Centre for Archaeology Report 2/2003

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ISSN 1473-9224

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Summary

A tree-ring dating programme was initially commissioned on a number of timbers recovered during repairs to the south transept roof of the church of St John the Baptist, Bradworthy, Devon, by English Heritage in AD 2002. Subsequently additional work was undertaken during repairs to the westernmost trusses of the nave. The tree-ring results indicate that timbers felled in the later part of the fourteenth century are present in both areas of the roofs. The almost total absence of surviving sapwood prevents precise felling or construction dates from being obtained.

Keywords

Dendrochronology
Standing Building

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TREE-RING ANALYSIS OF OAK TIMBERS FROM THE SOUTH TRANSEPT AND NAVE ROOFS OF THE CHURCH OF ST JOHN THE BAPTIST, BRADWORTHY, DEVON

Introduction

This document is a technical archive report on the tree-ring analysis of oak timbers from two areas of the roofs of the church of St John the Baptist, Bradworthy, Devon (NGR SS 3256 1398) commissioned by English Heritage. It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. 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 church of St John the Baptist lies to the east of the market square that forms the distinctive centre to the village of Bradworthy. Bradworthy lies in the remote north-west corner of Devon, the Bristol Channel is *c* 12 km to both the north and west. Cornwall is *c* 5km west, Bideford is *c* 20km north-east, whilst Launceston is *c* 30km south (Figs 1 and 2). Unlike many Devon churches Bradworthy appears to have avoided extensive later rebuilding (Blaylock 2002; Cherry and Pevsner 1989). The church has been undergoing a series of English Heritage grant aided repairs. Initial contact was made over a series of timbers found laying on the tops of the walls of the south transept, which were apparently behind the current roof trusses. These were removed during the works and they were subsequently collected and tree-ring analysis undertaken on samples from them. Before this work was completed a further phase of repair work provided access to a series of timber trusses at the west end of the nave. These repairs found it was necessary to replace one of the original trusses entirely. Remarkably a further timber was found to be laying on the wall plates in this area in the same manner as those recovered earlier from the south transept. The results of the analysis of all of this material is reported here. The walls of the church include areas thought to date from the twelfth century through to the fourteenth century; however there are records that indicate extensive rebuilding work was carried out at Bradworthy after a lightening strike in or before AD 1395; the tower of *c* AD 1500 is clearly an addition to an existing nave (Blaylock 2002).

Methodology

The general methodology and working practises used at the Sheffield Dendrochronology Laboratory are described in English Heritage (1998). The methodology used for this building was as follows.

Seven timbers were initially collected from the church in March 2002. These timbers were photographed and then cross-sections were cut from them by band-saw. In July repair work in the nave had exposed additional material, and the church was visited in the expectation of coring some *in-situ* material and recovering sections of some of the removed material. On arrival an initial assessment was undertaken to ensure that there were suitable timbers present in the building. This assessment aimed to identify those oak timbers with the most suitable ring sequences for analysis. This assessment identified that the nave trusses contained some suitable material, and that some of the replaced timbers would also provide suitable

sections. A number of other fragments of replaced timbers and timbers located loose on the wall tops were also assessed.

The dendrochronological sampling programme attempted to cover the suitable phases by obtaining samples from as broad a range of timbers, in terms of structural element types, scantling sizes, carpentry features, and surface condition as was possible within the terms of the request.

The most promising *in-situ* timbers were sampled using a 15mm diameter corer attached to an electric drill. The cores were taken as closely as possible along the radius of the timbers so that the maximum number of rings could be obtained for subsequent analysis. The core holes were left open to aid ventilation. The ring sequences in the cores were revealed by sanding. Sections were cut from the *ex-situ* timbers by hand-saw. These samples were removed to Sheffield, and then they were further trimmed by band saw.

The complete sequences of growth rings in the cores and slices that were selected for dating purposes were measured to an accuracy of 0.01mm using a micro-computer based travelling stage (Tyers 1999a). The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition a cross-correlation algorithm (Baillie and Pilcher 1973) was employed to search for positions where the ring sequences were highly correlated. These positions were checked visually using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences. The *t*-values reported below are derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position must be obtained from a range of independent sequences, and that these positions are supported by satisfactory visual matching.

All the measured sequences from this assemblage were compared with each other and any found to cross-match were combined to form a site master curve. These, and any remaining unmatched ring sequences, were tested against a range of reference chronologies, using the same matching criteria: high *t*-values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found these provide calendar dates for the ring-sequence.

The tree-ring dates produced by this process initially only date the rings present in the timber. The interpretation of these dates relies upon the nature of the final rings in the sequence. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings which are missing. This *tpq* may be many decades prior to the real felling date. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimates applied throughout this report are a minimum of 10 and maximum of 46 annual rings, where these figures indicate the 95% confidence limits of the range (Tyers 1998). These figures are applicable to oaks from England and Wales. Alternatively, if bark-edge survives, then a felling date can be directly utilised from the

date of the last surviving ring. The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the re-use of timbers, seasoning, and repairs before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of phases within the structure.

Results

Seven timbers were collected during the initial visit, these were assessed once back in the laboratory. The timbers were assigned arbitrary labels **A-G** inclusive. This material is known to be derived from the south transept but its precise original location is unknown (Table 1). During the subsequent visit 16 timbers were selected for sampling from a much larger number that were examined within the nave. These samples were numbered **1-16** inclusive. Samples **1-12** inclusive were cores from the southern elements of the western trusses of the nave roof (following the numbering scheme adopted by Stuart Blaylock on site where T1 is the truss adjacent to the tower these are from T2-T8; Fig 3). Sample **13** was from a loose timber collected by the contractors from the northern nave wall, whilst samples **14-16** were from the original elements of the westernmost truss (T1). Sample locations throughout the nave were recorded by a combination of the truss number, and the structural element description (Figs 3 and 4; Table 1). All the timbers are oak (*Quercus* spp.).

Two of the south transept timbers (samples **F** and **G**) when examined in the laboratory were rejected because they had too few rings for reliable analysis. The tree-ring sequences from the remaining 21 timbers were measured and the resultant series were then compared with each other. Nineteen sequences were found to match together to form an internally consistent group (Table 2). A 243-year site mean chronology was calculated, named BRDWRTHY. This site mean, and the two unmatched samples, were then compared with dated reference chronologies from throughout the British Isles and northern Europe. A single well correlated position was identified for the BRDWRTHY sequence. Table 3 shows example correlations at its identified dating position against independent reference chronologies. Table 1 provides the chronological dates identified for each component sample by this process and their interpretation. Figure 5 graphically shows the chronological position identified for each component sample. Appendix 1 lists the individual sample series. The remaining two measured samples did not match either the rest of the material from Bradworthy nor reference chronologies and are thus undated by this analysis.

Discussion

The 243-year chronology BRDWRTHY is dated AD 1125 to AD 1367 inclusive. It was created from nineteen timbers, five from the south transept timbers, and 12 from the nave timbers. None of the dated samples were complete to the original bark surface, and only two of the dated samples are complete to the heartwood/sapwood boundary, one of which includes a detached fragment of sapwood (Table 1).

South transept roof. None of these timbers is attributed to a specific location. They don't need to have come from the church roofs at all, although it seems logical to assume their presence on the south transept walls indicates they were originally from this area. The seven collected timbers comprised two distinctive

types. Five have a tenon at one end, with the tenon and haunches slightly angled. At the opposite end are the remains of a mortise, pegged through. In every case the joint has been cut through, presumably to release the timber. These timbers are mostly quarters or smaller sections of large trees and contain large numbers of fairly slow-grown rings. No sapwood survives on any of this material. The other two timbers had almost no distinguishing features, and they are also different in their suitability for tree-ring analysis. They are made from small whole fast growing trees and neither contained more than 20 annual rings. The five useable timbers (Table 1; Fig 5) from this area were all found to be datable. Unfortunately the dates of the latest rings in each sample are spread over nearly a century – sample **D** ends at AD 1228, whilst **E** ends at AD 1324. The variation in the end dates seems likely to be a reflection of the method of converting the timbers from segments of larger trees. Thus it seems most probable that they are a co-eval group of timbers, dating from sometime after AD 1334.

Nave roof. The nave consists of about 40 arch-braced trusses. The south side of the westernmost eight trusses were safely accessible for assessment and sampling (Figs 3 and 4). The timbers selected for sampling are again mostly quarters or smaller sections of large trees and contain large numbers of fairly slow-grown rings. Almost no sapwood survives on any of this material but several curving surfaces derived from the heartwood/sapwood boundary were observed. Some of these were accessible for coring. Two of the cored timbers and one of the removed T1 timbers included sapwood, but in every case this disintegrated during sampling due to its poor condition. Fourteen of the sixteen samples (Table 1; Fig 5) from this area were found to be datable. Here the dates of the latest rings in each sample are spread over more than a century – sample **9** ends at AD 1237, whilst **16** ends at AD 1367. This variation in the end dates again seems likely to be a reflection of the method of converting the timbers from segments of larger trees. Thus it seems most probable that they are a co-eval group of timbers. Two of the dated samples include the heartwood/sapwood boundary, one of which can be slightly refined by adding on the number of sapwood rings in a detached fragment. These samples indicate the group was felled between AD 1383 and AD 1402.

Conclusion

It is notable that the south transept material has a range of end dates quite similar to those recovered from the more obviously co-eval nave timbers (Fig 5). No sample with the outer surfaces of the tree is present in the somewhat smaller south transept group. Inspection of the nave structure suggests that the south transept samples **A-E** were originally analogous to the sole pieces of the nave trusses, the slight angle of the haunches would receive the curving lower braces on an arch-braced style truss.

Because of the complete absence of sapwood the tree-ring results from the *ex-situ* south transept timbers do not provide any precise dating evidence. However due to both the similar nature of the material, that is fairly long lived and slow grown, and the similar range of end dates obtained from the dated samples, it is concluded that they are probably of broadly similar date as those sampled *in-situ* in the nave roofs. Note that although none of the *ex-situ* timbers is attributed to a specific location it is being assumed here that their presence on the south transept walls indicates they were originally from this area. If this assumption is correct then timbers from both areas are most likely of later fourteenth-century date. It seems possible, but

cannot be proven due to the widespread absence of sapwood, that they both derive from documented reconstruction work carried out after a lightening strike in the late fourteenth century.

Devon has been the subject of fairly extensive tree-ring studies over the past few years following its recognition as a 'difficult' area for dendrochronological work (Groves pers comm). The material from Bradworthy has provided a long and well-replicated data set from the north-west part of the county well away from the principal landscape zones hitherto examined. The composite series matches data from the landscape zones in southern and central Devon as well as data from much further north and east in England (Table 3). The earlier periods have proven least problematic within Devon but this particular data set from the North West Devon Heaths landscape zone appears to match chronologies much further distant than those constructed from buildings in the Crediton Trough and South Hams landscape zones (Groves pers comm). Whether this is a reflection of differences in patterns of settlement and resource exploitation is currently unknown.

Acknowledgements

The sampling and analysis programme was funded by English Heritage. Stuart Blaylock of Exeter Archaeology kindly discussed his observations both on site and subsequently, supplied the original of Figures 3 and 4, and a preliminary draft of his report on the nave structure. Paul Stephenson of Carrek Ltd made me most welcome on site and provided useful discussion of the origin of the south transept timbers. The churchwarden Mr Lynch kindly facilitated the collection of the south transept timbers. Peter Marshall from English Heritage kindly put together the request documentation, Alex Bayliss provided helpful comments on a preliminary draft of this report, and Cathy Groves provided useful discussion of the results and their implications for Devon.

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Figure 1 Location of Bradworthy within England and Wales.

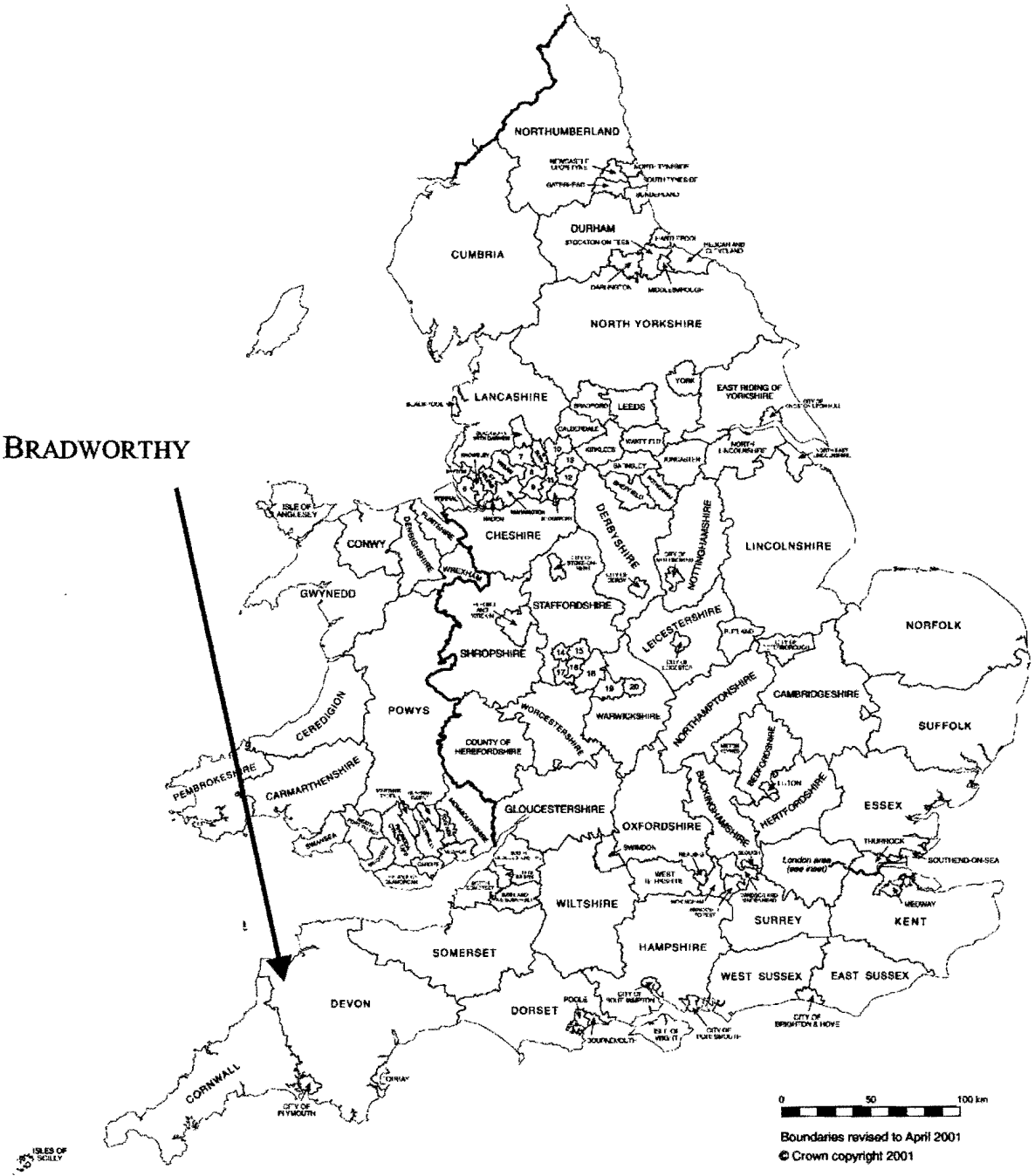


Figure 3 a) plan and b) elevation looking north of the western end of the nave roof of the church of St John the Baptist, Bradworthy (based on a figure supplied by Stuart Blaylock (see Blaylock 2002)) showing the location of the sampled roof trusses. The truss numbering scheme employed in the report is indicated.

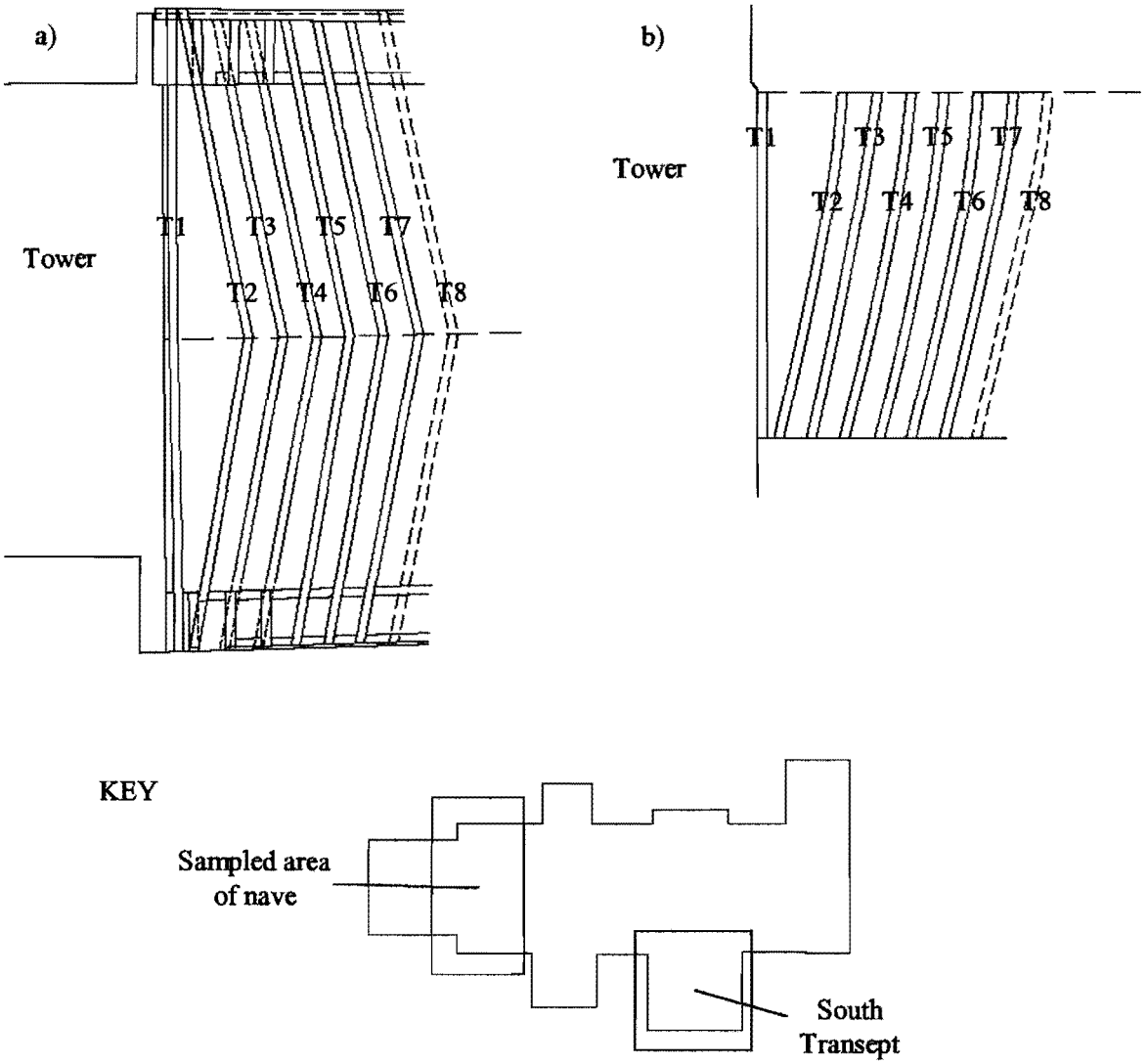


Figure 4 Typical truss from the nave roof of the church of St John the Baptist, Bradworthy (based on a figure supplied by Stuart Blaylock (see Blaylock 2002)). The nomenclature employed in the report for the structural elements is indicated.

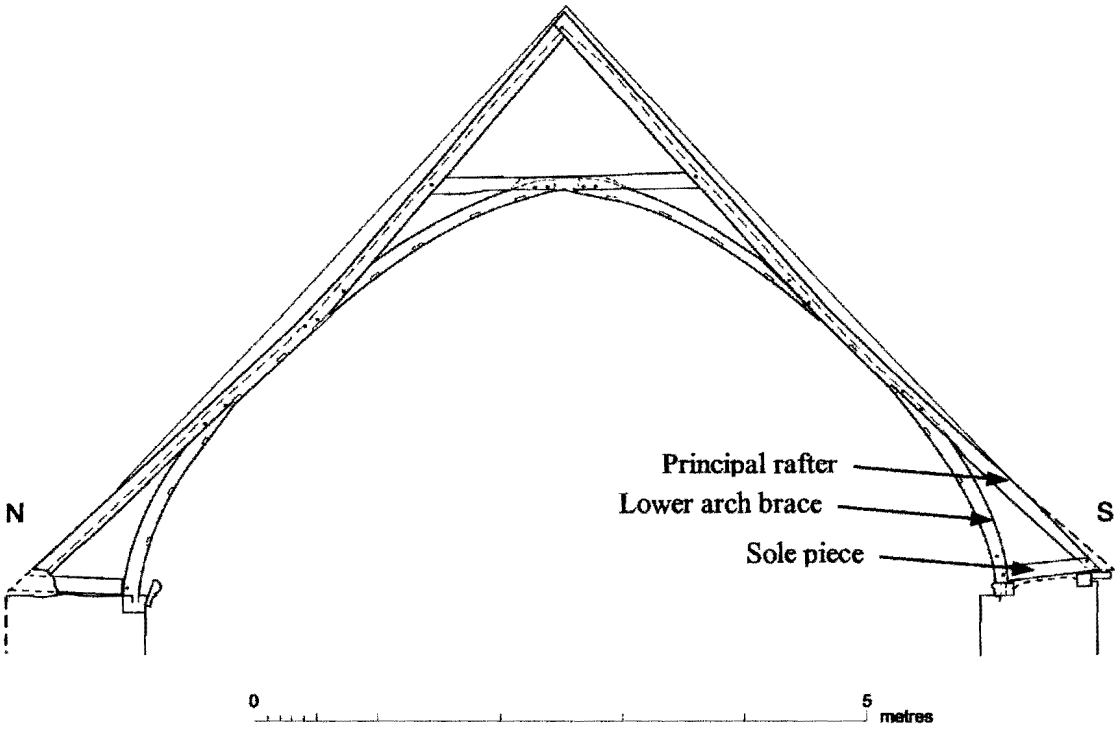
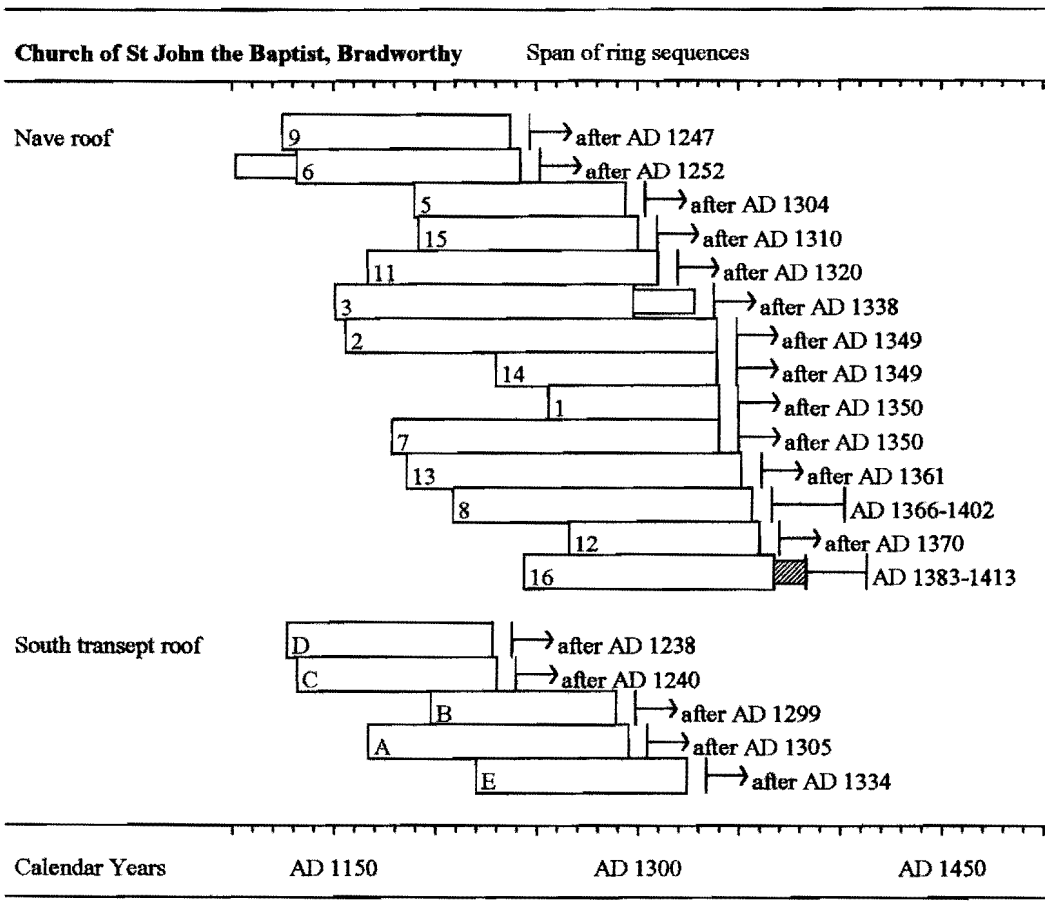


Figure 5 Bar diagram showing the chronological positions of the dated timbers from the two areas of roof at the Church of St John the Baptist, Bradworthy. The estimated felling period for each sequence is also shown



KEY for figure 5

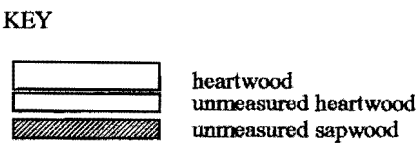


Table 1 List of samples from timbers from the south transept and nave roofs of the Church of St John the Baptist, Bradworthy

Sample	Origin of section [s] or core [c]	Cross-section size (mm)	Total rings	Sapwood rings	ARW (mm/year)	Date of sequence	Felling period
A	South Transept sole piece? [s]	130 x 115	129	-	1.76	AD 1167-AD 1295	after AD 1305
B	South Transept sole piece? [s]	135 x 135	92	-	1.82	AD 1198-AD 1289	after AD 1299
C	South Transept sole piece? [s]	115 x 115	99	-	1.84	AD 1132-AD 1230	after AD 1240
D	South Transept sole piece? [s]	125 x 115	102	-	1.75	AD 1127-AD 1228	after AD 1238
E	South Transept sole piece? [s]	130 x 115	105	-	1.49	AD 1220-AD 1324	after AD 1334
F	South Transept unknown timber [s]	120 x 100	*c* 20	-	-	Unmeasured	-
G	South Transept unknown timber [s]	120 x 100	*c* 20	-	-	Unmeasured	-
1	Nave T2 south principal rafter [c]	130 x 125	85	-	1.83	AD 1256-AD 1340	after AD 1350
2	Nave T3 south lower brace [c]	120 x 120	184	-	0.73	AD 1156-AD 1339	after AD 1349
3	Nave T4 south lower brace [c]	130 x 115	148+*30*	-	0.58	AD 1151-AD 1298	after AD 1338
4	Nave T3 south principal rafter [c]	130 x 120	73	H/S	1.47	undated	-
5	Nave T3 south sole piece [c]	130 x 130	105	-	1.37	AD 1190-AD 1294	after AD 1304
6	Nave T4 south sole piece [c]	120 x 110	*30*+111	-	0.79	AD 1132-AD 1242	after AD 1252
7	Nave T5 south sole piece [c]	125 x 115	162	-	0.91	AD 1179-AD 1340	after AD 1350
8	Nave T6 south sole piece [c]	125 x 115	148	H/S	0.81	AD 1209-AD 1356	AD 1366-1402
9	Nave T7 south sole piece [c]	135 x 130	113	-	1.30	AD 1125-AD 1237	after AD 1247
10	Nave T7 south lower brace [c]	120 x 120	101	H/S	0.90	undated	-
11	Nave T8 south lower brace [c]	120 x 115	144	-	0.93	AD 1167-AD 1310	after AD 1320
12	Nave T7 south principal rafter [c]	130 x 100	95	-	1.44	AD 1266-AD 1360	after AD 1370
13	Nave unknown timber from north side [s]	120 x 105	166	-	0.88	AD 1186-AD 1351	after AD 1361
14	Nave T1 south lower brace [s]	120 x 95	110	-	0.65	AD 1230-AD 1339	after AD 1349
15	Nave T1 south principal rafter [s]	135 x 100	109	-	1.34	AD 1192-AD 1300	after AD 1310
16	Nave T1 north principal rafter [s]	130 x 130	124	H/S +*16s*	1.13	AD 1244-AD 1367	AD 1383-1413

KEY for Table 1 Total rings = all measured rings, figures in *italics* indicate unmeasured heartwood rings. Sapwood rings: H/S heartwood/sapwood boundary, figures in *italics* indicate unmeasured sapwood rings. ARW = average ring width of the measured rings

Table 2

t-value matrix for the timbers forming the chronology BRDWRTHY. KEY - = *t*-value less than 3.0, \ = overlap less than 15 years, pairs highlighted in bold are derived from a single tree

	B	C	D	E	1	2	3	5	6	7	8	9	11	12	13	14	15	16
A	3.44	5.02	4.09	9.62	-	5.95	7.11	8.33	4.49	5.52	5.76	3.41	5.62	-	10.64	5.90	5.17	4.52
B		3.11	-	3.63	3.15	3.35	3.69	6.96	3.54	5.02	3.60	-	6.23	-	5.04	-	4.71	4.25
C			9.27	\	\	3.14	3.81	6.28	4.56	3.43	-	4.14	-	\	6.27	\	-	\
D				\	\	3.21	3.69	7.00	6.77	5.18	-	6.61	4.64	\	4.91	\	-	\
E					4.83	6.39	6.91	7.27	-	7.28	7.60	3.98	4.60	-	7.33	5.34	5.03	6.30
1						3.41	-	5.19	\	4.41	5.21	\	-	3.81	4.70	-	-	3.23
2							**12.92**	5.09	7.70	**11.14**	7.70	4.58	5.12	-	7.12	5.31	6.77	6.64
3								5.92	9.58	**13.05**	8.41	5.19	7.24	-	6.80	5.44	6.48	3.73
5									6.18	6.35	6.08	5.20	7.47	3.47	8.51	5.39	6.57	5.94
6										12.40	7.10	6.49	5.52	\	5.77	\	5.88	\
7											9.81	5.79	7.34	5.18	8.38	7.45	6.11	6.37
8												4.09	5.14	6.64	9.83	5.69	7.30	6.10
9													3.62	\	4.08	\	3.74	\
11														-	5.52	3.56	4.32	4.22
12															5.54	3.60	5.00	5.01
13																5.68	5.91	6.66
14																	3.91	5.03
15																		**10.48**

Table 3

Dating the mean sequence BRDWRTHY, AD 1125-1367 inclusive. Example *t*-values with independent reference chronologies

Area	Reference chronology	*t*-values
Avon	Winterbourne Tithe Barn (Hillam 1991)	7.49
Devon	Bury Barton Lapford (Tyers *et al* 1997)	10.36
Devon	Exeter Cathedral (Mills 1988)	10.76
Devon	Rudge Morchard Bishop (Tyers *et al* 1997)	11.42
Devon	Thorne Clannaborough (Tyers *et al* 1997)	8.61
Gloucestershire	Gloucester Blackfriars S. Range (Hillam and Groves 1993)	8.58
Nottinghamshire, etc	East Midlands regional master (Laxton and Litton 1988)	9.24
Somerset	Glastonbury Abbey Barn (Bridge 1981)	10.38
Wales	Magor Pill Wreck (Nayling 1998)	7.46
Wiltshire	The Manor Barn Avebury (Tyers 1999b)	7.02
Wiltshire	Bradford on Avon Barn (Groves and Hillam 1994)	7.39
Worcestershire	Droitwich Upwich (Groves and Hillam 1997)	8.11

Appendix 1 Ring width data for samples from the Church of St John the Baptist, Bradworthy, Devon, 100 = 1mm

N1-N16 from the Nave

N1

341	260	286	269	247	298	359	356	239	195
243	198	245	299	337	550	224	475	366	256
124	138	122	104	135	211	255	209	216	202
291	182	131	97	148	320	307	256	297	247
376	174	259	148	114	92	76	75	96	140
148	246	228	163	191	139	110	112	88	78
115	139	96	122	114	124	125	126	100	91
105	101	107	119	81	46	72	86	72	80
85	76	71	89	111					

N2

96	142	121	118	84	67	69	76	71	91
98	54	92	94	67	69	62	53	47	61
91	65	56	110	95	78	80	79	51	69
51	47	35	47	44	94	98	87	91	107
150	104	74	72	115	113	107	100	118	129
88	38	52	49	74	114	63	100	83	63
51	93	53	56	75	114	60	45	49	37
47	43	57	76	61	36	32	57	42	60
53	78	61	44	42	44	50	58	56	46
42	35	31	21	32	39	32	52	48	67
48	44	41	43	51	61	86	70	55	67
70	58	65	67	67	99	101	174	103	109
86	100	94	90	100	112	100	103	81	60
138	78	43	52	78	64	109	96	101	107
99	75	90	108	121	75	131	88	96	83
82	69	62	56	89	84	51	37	39	65
68	82	62	73	75	84	118	94	74	68
82	89	47	41	38	25	35	59	56	45
48	57	60	50						

N3

61	49	68	76	68	69	93	89	74	82
90	82	82	64	76	87	67	91	91	85
60	47	65	52	43	55	39	46	80	87
57	63	63	50	74	55	70	38	69	78
112	91	95	62	74	82	53	30	53	64
59	59	84	86	77	67	32	52	42	70
85	53	71	61	45	39	40	32	40	60
88	43	49	52	59	83	67	77	87	72
35	40	60	50	60	52	88	78	72	60
49	74	101	76	53	51	45	29	35	53
59	49	79	64	93	66	56	39	32	40
46	88	46	44	39	46	35	37	37	37
47	51	91	62	51	43	40	40	36	44
39	43	45	39	30	37	26	20	20	29
28	54	43	44	48	37	27	47		

N4

200 177 160 191 196 160 113 105 87 94
108 145 85 117 162 178 126 150 141 164
97 82 50 61 78 112 116 122 95 142
159 226 159 137 129 142 129 112 115 122
69 117 172 155 150 122 163 274 258 297
159 164 226 131 134 175 153 131 166 202
449 330 243 216 145 117 84 62 86 68
85 68 81

N5

222 241 229 184 117 210 199 123 77 85
125 167 136 144 154 167 180 85 141 128
108 104 169 158 179 183 216 190 124 135
259 197 165 86 102 205 240 155 227 244
114 53 53 105 142 213 105 199 222 129
59 102 132 223 178 95 128 88 100 183
125 101 84 135 125 222 90 49 53 53
58 103 144 127 119 98 110 58 88 100
106 204 102 142 180 154 121 102 61 47
94 114 134 144 171 121 175 76 55 85
117 217 196 141 141

N6

40 46 34 41 42 35 59 36 64 53
64 50 64 57 57 85 112 95 69 108
83 136 119 77 151 114 96 131 124 131
130 135 142 124 97 72 64 92 86 103
69 108 77 73 101 60 73 111 69 68
62 77 51 87 56 71 52 85 79 102
102 94 72 78 107 59 41 55 55 69
68 80 83 85 89 51 76 55 65 82
64 90 87 79 75 84 75 77 108 141
63 49 46 76 89 90 92 99 70 38
50 80 58 94 59 73 70 75 60 47
71

N7

142 112 89 105 119 70 140 90 120 64
101 70 86 77 101 74 97 107 73 57
75 65 66 65 89 111 91 98 60 75
69 74 80 76 90 88 77 78 96 66
71 106 173 78 52 53 86 98 75 78
96 76 48 45 69 68 90 66 91 86
82 76 67 94 102 95 74 77 84 48
47 104 83 75 132 112 176 120 87 87
49 60 116 140 101 61 62 69 62 73
71 70 102 105 189 141 177 86 82 90
65 82 110 94 104 97 92 112 88 53
71 99 88 179 139 119 147 109 89 104
94 60 50 45 49 48 60 111 125 107
103 173 126 46 42 45 64 98 102 73
83 89 119 102 128 79 72 91 126 90
93 80 54 81 105 94 96 92 114 147
165 113

N8

92 90 122 88 132 110 81 113 130 106
106 152 147 81 62 54 97 110 85 90
139 73 54 48 79 76 90 70 120 97
109 114 82 127 154 138 120 91 62 47
61 51 52 53 91 69 104 87 47 44
37 57 78 115 91 70 76 72 52 80
103 91 95 65 121 105 126 52 55 75
50 62 47 60 59 40 32 68 47 36
47 50 51 99 47 90 71 66 34 70
51 51 38 41 38 47 51 80 79 69
50 50 65 38 35 32 45 55 86 52
70 81 88 83 112 80 77 68 76 74
73 59 38 48 53 71 79 64 72 81
89 73 62 61 59 76 143 114 125 125
177 122 165 119 132 177 134 146

N9

160 156 139 160 106 138 138 173 160 150
111 95 83 109 112 166 150 168 150 168
187 106 114 160 159 148 218 186 173 157
151 181 187 145 160 163 167 152 187 175
145 215 171 203 199 164 204 130 111 113
116 122 88 103 120 106 146 195 114 89
108 92 74 49 87 103 136 113 127 147
169 162 119 73 94 113 76 99 146 148
203 235 137 156 130 132 115 159 156 100
105 84 105 102 71 77 112 68 54 42
66 86 95 138 180 93 45 44 60 59
86 85 97

N10

64 50 48 38 43 31 37 30 43 40
40 40 49 44 67 58 52 35 43 36
53 53 33 51 43 59 48 56 36 62
70 59 54 92 122 101 62 39 52 63
76 80 83 88 82 107 94 87 75 75
73 78 60 66 79 99 111 109 123 129
84 73 54 68 88 110 124 128 101 121
160 133 173 120 97 93 92 128 143 103
83 101 137 122 122 117 166 208 141 183
155 154 141 169 207 161 161 106 136 126
110

N11

84 111 102 103 162 128 145 133 77 110
94 120 244 126 102 109 79 55 63 45
39 34 71 59 40 53 68 54 57 66
51 62 99 98 99 82 111 84 96 95
55 91 95 106 112 84 100 89 89 106
111 98 99 101 79 95 73 75 112 122
92 108 121 119 73 63 101 91 111 77
148 142 107 55 38 69 163 156 117 139
107 109 69 121 119 142 268 213 396 189
138 94 94 121 158 201 149 93 94 98
73 111 84 82 152 91 133 129 111 75
61 43 49 80 74 79 87 52 50 65
51 47 43 56 62 86 93 39 40 39
38 50 44 39 40 33 31 25 34 42
32 39 42 58

N12

121	82	134	145	165	184	147	167	173	202
129	123	125	130	130	126	118	120	110	133
158	111	106	111	124	183	179	119	201	192
193	126	158	135	96	62	56	70	96	112
162	183	194	149	178	148	92	79	100	128
128	117	117	107	129	132	135	168	144	104
145	165	142	151	116	96	96	89	120	158
118	155	183	205	188	168	145	165	122	147
145	135	175	216	189	201	173	221	209	152
189	190	192	188	181					

N13

142	119	73	146	143	144	144	113	158	143
138	114	92	99	79	91	109	84	91	99
130	49	73	59	67	77	71	86	82	84
84	81	78	78	120	78	49	32	67	88
87	68	101	126	82	64	69	103	99	108
66	91	93	88	59	79	107	134	125	83
89	81	89	106	88	68	53	83	83	107
89	73	60	69	42	84	118	96	84	80
94	40	62	72	92	131	89	137	108	120
73	78	95	94	94	88	101	103	93	72
99	83	59	65	81	77	100	106	117	113
100	53	106	80	79	63	67	74	89	95
98	104	98	70	97	97	70	44	63	80
93	89	58	59	66	82	78	82	79	72
65	110	78	107	74	50	81	69	64	76
55	104	95	90	94	97	74	69	59	72
83	81	79	79	85	90				

N14

75	54	40	101	94	121	60	104	87	102
75	71	77	66	65	55	54	58	42	55
74	61	49	74	79	121	79	45	48	51
56	54	88	62	49	42	37	29	36	56
51	57	73	75	64	74	85	76	59	40
48	85	77	77	95	81	88	57	43	48
61	61	97	96	101	114	90	67	101	91
61	63	50	59	61	71	88	93	80	76
66	65	42	35	42	59	62	66	63	64
71	56	55	66	53	46	49	53	55	51
57	36	40	40	50	57	49	58	59	48

N15

286	266	293	311	345	265	249	156	231	231
165	249	224	212	144	88	158	119	153	206
194	183	184	127	134	229	157	146	155	196
98	59	43	89	131	170	139	155	112	84
69	132	81	91	72	108	96	77	63	72
104	115	103	104	97	85	100	161	125	108
77	197	155	186	136	117	89	106	126	140
234	129	117	94	116	61	95	86	100	127
116	131	127	146	104	92	88	122	111	97
106	86	88	86	98	93	57	99	93	131
118	96	111	127	110	93	104	96	92	

N16

105	84	118	94	88	114	108	96	83	214
171	176	113	113	99	115	117	153	204	160
128	118	143	71	108	85	93	136	126	133
108	143	87	84	69	81	115	115	103	99
87	87	119	90	58	108	114	152	151	126
99	124	108	83	121	95	145	74	77	66
105	123	125	112	89	85	103	105	49	54
61	102	118	102	82	88	96	109	123	117
74	84	74	89	89	118	144	71	65	90
93	113	93	129	135	118	139	138	113	126
137	146	94	94	120	152	124	153	110	102
116	118	100	154	152	166	118	86	176	157
144	139	158	152						

STA-STE from the South Transept

STA

202	219	215	174	191	210	279	285	229	315
161	127	275	300	425	327	221	211	244	208
231	111	178	218	273	208	278	307	297	348
254	229	184	204	242	254	274	321	255	341
133	153	131	149	142	137	203	219	177	192
187	201	250	309	224	156	133	211	191	204
124	168	218	155	137	96	187	146	155	104
195	207	165	130	133	163	262	165	132	141
115	130	162	179	168	128	184	153	180	115
71	59	77	65	110	152	113	95	114	84
65	72	117	123	191	129	124	170	139	107
96	98	86	111	131	171	112	164	124	137
86	70	125	156	120	140	127	132	103	

STB

207	202	274	266	206	164	156	146	178	83
170	140	150	180	184	132	156	159	190	136
167	126	133	129	133	60	54	159	125	114
171	167	111	106	107	105	115	176	91	157
117	111	86	84	135	194	213	94	81	93
86	119	146	88	79	132	155	193	136	145
130	157	201	260	245	242	177	153	227	237
225	204	186	465	293	433	280	342	280	268
229	258	292	347	400	289	252	266	421	185
121	174								

STC

183	178	151	156	166	106	108	120	245	229
212	121	132	117	90	122	220	271	201	224
192	210	179	213	234	218	169	171	185	177
151	178	156	208	195	148	253	216	172	156
157	185	145	118	162	108	136	152	207	272
336	336	249	221	208	267	154	256	222	207
228	245	209	236	202	147	120	124	156	185
237	208	269	245	267	94	147	171	133	162
222	195	172	183	191	166	151	214	233	181
127	91	118	143	173	154	187	160	128	

STD

171	231	153	154	205	225	188	184	196	164
123	172	124	202	157	210	162	208	177	120
120	207	202	176	290	158	221	157	124	164
184	136	205	203	226	189	234	200	151	156
145	243	193	164	204	162	153	113	127	161
145	169	213	173	184	220	177	149	174	132
170	92	181	141	125	132	203	146	221	199
125	115	104	122	145	137	147	187	229	226
86	117	126	117	128	209	285	159	176	200
182	146	214	325	284	178	130	147	203	237
204	192								

STE

204	176	195	188	244	262	347	188	387	434
294	130	106	161	189	206	136	247	209	169
232	140	186	244	187	154	194	139	106	155
139	138	90	177	164	195	129	97	94	108
120	170	244	162	133	110	108	74	97	142
150	212	109	171	171	134	114	120	163	156
152	201	161	125	125	97	124	101	56	97
117	134	188	198	308	218	161	143	157	116
124	137	78	58	57	81	92	116	82	85
122	82	50	54	51	89	141	140	59	80
66	87	132	146	74					