building is given below, using information available prior to the dendrochronological analysis. For the full details, the report by Lindsey Archaeological Services should be consulted (Clarke forthcoming).

Vicars' Court was originally a closed range of buildings around the quadrangle but parts were damaged during the Civil War and never rebuilt. Nos 3 and 3A are the earliest and least altered buildings now remaining. Construction was started by Bishop Sutton in 1290 and completed by his successor Bishop Buckingham 1309-1310 (Clarke pers comm). The building was re-roofed in the seventeenth century but the survey of the roof timbers revealed that many were reused from one or more medieval buildings.

The roof of 3-3A Vicars' Court can be divided into three sections (Fig 1) in which there is a mixture of original, reused, and seventeenth-century timbers (Fig 2):

- In the west bay there is less evidence of reuse than in the centre and east bays. The collars are thought to be primary to the seventeenth-century re-roofing, although the rafters could be a mixture of primary and reused timbers. Any reused rafters were thought to be from a different source to those used in the centre and east bays (see below). The wallplates and binders, which supported the joists, are thought to date to *circa* 1300.
- The central bay is dominated by three trusses of medieval date which originally supported a low-pitched leaded roof. Tiebeams TC5 and TC1 are low-cranked types whilst TC3 is high-cranked. The rafters are medieval in date but were reused from another medieval building when 3-3A was re-roofed

in the seventeenth century. They had not been reused in their original sequence. There are two sizes of rafters, one type larger than the other. The larger rafters tended to be more weathered whilst the smaller ones were jointed at purlin level. The collars were thought to be contemporary with those in the western section.

- At the end of the east bay is the fourth medieval truss, but this was not accessible for sampling. The rafters are from the same medieval building as those in the central bay, but again were not in their original sequence. The collars were thought to be contemporary with those in the west bay.

A visit to assess the timbers for their dendrochronological dating potential was made in June 1995. The timbers were sampled and analysed in July and August 1995.

METHODS

Core samples were removed using a hollow borer, 15mm in diameter, attached to an electric drill. The cross-sections of the cores were polished using a sander attachment on the drill. The surfaces were finished by hand polishing. The ring widths were measured to an accuracy of 0.01mm on a travelling stage which is connected to an Atari microcomputer. The Atari uses a suite of dendrochronology programs written by Ian Tyers (pers comm 1994). The measured ring sequences were plotted as graphs using an Epson HI-80 plotter, also connected to the Atari. Crossmatching was carried out first visually by comparing the graphs on a light box, and then using a computer program to measure the amount of correlation between two ring sequences. The crossmatching routines are based on the Belfast CROS program (Baillie and Pilcher 1973; Munro 1984), and all the t values quoted in this report are identical to those produced by the first CROS program (Baillie and Pilcher 1973). Generally t values of 3.5 or above indicate a match provided that the visual match between the tree-ring graphs is acceptable (Baillie 1982, 82-5). t values over *circa* 10 usually indicate an origin in the same tree, although t values less than 10 may be produced when different radii are measured on the same trunk. Visual matching can sometimes aid the decision as to whether timbers come from the same tree.

Dating is achieved by averaging the data from the matching sequences to produce a site master curve, and then testing that master for similarity against dated reference chronologies. A site master is used for dating whenever possible because it enhances the general climatic signal at the expense of the background noise from the growth characteristics of the individual samples. Any unmatched sequences are tested individually against the reference chronologies. All potential tree-ring dates are then checked by examining the quality of the visual match between the graphs.

If a sample has bark or bark edge, the date of the last measured ring is the year in which the tree was felled. In the absence of bark edge, felling dates are calculated using the sapwood estimate of 10-55 rings. This is the range of the 95% confidence limits for the number of sapwood rings in British oak trees over 30 years old (Hillam *et al* 1987). Where sapwood is absent, felling dates are given as *termini post quem* by adding

10 years, the minimum number of missing sapwood rings, to the date of the last measured heartwood ring. The actual felling date could be much later depending on how many heartwood rings have been removed.

At this stage of the study, factors such as reuse, stockpiling, or repairs have also to be taken into account. Thus whilst the tree-ring dates for the measured rings are precise and independent, the interpretation of these dates often requires other archaeological or historical evidence.

THE TIMBERS

All the timbers were oak (*Quercus* spp.). Those selected for sampling are shown in Fig 1 and described in Table 1. All suitable timbers, ie those that appeared to have more than 50 rings, were sampled in the western section. Binder B6 was rejected because it had fewer than 50 very wide rings; it had obviously come from a fast-grown oak. By contrast, binder B5 (sample 8) came from a slow-grown oak, the trunk of which was less well trimmed than that of B6. All three tiebeams in the centre bay were sampled as were a representative spread of rafters in the centre and east bays. The collars in the east and central sections were either inaccessible or were unsuitable for dating purposes and were not sampled.

The collars in the west bay were cut tangentially from the trunk. The two sampled rafters were halved trunks. One of them, principal rafter S49, was unworked with only the bark missing from the outside.

The tiebeams were shaped from whole trunks. Their cranked shape seems to have been obtained by woodworking techniques rather than the selection of curved trunks. The rafters in the east and centre bays were quartered or, occasionally, halved trunks. Presumably several rafters were obtained from a single trunk. The exception was rafter S11 (sample 14). This was a radially split timber which contained a band of very narrow rings. It proved to be undatable (see below).

Sapwood was present on many of the timbers in the west section. It was not as obvious as sapwood in other parts of the roof because there was less damage from insect attack. For this reason, the sapwood in the west end often survived sampling and was therefore present on the cores. Bark edge was probably present on cores 2 and 5. By contrast, there was less sapwood in the central and eastern sections and, where it did survive, it was impossible to sample because of insect attack. This suggested that the timbers sampled at the west end were younger than those elsewhere.

When the cross-sections of the cores were prepared, three were rejected as they had less than 50 rings (samples 7, 12, and 20). The remainder contained 53-138 rings.

THE TREE-RING DATES

The ring patterns from the collars and rafters in the west section (samples 1-6) crossmatched each other (Fig 3; Table 2) and were combined to give an 86-year master curve, LINC_VC2 (Table 3). The master was dated to 1578-1663 by comparison to reference chronologies (Table 4).

A second master curve of 197 years, LINC_VC1 (Table 5), was constructed from ring sequences 10, 11, 13, and 15-19 (Fig 3). The ring patterns from 16 and 18 were almost identical and matched with a t value of 14.2. Their ring widths were therefore first averaged before inclusion in the master since the timbers undoubtedly came from the same tree. The ring sequences from the reused rafters matched much better as a group than they did with those from tiebeams 10 and 19 (Table 2), supporting the view that the rafters had been reused from another building. That building was medieval since the master curve matched over the period 1090-1286 (Table 6). It matched particularly well with the East Midlands chronology (Laxton and Litton 1988). This contains data from the roof timbers in Lincoln Cathedral, some of which may have come from the same woodland as those for Vicars' Court.

When the unmatched sequences were tested against reference chronologies, sample 9 from tie TC5 was found to crossdate over the period 1190-1279 (Tables 6 and 7). It gave a very weak match with the LINC_VC1 master over this period ($t = 3.2$). Samples 8, 14, and 21 remain undated.

INTERPRETATION

1. Centre and East Bays - the original medieval roof

Sample 9 from tiebeam TC5 had heartwood-sapwood boundary, giving a felling date range of 1289-1334. Sample 19 from TC1, felled after 1279, is probably contemporary with this. Sample 10 from TC3 did not have sapwood but the heartwood-sapwood boundary was observed elsewhere on the timber. Using the sapwood estimate of 10-55 rings gives a felling date range for this timber of after 1218 and probably before *circa* 1263. So, whilst the results from two of the tiebeams support the fact that construction took place between 1290 and 1310, tie TC3 could have been felled slightly earlier. However, since the 10-55 sapwood estimate represents 95% confidence limits, it is also possible that the tree had more than 55 sapwood rings and that the timber could in fact be contemporary with the other ties.

2. Centre and East Bays - the reused medieval timbers

All reused rafters appear to be contemporary. There is no difference in date between the two sizes of rafters and therefore the difference in appearance, the larger ones being more weathered than the smaller, must be due to some other factor.

Although none of the samples had sapwood, heartwood-sapwood boundary was probably present on sample 16. It was also observed near the coring position on timbers 13 and 15. The earliest end date was on sample 18. Since this timber is from the same tree as 16, it must have lost some heartwood rings during timber conversion. The timbers were felled after 1296 and probably before *circa* 1332 (Fig 3), which is very similar to the 1290-1310 construction date for Vicars' Court obtained from documentary evidence. The building they were taken from was therefore probably built at the same time as Vicars' Court, and may be from the same complex.

3. West bay - the seventeenth-century roof

All the dated timbers from this section proved to be seventeenth-century in date (Fig 3 and Table 1). Samples 2 and 5, from collar C49 and rafter S49 respectively, ended in 1663. The outer rings of both these samples were thought to be bark edge, suggesting that the timbers were felled in 1663/4. There is a slight element of doubt about the presence of bark edge because one or two outer rings may have been damaged during coring. A conservative estimate would be that the timbers were felled in 1663/4 or just after. If bark edge is indeed present, the timbers were felled in the winter or early spring of 1663/4 since the growth of the outer rings was complete. Construction of the seventeenth-century roof probably took place soon after felling since the seasoning of building timber was a rare occurrence until recently (Charles and Charles 1995, 46-7). It therefore seems that repairs to the damage inflicted during the Civil War took place soon after the Restoration of Charles II in 1660.

CONCLUSION

Tree-ring analysis of samples from the roof of 3 and 3A Vicars' Court has produced two new reference chronologies for the periods 1090-1286 and 1578-1663. The latter is particularly useful as it is a period which is relatively under-represented by tree-ring reference data. The results support the documentary evidence which indicates that Vicars' Court was constructed between 1290 and 1310. A similar felling date range for the reused medieval rafters suggests that these may have belonged to another building in the complex which was later damaged in the Civil War. The primary timbers from the seventeenth-century roof were felled in the winter/early spring of 1663/4 or just after.

ACKNOWLEDGEMENTS

The tree-ring analysis was funded by English Heritage. We are also grateful to Naomi Field and Mick Clarke for providing information about Vicars' Court, and to Ian Tyers for unpublished computer programs.

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Figure 1: Plan of the south range roof showing the location of the tree-ring samples (drawing provided by Mick Clarke).

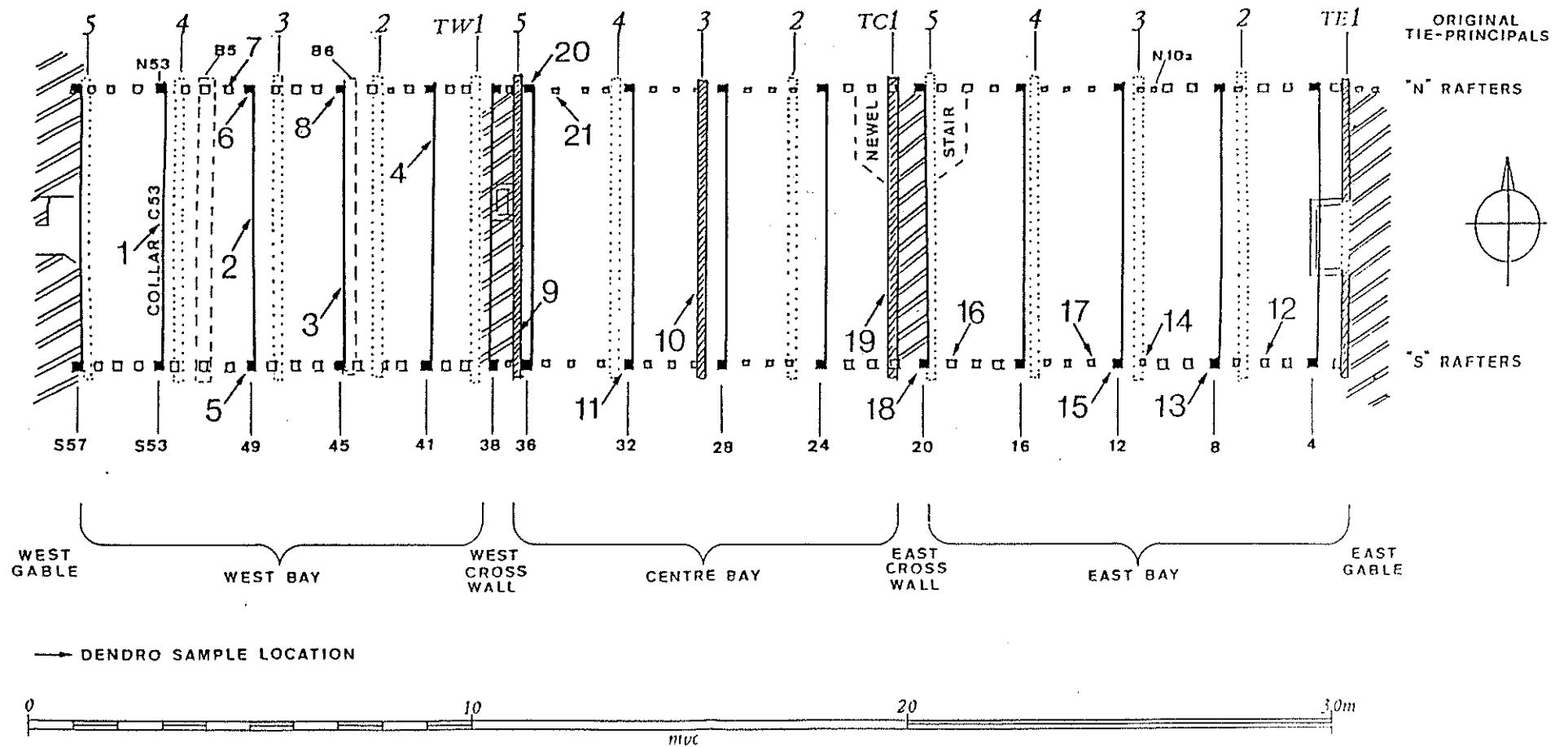
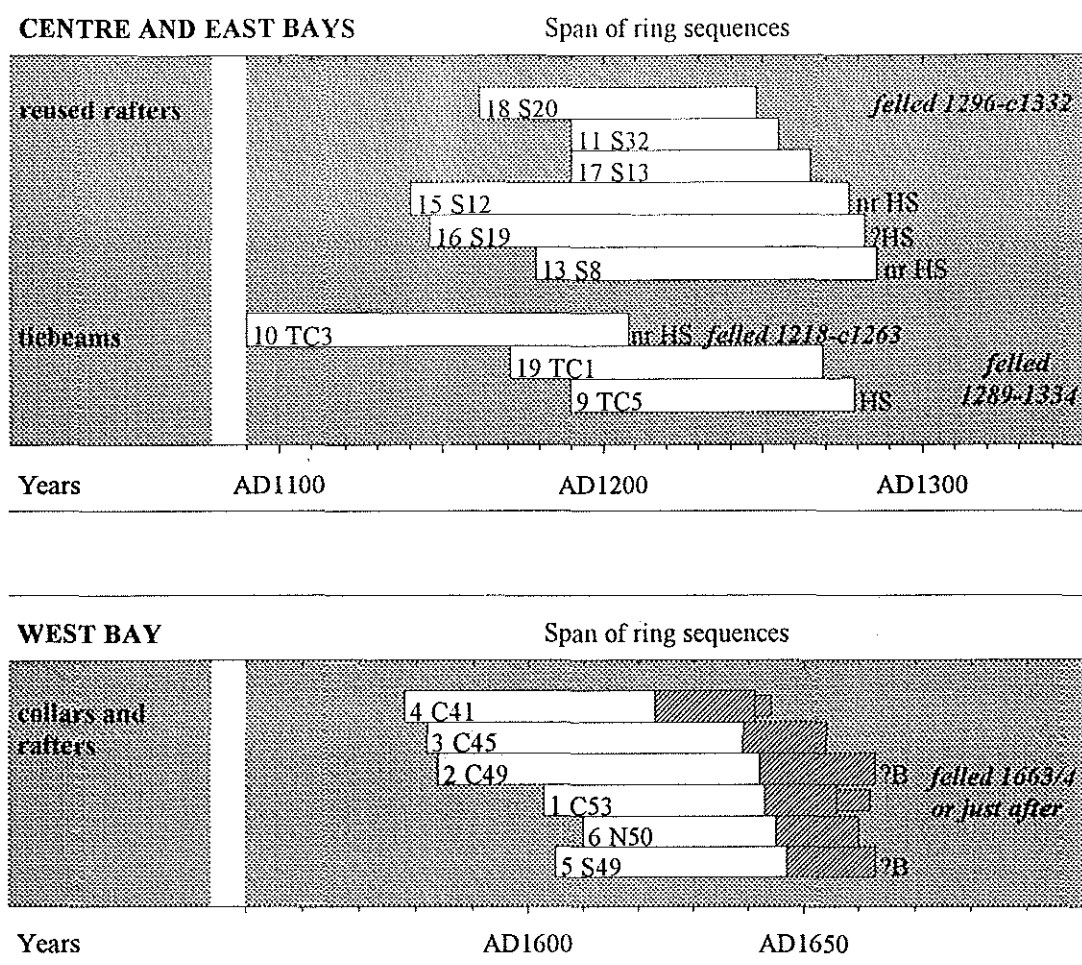


FIGURE 2: Schematic plan of the roof with its complex mixture of original, reused, and seventeenth-century timbers.

WEST BAY trusses TW1-5	CENTRE BAY trusses TC1-5	EAST BAY trusses TE1-5
collars - seventeenth-century roof rafters - seventeenth-century and reused from a medieval building? wallplates, binders - part of original medieval roof?	collars - contemporary with those in west bay? rafters - reused from another medieval building tiebeams - part of original medieval roof	collars - contemporary with those in west bay? rafters - reused from the same medieval building as centre rafters

FIGURE 3: Bar diagrams showing the relative positions of the dated tree-ring sequences.



Key:

White bars - heartwood rings

Hatching - sapwood

Broken bars - unmeasured rings

B - bark edge

HS - heartwood-sapwood boundary

TABLE 1: Details of the tree-ring samples.

Core	Timber	No of rings (sapwood)	ARW ¹ (mm)	Dimensions (mm)	Date span of rings (AD)	Felling date ² (AD)	Comment
west bay							
1	collar C53	54 (13+6) ³	1.9	210x80	1603-1654 (+6)	1660-1696	
2	collar C49	80 (21)	1.9	220x65	1584-1663	1663-1697	
3	collar C45	73 (15)	1.6	200x65	1582-1654	1654-1694	
4	collar C41	64 (18+3)	1.5	210x65	1578-1641 (+3)	1644-1678	
5	principal rafter S49	59 (16)	1.5	145x90	1605-1663	1663-1702	
6	rafter N50	51 (15)	1.3	150x70	1610-1660	1660-1700	
7	wallplate next to rafter N49	41 (HS ⁴)	-	-	rejected	-	
8	binder B5	53 (22)	1.8	undated		-	core broken due to knot/rot at centre of timber
centre bay							
9	low cranked tie TC5	90 (HS)	2.0	320x180	1190-1279	1289-1334	
10	high cranked tie TC3	119	2.5	310x220	1090-1208	1218- <i>c</i> 1263	HS elsewhere on timber
11	principal rafter S32	66	1.3	165x140	1190-1255	1265+	inner rings broken off
east bay							
12	rafter S6	28+	-	165x130	rejected	-	
13	principal rafter S8	108	1.2	170x155	1179-1286	1296- <i>c</i> 1341	sapwood about 80mm above coring position

¹ ARW - average ring width² In the absence of bark edge, felling date ranges or *termini post quem* for felling are estimated using the sapwood estimate of 10-55 rings (see Hillam *et al* 1987).³ +*n* indicates *n* unmeasured rings⁴ HS - heartwood-sapwood boundary

14	rafter S11	87 (HS?)	1.7	150x80	undated	-	small rafter, jointed at purlin level
15	principal rafter S12	138	1.0	170x150	1140-1277	1287-c1332	sapwood adjacent to coring position
16	rafter S19	137 (HS?)	1.2	160x160	1146-1282	1292+	same tree as 18
17	rafter S13	76	1.0	155x80	1190-1265	1275+	small rafter, jointed at purlin level
18	principal rafter S20	88	1.5	160x140	1161-1248	1292+	same tree as 16
central section							
19	low cranked tie TC1	99	1.8	250x200	1171-1269	1279+	
20	principal rafter N36	49	-	160x150	rejected	-	
21	rafter N35	92	1.0	140x75	undated	-	small rafter, jointed at purlin level

TABLE 2: *t* value matrix. Values less than 3.5 are not printed; \ - overlap less than 15 years.

collars, rafters - western section							reused rafters						tiebeams	
	1	2	3	4	5	6	11	13	15	16	17	18	10	19
1	*	8.3					\	\	\	\	\	\	\	\
	2	*	4.2	4.8	3.8	5.2	\	\	\	\	\	\	\	\
		3	*	4.3			\	\	\	\	\	\	\	\
			4	*		3.5	\	\	\	\	\	\	\	\
				5	*	4.0	\	\	\	\	\	\	\	\
					6	*	\	\	\	\	\	\	\	\
						11	*	6.0	7.4	9.1	6.2	7.7		4.1
							13	*	5.3	6.3	5.1	5.7		
								15	*	8.6	6.9	7.7		5.4
									16	*	8.3	14.2		3.7
										17	*	8.3		4.3
											18	*	4.2	5.6
												10	*	4.1
													19	*

TABLE 3: Chronology LINC_VC2, 1578-1663

year	ring widths (0.01mm)										number of samples						
AD1578											188	276	375				
	287	317	272	240	353	327	338	420	371	240	1	2	2	3	3	3	3
	157	167	252	320	228	247	237	248	139	130	3	3	3	3	3	3	3
AD1601	90	97	188	245	168	238	253	230	195	177	3	3	4	4	5	5	6
	203	218	247	178	107	142	168	194	161	171	6	6	6	6	6	6	6
	179	195	193	135	95	80	131	143	163	125	6	6	6	6	6	6	6
	114	122	116	81	90	112	90	129	117	132	6	6	6	6	6	6	6
	138	131	122	152	133	166	124	143	124	137	6	5	5	5	5	5	5
AD1651	101	91	75	109	156	133	78	110	82	122	5	5	5	5	4	4	3
	101	78	92								2	2	2				

TABLE 4: Dating LINC_VC2. t values with dated reference chronologies. All reference chronologies are independent of each other.

chronology	t value
East Midlands (Laxton and Litton 1988)	6.9
English/Welsh Border (Siebenlist-Kerner 1978)	4.5
Featherstone Church, West Yorkshire (Hillam 1978)	5.4
Ridgeway, Derbyshire (Groves unpubl)	4.1
Sutton-in-the-Isle, Cambs (Tyers 1995)	5.7
Yorkshire Buildings "YORKMED" (Hillam unpubl)	5.1

TABLE 5: Chronology LINC_VC1, 1090-1286

year	ring widths (0.01mm)										number of samples									
AD1090	311										1									
	239	153	194	205	241	169	216	262	333	378	1	1	1	1	1	1	1	1	1	1
AD1101	267	225	321	394	317	279	201	164	170	137	1	1	1	1	1	1	1	1	1	1
	220	237	272	302	287	355	452	246	117	96	1	1	1	1	1	1	1	1	1	1
	146	295	428	193	244	389	424	254	176	227	1	1	1	1	1	1	1	1	1	1
	280	201	207	249	380	276	174	197	156	356	1	1	1	1	1	1	1	1	1	2
	409	313	236	189	198	219	237	289	272	210	2	2	2	2	2	3	3	3	3	3
AD1151	199	155	243	190	195	209	207	167	175	186	3	3	3	3	3	3	3	3	3	3
	182	182	181	171	142	159	145	192	234	210	3	3	3	3	3	3	3	3	3	3
	198	143	153	170	193	169	128	143	149	162	3	3	3	3	3	3	3	3	4	4
	188	195	156	103	107	107	135	110	107	141	4	4	4	4	4	4	4	4	4	6
	129	132	180	141	139	149	120	113	149	141	6	6	6	6	6	6	6	6	6	6
AD1201	166	131	169	131	130	135	121	149	122	164	6	6	6	6	6	6	6	6	5	5
	148	126	127	123	118	144	140	102	119	117	5	5	5	5	5	5	5	5	5	5
	84	59	88	116	151	121	90	86	109	124	5	5	5	5	5	5	5	5	5	5
	119	108	72	79	130	113	152	133	138	90	5	5	5	5	5	5	5	5	5	5
	59	49	69	87	102	87	81	55	81	107	5	5	5	5	5	5	5	5	5	5
AD1251	131	96	132	112	119	106	109	90	96	91	5	5	5	5	5	4	4	4	4	4
	95	131	114	108	98	113	84	140	152	122	4	4	4	4	4	3	3	3	3	3
	155	132	147	122	96	75	87	80	76	122	3	3	3	3	3	3	3	2	2	2
	124	136	100	96	82	71					2	2	1	1	1	1				

TABLE 6: Dating LINC_VC1 to 1090-1286 and sample 9 to 1190-1279. t values with dated reference chronologies. Values less than 3.5 are not printed. All chronologies are independent of each other.

chronology	LINC_VC1	9
Beverley, Eastgate (Groves 1992a)	6.4	-
Beverley, Hall Garth (Hillam 1981)	-	5.1
Bradford-on-Avon, Wiltshire (Groves and Hillam 1994a)	4.3	4.0
Droitwich, Upwich 2 (Groves and Hillam forthcoming)	-	4.5
East Midlands (Laxton and Litton 1988)	11.0	3.7
Exeter Cathedral 1 (Mills 1988)	6.5	4.0
Grimsby 2 (Groves 1992b)	6.5	3.5
Hull, Chapel Lane Staithe (Hillam 1979)	6.5	4.6
Lincoln, Jew's House (Groves 1994)	7.0	-
Marwell Hall, Hampshire (Groves and Hillam 1994b)	4.9	4.5

TABLE 7: Ring width data for sample 9 from tiebeam TC5, 1190-1279

year	ring widths (0.01mm)										
AD1190											189
	237	416	446	376	396	440	356	223	249	239	
AD1201	322	290	304	257	326	153	176	315	210	276	
	359	232	165	220	229	233	219	326	257	289	
	201	187	121	210	248	158	152	340	279	267	
	141	110	120	196	161	108	139	115	108	78	
	118	141	166	261	180	198	135	86	158	185	
AD1251	129	103	128	134	223	163	154	164	188	227	
	134	157	169	164	121	132	81	165	137	115	
	139	108	123	108	135	111	124	107	146		