Ancient Monuments Laboratory
Report 84/93

TREE-RING ANALYSIS OF OAK TIMBERS
FROM THE 1991 EXCAVATIONS AT
VINDOLANDA, NORTHUMBERLAND

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Summary

Analysis of 53 tree-ring samples indicated that 32 were
suitable for dating purposes. Lack of sapwood and poor
condition of the timbers prevented the production of
precise felling dates in most cases, but a master
chronology for the period 367BC-AD103 was constructed.
The timbers were local in origin and had been felled
from mature woodland.

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The tree-ring analysis of 31 samples from excavations prior to 1991 has already been described (Hillam 1991, 1993). A further 53 samples were submitted from the 1991 excavations, of which 32 were suitable for dating purposes and 21 were rejected (Table 1).

Fourteen of the samples analysed came from a lavish period V building which may have been erected by the army to house Hadrian and his entourage when he visited the wall area in AD122. It is suspected, however, that the timbers for this prestigious building may have been brought to Vindolanda from some other stores base, and that they could have been in store for some years (Birley pers comm).

Of the remaining samples suitable for dating purposes (Table 2), one came from period I, which was thought to be *circa* AD85-92 in date (Birley pers comm 1992); three came from period II, *circa* AD92-97; four from period III, *circa* AD97-103, and six from period IV, *circa* AD104-120. Period V is thought to date to *circa* AD121-128; only one sample post-dates this period.

Analysis of the timbers was undertaken to test, and possibly refine, this dating framework which is based on other archaeological evidence. The methodology follows that given in the previous Vindolanda tree-ring report (Hillam 1991, 1993), except that all the computing was done on an Atari microcomputer, using an Epson HI-80 plotter to produce the tree-ring graphs.

Results

After extensive checking, 18 ring sequences were found to match (Fig 1). The levels of agreement between the sequences do not suggest that more than one source of timber had been used (Table 3). An 18 timber master of 445 years was constructed (Table 4). When this was tested against the undated ring sequences, a further sample (931) was found to date.

The 445-year master was next tested against the published Vindolanda chronology (Hillam 1993), and it was found to match

over the period 367BC-AD78. Comparison with other dated
chronologies confirmed this result (Table 5). A final Vindolanda
chronology for the period 367BC-AD103 was made by combining the
tree-ring data from the two studies (Table 6). This master
chronology replaces the previously published version.

Interpretation

Interpretation of the tree-ring results is made difficult by the
absence of sapwood on most of the samples (Table 2). In addition
several timbers (eg 944, 937, 1100) have been cut from the inner
part of a tree. With the exception of 931, which was probably
felled in AD92, none of the felling dates are precise. Felling
date ranges are produced for four timbers; the remaining felling
dates are expressed as *termini post quem* (Table 7).

931 is a timber which is possibly from period II. If this is
correct, its probable felling date of AD92 supports the date given
by Birley for the start of period II. None of the other results
can confirm, refute or refine the proposed dating framework.

The timbers

Although the interpretation of the tree-ring results is
disappointing, something can be said about the timbers and the
trees from which they were cut. Crossmatching between the Vindo-
landa ring sequences, and between Vindolanda and other sites in
the region, indicates that the timber was local in origin. There
was also no difference between the ring sequences from the period
V building and other timbers from the site. It is unlikely
therefore that the timbers for "Hadrian's building" were brought
from elsewhere. Lack of sapwood makes it impossible to deduce
whether or not the timbers had been stored.

The length of some of the ring sequences indicates that long-lived
oak trees were being felled. 934, for example, contained over 400
rings, without the centre of the tree and most of its sapwood
being present. As at Carlisle, therefore, mature local woodland
was being exploited.

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Conclusion

Although few precise felling dates were obtained, the study produced a tree-ring chronology for the period 367BC-AD103. It also provided more information about the woodlands exploited by the Romans in northern England.

Acknowledgements

References

Brown DM, Munro MAR, Baillie MGL & Pilcher JR 1986 Dendrochronology - the absolute Irish standard. *Radiocarbon* 28 (2A), 279-83.

Groves C 1987 Tree-ring analysis of timbers from Walton-le-Dale, Preston, 1981-83. *Ancient Monuments Laboratory report series* 136/87.

Groves C 1990 Tree-ring analysis of timbers from Annetwell Street, Carlisle, Cumbria, 1981-84. *Ancient Monuments Laboratory report series* 49/90.

Groves C 1991 Absolute dating. In MR McCarthy, *The structural sequence and environmental remains from Castle Street, Carlisle: Excavations 1981-2,* Fascicule 1, 50-53.

Groves C & Hillam J 1993 Tree-ring analysis and dating of timbers. In JD Hurst (ed), *Multiperiod Saltmaking at Droitwich, Hereford & Worcester - excavations at Upwich 1983-4,* CBA Research Report (forthcoming).

Hillam J 1988 Tree-ring analysis of Roman timbers from Papcastle, Cumbria. *Ancient Monuments Laboratory report series* 148/88.

Hillam J 1991 Tree-ring analysis of Roman timbers from Vindolanda, Northumberland. *Ancient Monuments Laboratory report series* 3/91.

Hillam J 1993 The Dendrochronology, *Vindolanda Research Reports, New Series* III, 120-33.

Hillam J, Morgan RA & Tyers I 1987 Sapwood estimates and the dating of short ring sequences. In RGW Ward (ed), *Applications of tree-ring studies: current research in dendrochronology and related areas,* BAR S333, 165-85.
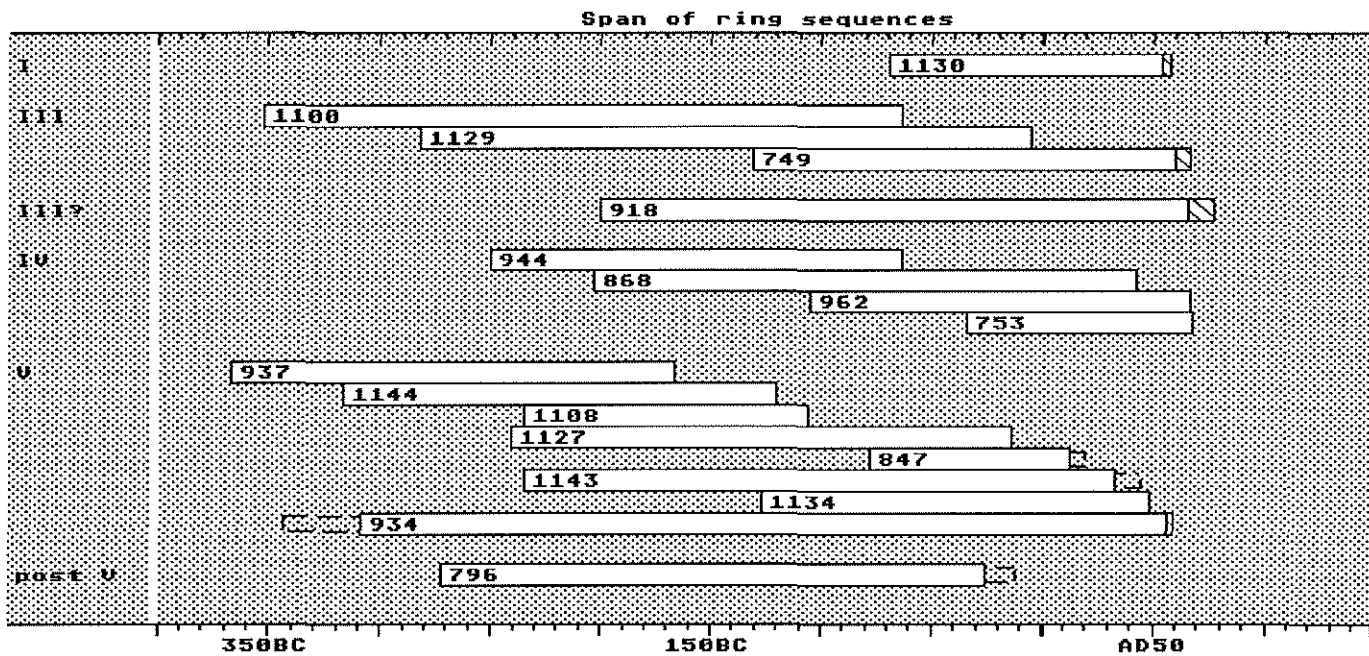
Fig 1: Bar diagram showing the relative positions of the dated
ring sequences. White bars - heartwood rings; hatching - sapwood;
broken lines - unmeasured rings.

Table 1: List of tree-ring samples unsuitable for dating
purposes.

sample	phase	reason for rejection
752	V	unmeasurable narrow rings
793	V	knotty
799	?	too decayed
803	VIa	insufficient rings - less than 50
820	V	alder
824	VIa	insufficient rings
872	III	too decayed
898	III	alder
912	IV	too decayed
922	II?	insufficient rings
929	II	insufficient rings; knotty
930	II	insufficient rings; not oak
948	V	broken and knotty; not oak
959	II	insufficient rings
960	II	elm
961	II	insufficient rings
963	VII	insufficient rings
947	II	alder
966	II	elm
1109	IV	insufficient rings
1128	V	not oak

Table 2: Details of the measured tree-ring samples. Sketches not to scale; sapwood represented by shading. HS - heartwood-sapwood transition; "+" - unmeasured rings present.
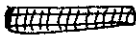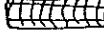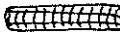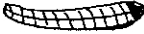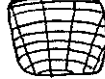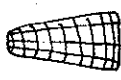
sample	phase	total no. of rings	sapwood rings	av. ring width (mm)	sketch	dimensions (mm)	comments
749	III	198	6	0.91		190x30	
753	IV	103	-	1.59		160x85	
783	IV	58	-	1.60		100x65	
796	post V	248+	-	0.95		245x50	plus about 14 outer rings
809	V	140	-	1.20		165x90	
811	III	50	17	1.92		100x85	bark edge?
819	V	59	-	1.97		135x25	
847	V	91+	-	1.38		285x30	plus 7 outer rings
868	IV	246	-	0.83		210x35	
900	II	94	HS	1.08		135x100	
901	II	65	9	1.69		150x90	
918	III?	278	11	1.09		310x25	
921	V	112	1	2.57		305x25	
931	II?	81	7	2.81		245x20	
934	V	+368	2	0.71		305x285	plus about 35 narrow inner rings
937	V	202	-	1.62		330x160	
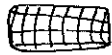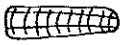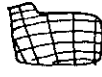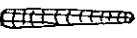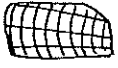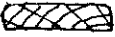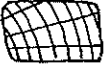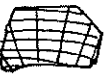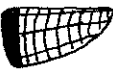
sample	phase	total no. of rings	sapwood rings	av. ring width (mm)	sketch	dimensions (mm)	comments
944A	IV	149+	-	0.74		140x60	plus many narrow rings
B	IV	135+	-	0.79		125x35	plus about 12 rings
A/B	IV	188+	-	0.75	-	-	plus outer rings
952	II	130	-	1.35		195x50	
962	IV	172	-	0.98		230x170	
985	IV	85	-	1.87		160x40	
1100	III	290	-	0.85		255x40	knot at inside
1108	V	131	-	0.86		115x105	
1122	V	107	-	1.62		175x20	
1127	V	228	-	0.97		235x45	
1129	III	278	-	0.71		190x85	
1130	I	128+	3+	1.75		230x160	bark present but sapwood unmeasurable
1131	V	116	-	1.64		265x45	knotty
1134	V	176	-	1.00		315x285	knotty
1143	V	268+	-	0.85		225x210	plus about 12 rings
1144	V	198	-	0.75		155x155	
1149	I?	43	13	2.62		140x125	felled winter
1160	V	88+	18+	1.87		180x120	plus about 20 rings to bark edge

Table 3: *t* value matrix for the 1991 samples. Values less than 3.0 are not printed; / - overlap less than 15 years.

File 1 = D:\VINDLNDA\V0749.D
File 2 = D:\VINDLNDA\V0753.D
File 3 = D:\VINDLNDA\V0796.D
File 4 = D:\VINDLNDA\V0847.D
File 5 = D:\VINDLNDA\V0868.D
File 6 = D:\VINDLNDA\V0918.D
File 7 = D:\VINDLNDA\V0934.D
File 8 = D:\VINDLNDA\V0937.D
File 9 = D:\VINDLNDA\V0944.D
File 10 = D:\VINDLNDA\V0962.D
File 11 = D:\VINDLNDA\V1100.D
File 12 = D:\VINDLNDA\V1108.D
File 13 = D:\VINDLNDA\V1127.D
File 14 = D:\VINDLNDA\V1129.D
File 15 = D:\VINDLNDA\V1130.D
File 16 = D:\VINDLNDA\V1134.D
File 17 = D:\VINDLNDA\V1143.D
File 18 = D:\VINDLNDA\V1144.D

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
V0749		3.4	3.7	6.1	3.5	4.3	\	3.2	8.1	4.1	5.9	3.1	3.4	3.7	6.7		\
V0753		\		5.8		3.4	\	\	3.8	\	\			3.8	3.4		\
V0796				7.2	5.2	5.1	3.9	5.2	5.7	6.4		5.0	7.0		3.2	5.4	4.7
V0847							\		3.9		\			5.0	4.3		\
V0868					6.2			5.5	6.9	6.8		4.0	3.6	5.5	4.3	4.3	4.8
V0918						3.4		4.6		5.4			3.2	3.3		6.0	3.2
V0934							3.5	3.6	4.0	5.2		5.4	4.1	3.4	5.9	4.2	5.0
V0937								\		4.3			5.5	\	\		5.2
V0944										5.7	4.6		3.8	\		3.5	4.5
V0962											\	4.9	4.4	3.8	6.5		\
V1100											4.3		5.1	\		3.9	5.8
V1108													3.4	\		4.7	3.0
V1127														3.7		3.4	6.0
V1129															3.1	4.6	4.3
V1130															3.5		\
V1134																3.4	\
V1143																	3.3

Table 4: 1991 Vindolanda samples - 18 timber mean, 367BC to AD78

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date          rings widths (0.01mm)                  no. of samples
367BC                 215 203 162 196 253 282 290              1  1  1  1   1  1  1
       381 339 264 273 219 254 234 277 239 167    1  1  1  1  1  1  1  1  2  2

350BC  181 208 150 211 170 207 158 203 253 230    2  2  2  2  2  2  2  2  2  2
       220 239 235 202 165 218 200 178 307 185    2  2  2  2  2  2  2  2  2  2
       160 128 101 140 161 169 151 172 170 196    2  2  2  2  2  2  2  2  2  2
       219 186 200 165 181 178 183 174 194 137    2  2  2  3  3  3  3  3  3  3
        96  61 108 129 130 123 133 156 139 123    3  4  4  4  4  4  4  4  4  4

300BC  115 142 146 147 116 123 139 157 162 135    4  4  4  4  4  4  4  4  4  4
       148  81 118 138 112 159 124 142 149 141    4  4  4  4  4  4  4  4  5  5
       151 158 134 128 132 146 144 130 134 159    5  5  5  5  5  5  5  5  6  6
       124 147 116 121 142 108  78  89  69  97    6  6  6  6  6  6  6  6  6  6
       124  98  87 103  81  76  80 103 102 112    6  6  6  6  6  6  6  6  6  6

250BC  100 101  83  94  89 106  98  92  89  96    7  7  7  7  7  7  7  7  7  8
        96 107  83  95  97  87  82  76 104  82    8  8  8  8  8 10 10 10 10 10
        95  93 102  98  86 105  98  93  97  97   10 10 10 10 10 10 10 10 10 10
       111  79  81  84  95  91  91  87  80  75   10 10 10 10 10 10 10 10 10 10
        82  86  70  58  82  75  76  82  79  77   10 10 10 10 10 10 10 11 11 11

200BC   87  78  72  78  84  94  78  91  89  98   12 12 12 12 12 12 12 12 12 12
        77  91 102 103  97 101  92  95  80 101   12 12 12 12 12 12 12 12 12 12
        93  87  91  70  90  93  95  85  92 102   12 12 12 12 12 12 12 12 12 12
        84  85  87  86  93  96  88  83  79  90   12 12 12 12 12 11 11 11 11 11
       100 100  82  71  90  82  75  91  97  99   11 11 11 11 11 11 11 11 11 11

150BC   83  88  89 102 101  90  68  87  78  93   11 11 11 11 11 11 11 11 11 11
        83  84  84  82  71  83  64  64  79  87   11 11 11 11 11 11 11 11 11 12
        79  81  76  85 112  93  89  54  75  91   12 12 12 13 13 13 13 13 13 13
        97 103  97  95  90  99  85  75  86  96   13 12 12 12 12 12 12 12 12 12
       100  85  89  86  79  82  74  73  84  78   12 12 12 12 12 13 12 12 12 12

100BC   84  90  88  96  83 107  89  70  69  85   12 12 12 12 12 12 12 12 12 12
        78  79  91  83  80  90  83  78  69  71   12 12 12 12 12 12 12 12 12 12
        71  89  99  98 102 107 106  94  94  87   12 12 13 13 13 13 13 13 13 13
        88 118  98 116 119 107 106 110  89 102   13 14 14 14 14 14 14 14 12 12
       106  85  86  97 105 118 101  92  96  98   12 12 12 12 12 12 12 12 12 12

50BC    73  62  60  89  88 100 104 110  94  88   12 12 12 12 12 12 12 12 12 12
        78  50  59  75 103  94 101 125 125 117   12 12 12 12 12 12 13 13 13 13
        80  68  78 110 110 115 117 119 134 115   13 13 13 13 13 13 12 12 12 12
       104 104  95  98 102  82  89 107 103  98   12 12 12 12 12 12 12 11 11 11
       104 128 111 115 125 107 101  86  83  85   11 11 11 11 11 11 10 10 10 10

AD1    131 113  99 108  96 112 100  84 102  93   10 10 10 10 10 10 10 10 10 10
        96 110  88  90  93  88  92 106  90 104   10 10 10  9  9  9  9  9  9  9
       101  93  81  96  87  96 112 100  93  82    9  9  9  9  9  9  9  9  9  9
       100 113 109  79  96  95 107 115 102  91    9  9  9  8  8  8  8  8  8  8
        96 104  96 126  94 116 107  91 101 122    8  8  8  7  7  7  7  7  7  6

AD51   103  90  87 107 109 108  98  75  85  74    6  6  6  6  6  6  6  6  6  4
        95  97  90  87 100  98  89  92  79  69    4  4  4  4  4  4  4  2  2  1
        75  82  79  82  62  80  69  68             1  1  1  1  1  1  1  1
```

Table 5: Comparison of the Vindolanda masters with chronologies from elsewhere.

chronology	VIN90	VIN91	VIN90/91
Alcester (Baillie & Brown pers comm)	5.0	5.4	4.9
Carlisle, Annetwell St (Groves 1990)	12.6	13.8	14.7
Carlisle, Castle Street (Groves 1991)	8.9	10.0	9.9
Castleford, W Yorks (Hillam unpubl)	5.8	4.5	5.4
Droitwich, Upwich (Groves & Hillam 1993)	5.6	5.8	6.0
Greater London T95 (Tyers pers comm)	5.2	3.7	4.6
Northern Ireland (Brown et al 1986)	10.4	11.7	12.3
Papcastle, Cumbria (Hillam 1988)	5.6	6.2	6.3
Walton-le-Dale, Lancs (Groves 1987)	6.9	6.1	6.9

Table 6: Vindolanda chronology, 367BC to AD103, made up from the 1990 and 1991 tree-ring samples.

```
date          rings widths (0.01mm)                    no. of samples
367BC                 215 203 162 196 253 282 290            1  1  1  1  1  1  1
         381 339 264 273 219 254 234 277 240 168    1  1  1  1  1  1  1  1  2  2

350BC    181 208 151 212 170 207 158 203 253 231    2  2  2  2  2  2  2  2  2  2
         220 240 236 203 166 218 200 178 308 185    2  2  2  2  2  2  2  2  2  2
         160 128 101 140 162 170 151 172 170 197    2  2  2  2  2  2  2  2  2  2
         219 187 200 165 182 179 184 175 195 138    2  2  2  3  3  3  3  3  3  3
          97  62 109 130 131 123 134 156 139 124    3  4  4  4  4  4  4  4  4  4

300BC    116 143 148 148 117 124 140 158 162 136    4  4  4  4  4  4  4  4  4  4
         149  82 119 139 112 160 124 143 150 141    4  4  4  4  4  4  4  4  5  5
         152 158 135 129 133 147 145 131 135 160    5  5  5  5  5  5  5  5  6  6
         125 148 116 122 142 109  79  90  69  97    6  6  6  6  6  6  6  6  6  6
         124 100  88 103  82  77  81 104 103 113    6  6  6  6  6  6  6  6  6  6

250BC    100 102  96 102  97 125 100  96  93 103    7  7  8  8  8  8  9  9  9 10
         105 113  90 101 101  97  87  84 109  92   10 10 10 10 10 13 13 13 13 13
          99  96 107 108  90 113 104  97  99 105   13 13 13 13 13 13 13 13 13 13
         115  80  83  90  96  96 101  91  85  79   13 13 13 13 13 13 13 13 13 13
          89  90  74  61  90  84  86  94  85  83   13 13 13 13 13 13 13 14 14 14

200BC     90  78  74  79  84  96  82  91  92  98   14 14 14 14 14 14 14 14 15 15
          74  93 101  93  96 102  93  95  78 101   15 15 15 15 15 15 15 15 15 15
          95  90  94  67  89  97  96  87  93  99   15 15 15 15 15 15 15 15 15 15
          85  76  84  81  88  93  83  86  78  93   15 15 15 15 15 14 14 14 14 14
          99  95  81  70  92  79  74  92  94  98   14 14 14 14 14 14 14 14 14 14

150BC     83  85  90 101 111  95  72  84  74  93   14 14 14 14 14 14 14 14 14 14
          84  86  85  86  79  91  66  58  76  85   14 14 14 15 15 15 15 15 15 16
          83  84  78  85 121 100  91  54  69  89   16 16 16 17 17 17 17 17 17 17
          94 106  96  99  89  99  87  74  87 102   17 16 16 16 16 16 16 16 16 17
         111  95  98  97  82  88  80  79  97  90   17 16 16 16 16 17 16 16 16 16

100BC     96 104 104 106  89 116  93  79  72  90   16 16 16 16 16 16 16 16 16 17
          87  89 100  89  85  96  84  88  80  81   17 17 17 17 17 17 17 17 17 17
          81 102 105  99 106 109 118 102  96  92   17 17 18 18 18 18 18 18 18 18
          88 118  97 110 115 106 102 103  82  92   18 19 19 19 19 19 19 19 17 17
          96  77  77  88  96 104  91  87  97  99   16 16 16 16 16 16 16 16 16 16

50BC      74  63  60  88  84  96 105 109  94  96   16 16 16 15 15 14 14 14 14 14
          76  52  59  73 104  94 100 121 127 118   14 14 14 14 14 14 15 15 15 15
          81  70  76 108 109 115 113 114 129 110   15 15 15 15 15 15 14 14 14 14
         103 101  94  94  98  79  85 101 103  94   14 14 14 14 14 14 14 13 14 14
          98 119  98 106 118 102 101  89  86  86   14 14 14 14 14 14 13 13 13 13

AD1      129 110  96 105  86 107  95  80 100  89   13 13 13 13 13 13 13 13 13 13
          91 104  80  86  88  84  84 105  93 102   13 14 14 13 13 13 13 13 13 13
         101  89  80  96  94  98 115  99  96  87   13 13 13 13 13 13 13 13 13 13
         105 120 115  87  95  99 106 116 107  95   13 13 13 12 12 12 12 12 12 12
         105 111 101 120  99 119 115 101 105 118   12 12 12 11 11 11 11 11 11  9
```

Table 6/cont

date	rings widths (0.01mm)										no. of samples									
AD51	98	92	89	104	107	107	104	75	85	82	9	9	9	9	9	9	8	8	8	6
	95	110	105	103	104	112	95	115	101	105	6	6	6	6	6	6	6	4	4	3
	79	75	101	133	87	111	113	123	137	131	3	3	3	3	3	3	3	3	3	3
	131	149	125	97	65	87	101	121	91	91	3	3	2	2	2	2	2	2	2	2
	103	127	139	87	125	143	131	117	161	153	2	2	2	2	2	1	1	1	1	1
AD101	127	93	79								1	1	1							

Table 7: Summary of the tree-ring dates. A sapwood estimate of 10-55 rings is used (Hillam *et al* 1987).

sample	phase	date span of rings	comment	felled
1130	I	69BC-AD59	3 sapwood rings	AD66-111
931	II?	AD2-82	+ *c.*10 to bark?	*c.*AD92
749	III	131BC-AD67	6 sapwood rings	AD71-116
1100	III	352-63BC		53BC+
1129	III	282-5BC		AD5+
918	III?	200BC-AD78	11 sapwood rings	AD79-122
753	IV	34BC-AD69		AD79+
868	IV	203BC-AD43		AD53+
944	IV	250-63BC		53BC+
962	IV	105BC-AD67		AD77+
847	V	78BC-AD13	+ 7 rings	AD23+
934	V	309BC-AD59	2 sapwood rings	AD67-112
937	V	367-166BC		156BC+
1108	V	235-105BC		95BC+
1127	V	241-14BC		4BC+
1134	V	127BC-AD49		AD59+
1143	V	235BC-AD33	+ *c.*12 rings	AD55+
1144	V	317-120BC		110BC+
796	post V	272-25BC	+ *c.*14 rings	1BC+