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Ancient Monuments Laboratory
Report 135/87

TREE-RING ANALYSIS OF TIMBERS FROM EASTGATE STREET, STAFFORD, 1982-84.

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Cathy Groves
(April 1987)

Summary

Tree-ring analysis was carried out on 30 timbers from late Saxon and later medieval structures from Eastgate Street, Stafford. No absolute tree-ring dates were obtained for the late Saxon features. The later medieval feature 142 was constructed in AD 1255/56 and the timbers from feature 233 were probably felled after AD 1189. Eleven of the samples were poplar and the use of non-oak species and short ring sequences for relative dating is discussed.

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Tree-ring analysis of timbers from Eastgate Street, Stafford, 1982-84

Introduction

Thirty wood samples from timber structures revealed during the excavations at Eastgate Street, Stafford, 1982-84 (site code - ST32) were sent for tree-ring analysis. The excavations were carried out by the Birmingham University Field Archaeology Unit under the direction of John Cane. All the samples were given a unique timber number at Sheffield, prefixed with the letters ES (Appendix 1).

The four main features providing samples are all wells: features 245 and 363 are both late Saxon and feature 363 was the only well associated with the late Saxon pottery industry on this site; features 142 and 233 occur at the end of the two most important pit sequences on the site. Pottery evidence indicated a circa 10th century date for 245 and 363 and a circa 12/13th century date for features 142 and 233. Additionally a radiocarbon date of AD 1260 +/-70 was obtained for a sample from feature 142. It was thought possible that some of the timbers, particularly those associated with feature 233, could be secondary (Cane pers comm).

The aim of the study was to produce a more accurate indication of the construction dates of the wells and hence help to provide a more precise dating framework for the site.

Method

The samples were prepared following the method given by Hillam (1985). They were then divided into oak (Quercus spp) and non-oak samples. The latter were identified by examining thin sections of wood from the transverse, radial and tangential planes (see, for example, Schweingruber 1978). Any unsuitable samples were rejected before measurement. These are usually samples with unclear ring sequences or oak samples with sequences of less than 30 rings. The number of rings and their orientation and also the size of the cross-section of every sample was noted (Appendix 1, 2).

The growth rings were measured by placing the sample on a travelling stage connected to an Apple II microcomputer which automatically records the widths after each ring has been traversed (Hillam 1985: fig 4). The

ring sequences were plotted as graphs on transparent semi-logarithmic paper. These tree-ring curves were compared visually by superimposing two curves and sliding one past the other searching for similarities in the ring patterns. A computer program (Baillie & Pilcher 1973) is also used as an aid to crossmatching. This measures the amount of correlation between two ring sequences at each position of overlap. The Student's t-test is then used as a significance test on the correlation coefficient and generally a t-value of 3.5 or over represents a match provided that the visual match is acceptable (Baillie 1982: 82-5). The program was also used to compare the tree-ring sequences from the oak samples with dated reference chronologies from Britain and Europe.

The results only date the rings present in the timber and therefore do not necessarily represent the felling date. If the sapwood on an oak sample is complete, indicated by the presence of bark or bark edge, the exact felling year can be determined. A recent study of oak sapwood data showed that 19 out of 20 samples from British trees over 30 years old had 10-55 sapwood rings (Hillam et al 1987). These 95% confidence limits are used to estimate felling dates in the absence of complete sapwood. In the total absence of sapwood the addition of 10 rings to the date of the last measured heartwood ring produces a probable terminus post quem for felling. As the number of missing heartwood rings is unknown the actual felling date could be much later.

Construction usually followed soon after felling since in medieval times timber was rarely seasoned (see for example Hollstein 1980 or Rackham 1976). At this stage of tree-ring analysis, however, factors such as stockpiling or timber re-use must also be considered, since they might affect the interpretation of the tree-ring dates. Thus, whilst the production of dates is a completely independent process, their interpretation can be refined by studying other archaeological evidence.

Results

Feature 142

The timbers from well 142 were all oak. The heartwood-sapwood transition was present on three samples (ES1, ES4, ES29), of which one, ES1, had retained its full complement of sapwood, indicated by the presence of bark edge.

The curves from three timbers (ES1, ES4, ES29) crossmatched to give a total sequence of 89 years. Their ring widths were averaged to produce a master curve, ES1/4/29. The master curve and the two unmatched ring sequences (ES2, ES3) were compared with various reference chronologies from Britain and Europe, details of which are given in Appendix 3. Sample ES3 and the master curve were dated to the periods AD 1135-1189 and 1167-1255 respectively (Table 1; Figure 1).

Due to the absence of sapwood on timber ES3, a probable terminus post quem for felling of AD 1199 is obtained. The dates of the heartwood-sapwood transitions of timbers ES1, ES4 and ES29 are AD 1226, 1218 and 1227 respectively. It seems probable that these timbers are contemporary and were therefore felled in winter/early spring AD 1255/56.

Feature 233

Two (ES5, ES9) of eight oak samples were rejected as they had very few rings and had not retained any sapwood. Although the remainder had 35-249 annual growth rings, no reliable crossmatching was found between the ring sequences. The sequences were next tested against reference chronologies. Samples ES7 and ES8, both from context 1493, showed relatively high t-values with several of the chronologies when their rings cover the periods AD 1022-1156 and AD 937-1179 repectively (Table 1; Figure 1). ES8 matches particularly well with chronologies from Beverley:Eastgate, Bristol:Dundas Wharf and Dublin.

The outermost 16 rings of ES7 were counted rather than measured due to the presence of a narrow band of rings. Neither ES7 or ES8 had retained sapwood and therefore probable felling dates of after AD 1192 and after 1189 respectively are indicated.

Feature 245

The two oak samples from well 245 were both untrimmed roundwood with bark present. Unfortunately neither was suitable for measurement due to the presence of a band of narrow rings at the heartwood-sapwood transition.

Feature 363

Three of the samples were oak and eleven were poplar (Populus spp). The oak samples (ES15, ES16, ES28), all radially split segments, had 24, 27

and 25 rings respectively. Normally samples with less than 30 rings are not measured. Ring sequences of this length are generally not unique and so cannot be dated reliably. However, as all three samples had retained a full complement of sapwood these short sequences were measured. They crossmatched with high t-values (7.7, 9.4, 9.8), which the visual comparisons confirmed (Figure 2a), and the ring widths were combined to form a short master, ESOAK.

One poplar sample, ES20, was fragmented and the number of rings could not be determined. The remainder had 19-42 rings and bark was present on six (ES18, ES19, ES23, ES24, ES26, ES27). The rings sequences were measured as it was thought that relative dating may be possible. High t-values and very good visual matches were found between eight sequences (Table 2; Figure 2b) and their ring widths were averaged to form a master, ESPOPLAR1. ES21 and ES25 crossmatched with a t-value of 6.5 (Figure 2c) but did not appear to match ESPOPLAR1, and so were combined to produce a second master, ESPOPLAR2.

The ring sequence of an additional sample, an oak plank (ES30) with 106+ annual rings, was also measured and compared with various reference chronologies. ES30 gave t-values consistently over 4.0 with chronologies from East Midlands (Laxton et al pers comm), Beverley (eg Groves 1987) and Nantwich (Leggett 1980) when its rings spanned AD 1049-1154 (Table 1). The outer 32 rings of this sample were counted rather than measured as they were unclear. Therefore a probable terminus post quem for felling of AD 1196 is indicated. The ring width data of all the dated oak samples were averaged to produce a 325 year site master curve, STAFFORD-ES (Table 3) which spans the period AD 931-1255 (Table 1). The results are summarised in Appendix 4.

The timbers

Most of the timbers are radially split planks (eg ES12, ES15, ES23) though some are unworked roundwood (eg ES4, ES13). The average ring widths of the oak timbers vary from 0.80 to 4.01mm. Generally trees with very narrow rings are from woodland where competition was severe,

whereas trees with wider rings usually originate from more open contexts where less competition was experienced (Bartholin 1978).

The number of rings present on the medieval samples ranged from 23-249. In general during the medieval period, trees seem to have been felled under 100 years old, and often at about 70 years (Rackham 1976). However, the medieval well timbers appear to have originated from trees ranging from approximately 40 to 249+ years old with diameters of 0.1 to over 0.7m. Sample ES30, for example, has retained no sapwood and there is no indication of the pith, so it probably originated from a trunk of at least 0.7m diameter. The Saxon timbers, both poplar and oak, are all from trees under approximately 40 years old, with diameters ranging from 75 to 125mm.

Discussion

Although re-use of timbers has been suggested for all four features, it is less likely that the samples with sapwood, particularly ES1 which has bark edge, are secondary. Sapwood is more susceptable than heartwood to fungal and insect attacks and may be therefore less likely to survive secondary use. It would not be necessary to season timbers for use in a well, so the felling dates of the samples from feature 142 indicate that it was constructed in AD 1255/56 or shortly afterwards. Timber ES3, also associated with feature 142, has a probable terminus post quem of AD 1199 which suggests that it either has a number of heartwood rings missing or that it may have been re-used.

Feature 233 is represented by two dated timbers which appear to be contemporary. The lack of sapwood and the possibility of re-use causes the felling dates and therefore the construction date of the well to be less precise. However, the results indicate that this well was built after AD 1189. The terminus post quem of AD 1196 for ES30 does not give any indication as to which medieval feature it is associated with.

The lack of correlation between the majority of individual ring sequences from the later medieval samples suggests that the timbers either came from different sources or from trees which were responding to different local conditions.

The similar appearance of the two roundwood samples from feature 245 suggests that their ring sequences may have crossmatched if it had been possible to measure the narrow band of rings at the heartwood-sapwood transition. These timbers contained only approximately 35 rings and it is therefore unlikely that they could have been absolutely dated. Short ring sequences are generally not unique and therefore cannot be reliably absolutely dated. However, it is sometimes possible to obtain relative dating with such sequences, when they are associated with a single structure and bark or bark edge is present. The matches between the three short oak tree-ring sequences from feature 363 were very good and suggest that the planks may have been split from a single trunk. Comparable results were also obtained for the poplar sequences.

Although it has not yet been proved that non-oak ring sequences can be matched against oak, there are some indications that species such as ash (Fraxinus excelsior L.) do show similar ring patterns (see, for example, Morgan 1984). There was certainly no similarity between the Stafford oak and poplar but it is evident that further research is necessary concerning inter-species crossmatching.

Conclusion

No tree-ring dates were obtained for the late Saxon features (245, 363) as the only available oak samples were unsuitable for absolute dating. However the successful crossmatching of ring sequences from the poplar samples demonstrates the possibility of obtaining relative dating from species other than oak.

The dated samples from feature 142 indicate that the well was constructed in AD 1255/56 shortly after the timbers were felled. The absence of sapwood and the possibility of re-use of the timbers from feature 233 causes the felling date and therefore the construction date to be less precise. However, the well cannot have been built before AD 1189.

The dendrochronological results confirm the broad 12/13th century date for the later medieval features indicated by pottery and are consistent with the radiocarbon date obtained for feature 142.

Acknowledgements

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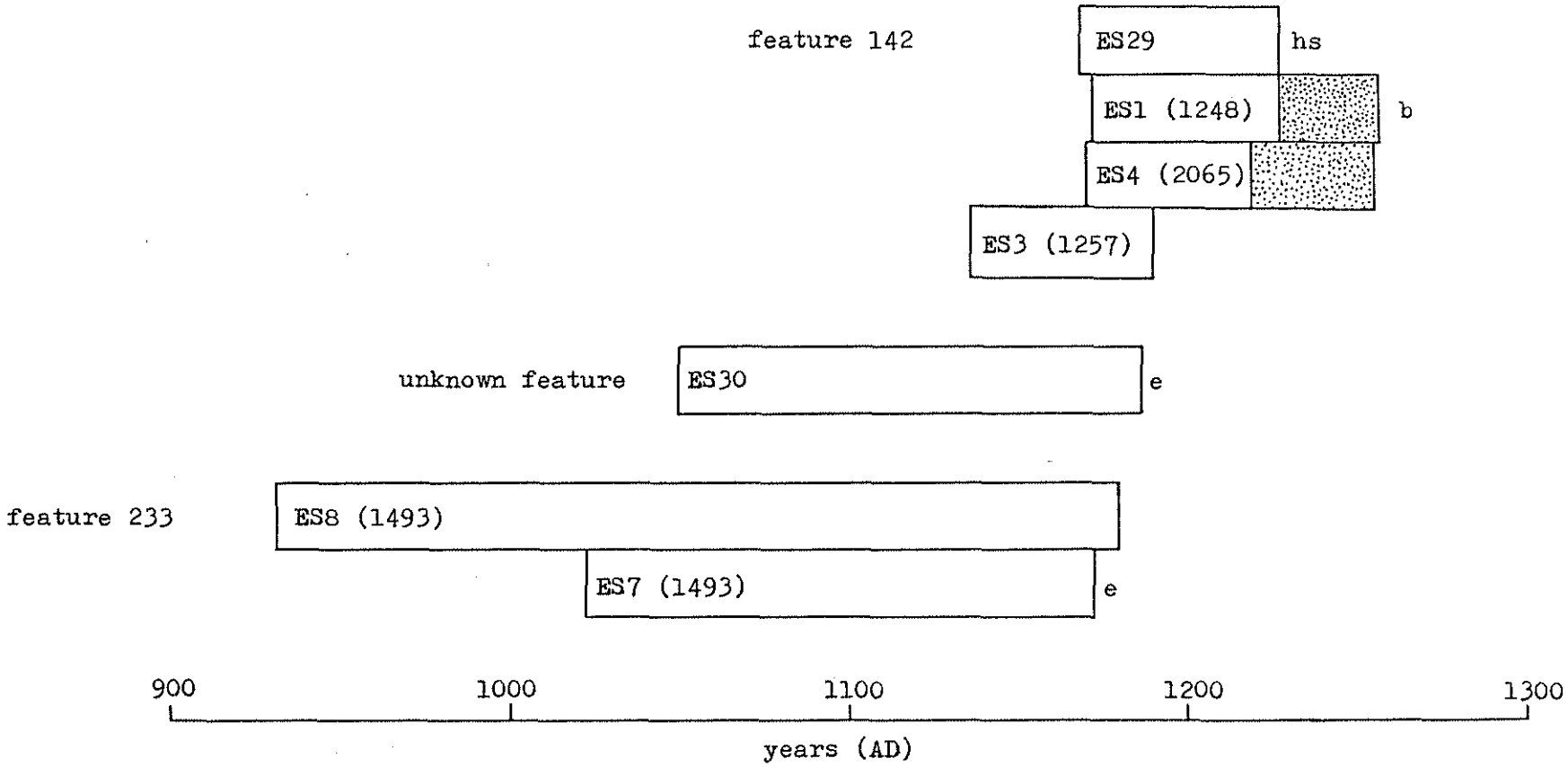


Figure 1: Bar diagram showing the relative positions of the dated ring sequences from Eastgate Street, Stafford. Context numbers are given in brackets where known; hs - indicates heartwood/sapwood boundary; b - indicates the presence of bark edge; e - indicates the presence of unmeasured rings; ▒ - indicates sapwood.

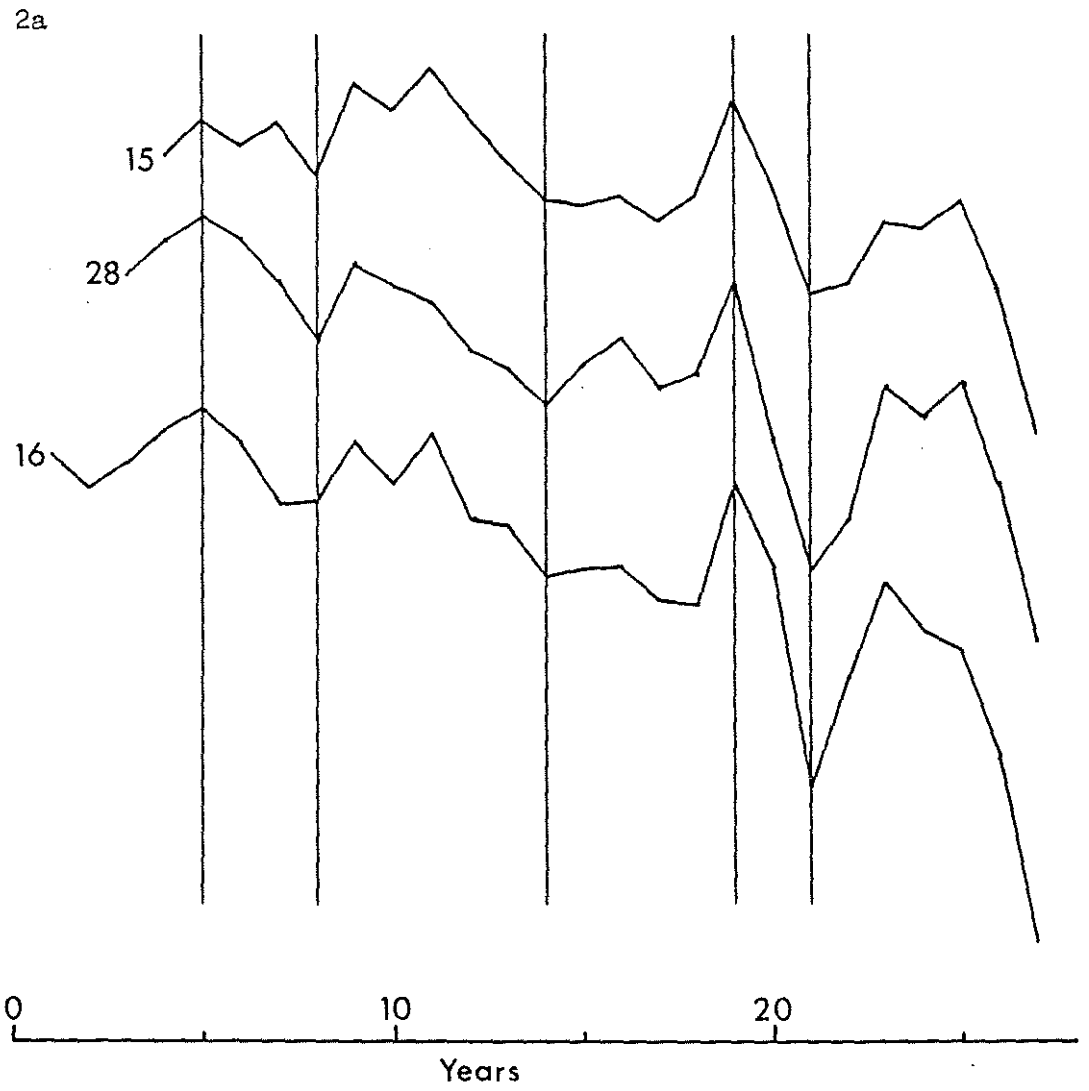
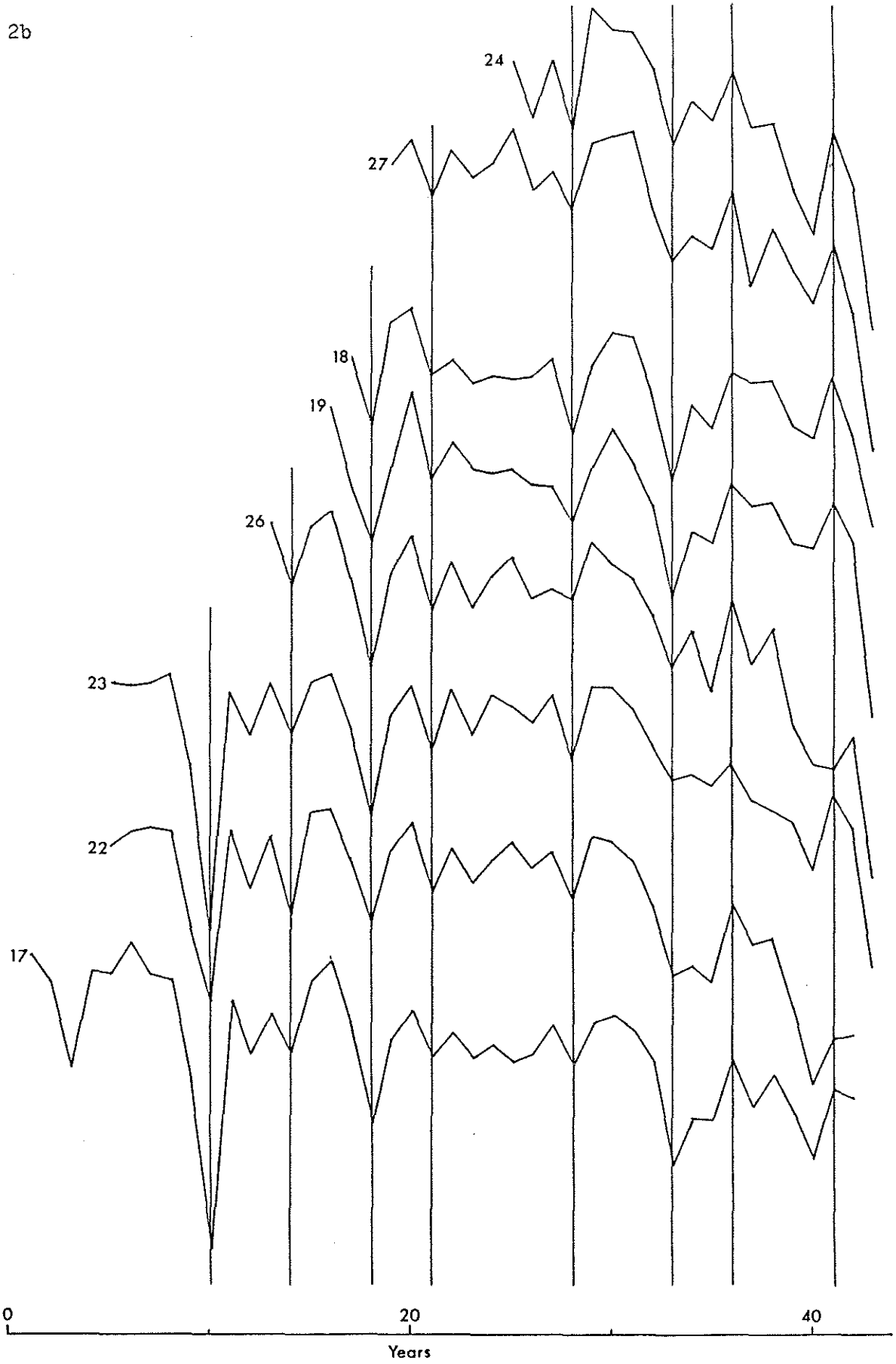


Figure 2: Matching tree-ring curves. The vertical scale is logarithmic and the ring widths are in units of 0.02mm: a) the matches between the oak ring sequences ES15, ES16 and ES28 are illustrated; b) the matches between the eight poplar sequences included in the master curve ESPOPLAR1 are illustrated; c) the match between the two poplar ring sequences ES21 and ES25 is illustrated.


2b
24
27
18
19
26
23
22
17
0
20
40
Years

2c

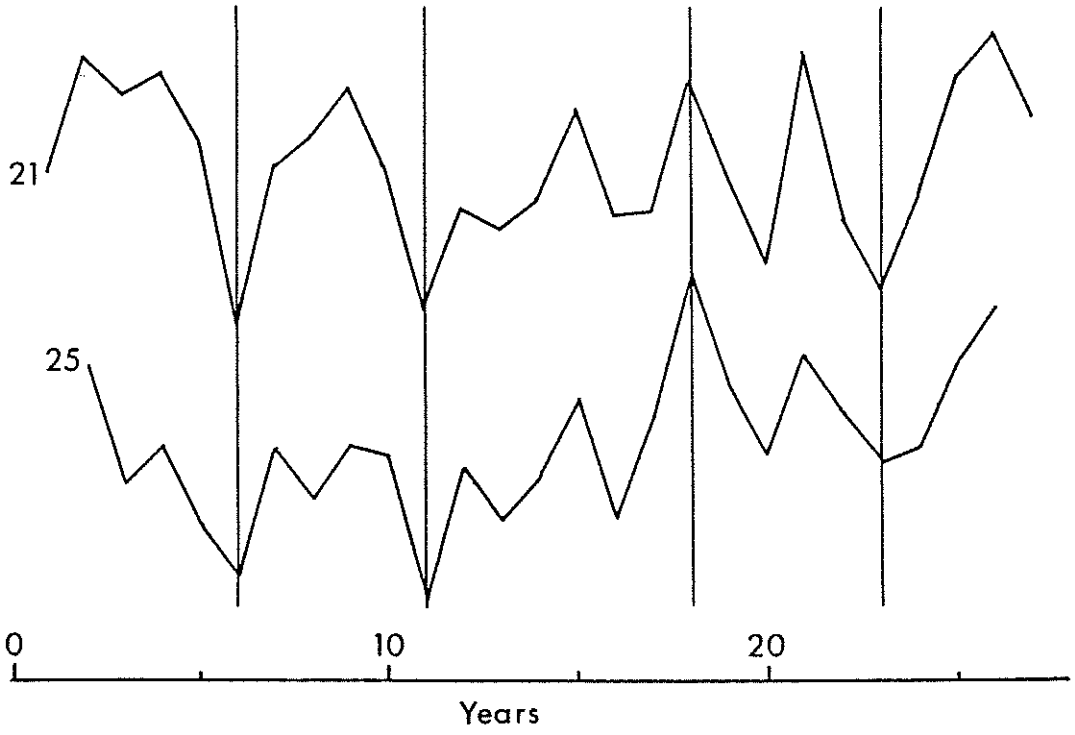


Table 1: Dating the Eastgate Street ring sequences. Results of comparisons with dated reference chronologies for ES1/4/29 (1167-1255), ES3 (1135-1189), ES7 (1022-1156), ES8 (931-1179), ES30 (1049-1134) and the master curve STAFFORD-ES (931-1255). x - indicates a t-value of less than 3.0 or an overlap of less than 30 years.

	t-values					
reference chronology	ES1/4/29	ES3	ES7	ES8	ES30	STAFFORD-ES
Baguley, Manchester	3.0	4.2	x	x	x	3.5
Bilby, Nottinghamshire	3.8	x	x	4.9	x	5.8
Carlisle medieval	x	3.0	x	5.7	x	5.9
Coppergate medieval, York	3.7	x	3.3	x	x	5.2
Dublin	3.4	5.8	x	7.1	x	5.0
Dundas Wharf, Bristol	x	5.1	3.4	8.6	x	6.0
East Midlands	3.4	4.3	4.3	6.2	4.2	7.4
Eastgate, Beverley	3.5	x	5.3	8.5	4.2	7.3
England	3.5	5.7	3.1	7.9	3.4	7.7
Hall Garth, Beverley	3.4	x	x	x	4.4	4.8
Hull	3.5	x	x	x	x	4.0
Nantwich, Cheshire	x	4.5	3.8	3.4	4.8	4.6
Reading	3.4	x	x	x	x	4.0
Scotland	3.2	4.2	x	4.9	x	4.5
Trier area, Germany	x	x	x	4.6	x	x

Table 2: Matrix of t-values obtained for comparisons between the eight poplar ring sequences included in the master curve ESPOPLAR1.

	ES17*	ES18*	ES19*	ES22*	ES23*	ES24*	ES26*	ES27*
ES17*	-	6.5	9.5	13.2	18.1	5.6	8.1	4.7
ES18*	6.5	-	11.5	5.6	6.0	6.2	3.8	4.8
ES19*	9.5	11.5	-	7.8	8.1	6.5	6.1	5.9
ES22*	13.2	5.6	7.8	-	12.2	7.2	11.5	5.3
ES23*	18.1	6.0	8.1	12.2	-	8.4	7.1	5.8
ES24*	5.6	6.2	6.5	7.2	8.4	-	3.7	5.6
ES26*	8.1	3.8	6.1	11.5	7.1	3.7	-	4.3
ES27*	4.7	4.8	5.9	5.3	5.8	5.6	4.3	-

Table 3: Ring width data, in units of 0.02mm, of the Eastgate Street, Stafford, master curve, STAFFORD-ES (AD 931-1255).

year	ring widths									
(AD)	0	1	2	3	4	5	6	7	8	9
931		88	97	43	52	48	52	70	81	61
940	58	63	53	55	47	49	51	62	60	58
950	46	35	35	36	33	36	30	27	26	30
960	30	32	32	37	37	27	31	35	35	37
970	36	34	46	34	34	38	30	42	33	46
980	42	40	41	48	31	34	40	35	31	38
990	30	36	39	34	35	35	32	37	37	44
1000	35	46	42	35	34	25	23	26	31	31
1010	31	27	32	41	31	37	32	30	31	30
1020	27	35	155	143	114	74	92	95	94	75
1030	87	75	66	53	39	44	41	57	57	52
1040	45	56	60	42	50	48	49	62	55	118
1050	108	112	114	110	107	100	103	115	111	149
1060	151	109	93	67	68	63	98	82	83	92
1070	114	99	54	91	110	117	107	88	101	90
1080	88	60	62	87	99	107	104	79	100	90
1090	54	75	98	73	64	64	65	57	72	71
1100	57	52	64	95	73	75	70	62	92	65
1110	51	76	82	82	56	55	57	72	55	38
1120	41	56	68	72	77	88	57	47	46	45
1130	55	53	56	52	53	71	50	45	47	57
1140	69	76	65	44	42	51	59	62	82	85
1150	71	72	78	86	83	74	77	80	81	122
1160	112	79	60	67	63	69	46	48	52	62
1170	57	64	78	82	65	61	60	50	65	86
1180	75	62	71	81	57	64	46	49	42	44
1190	40	41	46	52	39	55	67	63	39	45
1200	31	28	28	64	59	94	83	55	72	66
1210	68	46	37	34	62	65	65	73	49	50
1220	51	58	34	52	75	121	149	162	128	119
1230	94	43	30	31	43	49	29	40	43	39
1240	49	31	33	37	50	36	44	41	41	37
1250	28	26	20	30	37	48				

APPENDIX 1

Details of the samples

TIMBER - timber number allocated at Sheffield

FEATURE - feature number

CONT/SAMP - context and sample number

RINGS - total number of rings

SAP - number of sapwood rings

AV.WIDTH - average ring width in mm

DIMENSIONS - maximum dimensions of the cross-section in mm

hs - heartwood-sapwood boundary

+ - indicates the presence of rings which could not be measuered accurately

* - indicates that the sample is poplar

APPENDIX 1 - DETAILS OF THE SAMPLES
File: EAST
Report: SAMPLES

TIMBER	FEATURE	CONT/SAMP	RINGS	SAP	AV.WIDTH	DIMENSIONS	COMMENT
ES1	142	1248	85	30	1.73	165X130	felled winter
ES2	142	1257/2	38	-	2.04	105x85	-
ES3	142	1257/9	55	-	2.15	275x100	knotty
ES4	142	2065b/7	86	37	0.73	110x110	bark edge?
ES5	233	1472	27	-	-	100x15	-
ES6	233	1492	42	12	3.10	130x35	-
ES7	233	1493	135+	-	1.35	200x40	+16 rings
ES8	233	1493	249	-	0.80	195x60	-
ES9	233	1495	23	-	-	100x10	-
ES10	233	1495	54	-	2.40	130x25	-
ES11	233	1495	43	-	2.18	100x15	-
ES12	233	1495/D	35	-	2.81	110x15	-
ES13	245	1823/17	c35	c10	-	75x75	narrow rings
ES14	245	1823/20	c35	c10	-	95x80	narrow rings
ES15	363	1A	24	7	4.01	100x35	felled summer
ES16	363	1C/B	27	7	3.46	100x55	felled summer
ES17*	363	1D	42	-	2.24	100x40	-
ES18*	363	2	27	-	2.72	90x45	bark edge
ES19*	363	2	28	-	1.98	90x45	bark edge
ES20*	363	3	-	-	-	-	fragmented
ES21*	363	5	27	-	3.00	110x65	-
ES22*	363	6	38	-	2.47	95x25	-
ES23*	363	7	39	-	2.77	125x40	bark edge
ES24*	363	8	19	-	2.33	80x45	bark edge
ES25*	363	9	26	-	2.56	70x40	-
ES26*	363	10	31	-	2.63	80x50	bark edge
ES27*	363	12	25	-	2.72	80x55	bark edge
ES28	363	16	25	7	4.32	115x50	felled summer
ES29	142	unknown	60	-	0.82	100X85	hs boundary
ES30	-	plank	106	-	2.47	310x30	+32 rings

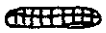
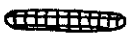
APPENDIX 2

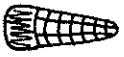
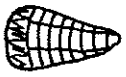
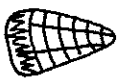
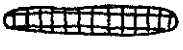
Cross-sectional sketches

These are not drawn to scale, and are intended as a rough guide to the way in which the timbers were cut or split.

Sapwood is indicated by shading.

APPENDIX 2

Timber	Sketch	Dimensions
Feature 142		
ES1		165x130
ES2		105x85
ES3		275x100
ES4		110x110
ES29		100x85
Feature 233		
ES5		100x15
ES6		130x35
ES7		200x40
ES8		195x60
ES9		100x10
ES10		130x25
ES11		100x15
ES12		110x15
Feature 245		
ES13		75x75

Timber	Sketch	Dimensions
ES14		95x80
Feature 363		
ES15		100x35
ES16		100x55
ES17*		100x40
ES18*		90x45
ES19*		90x45
ES20*	fragmented	-
ES21*		110x65
ES22*		95x25
ES23*		125x40
ES24*		80x45
ES25*		70x40
ES26*		80x50
ES27*		80x55
ES28		115x50
Unknown feature		
ES30		310x30

APPENDIX 3

Details of reference chronologies used in the dating of the Stafford Eastgate tree-ring sequences

chronology	date span
Baguley, Manchester (Leggett 1980)	1037-1290
Bilby, Nottinghamshire (Morgan unpublished)	1084-1311
Carlisle medieval (Baillie & Pilcher pers comm)	893-1600
Coppergate medieval, York (SDL unpublished)	1031-1248
Dublin (Baillie 1977a)	855-1306
Dundas Wharf, Bristol (Nicholson 1985)	770-1202
East Midlands (Laxton, Litton & Simpson pers comm)	882-1976
Eastgate Beverley (Groves 1987)	858-1310
England (Baillie & Pilcher pers comm)	404-1981
Germany Trier area (Hollstein 1980)	400BC-AD1965
Hall Garth, Beverley (Hillam 1981)	1002-1324
Hull (Hillam 1979)	1126-1297
Nantwich, Cheshire (Leggett 1980)	930-1330
Reading (Groves, Hillam & Pelling-Fulford 1985)	1160-1407
Scotland (Baillie 1977b)	950-1924

(SDL - Sheffield Dendrochronology Laboratory)

APPENDIX 4

Summary of the results

TIMBER - timber number allocated at Sheffield

FEATURE - feature number

CONT/SAMP - context and sample number

hs - heartwood-sapwood boundary

+ - indicates the presence of rings which could not be measuered accurately

* - indicates that the sample is poplar

APPENDIX 4 - SUMMARY OF RESULTS
File: EAST
Report: RESULTS

TIMBER	FEATURE	CONT/SAMP	RESULT1	RESULT2	COMMENT
ES1	142	1248	dated	1171-1255	felled winter
ES2	142	1257/2	undated	-	-
ES3	142	1257/9	dated	1135-1189	knotty
ES4	142	2065b/7	dated	1169-1154	bark edge?
ES5	233	1472	rejected	-	-
ES6	233	1492	undated	-	-
ES7	233	1493	dated	1022-1156	+16 rings
ES8	233	1493	dated	931-1179	-
ES9	233	1495	rejected	-	-
ES10	233	1495	undated	-	-
ES11	233	1495	undated	-	-
ES12	233	1495/D	undated	-	-
ES13	245	1823/17	rejected	-	narrow rings
ES14	245	1823/20	rejected	-	narrow rings
ES15	363	1A	rejected	-	felled summer
ES16	363	1C/B	rejected	-	felled summer
ES17*	363	1D	rejected	-	-
ES18*	363	2	rejected	-	bark edge
ES19*	363	2	rejected	-	bark edge
ES20*	363	3	rejected	-	fragmented
ES21*	363	5	rejected	-	-
ES22*	363	6	rejected	-	-
ES23*	363	7	rejected	-	bark edge
ES24*	363	8	rejected	-	bark edge
ES25*	363	9	rejected	-	-
ES26*	363	10	rejected	-	bark edge
ES27*	363	12	rejected	-	bark edge
ES28	363	16	rejected	-	felled summer
ES29	142	unknown	dated	1167-1226	hs boundary
ES30	-	plank	dated	1049-1154	+32 rings