THAMES STREET TUNNEL (TST'78)

Numerous oak timbers were sampled for tree-ring analysis during excavations at Thames Street Tunnel in 1978. All the timbers, except for 148, were from Roman revetments which were provisionally dated to c AD 100. Samples 303, 304, 305, 306, 307, 308, 311, 312 and 315 (Group 6) were from the same structure: a 'Box-type' revetment which was aligned east-west. The Group 7 samples (314, 335, 336, 337, 352, 353, 354, 506, 507, 604 and 605) were from a similar structure but the main timbers ran north-south across the site. Sample 148 was a base-plate, believed to be 17th century in date.

Analysis of the timbers (for a detailed description of the methods and techniques used in the Sheffield dendrochronology laboratory, see Hillam, 1979; Morgan, forthcoming) revealed that samples 148 and 506 were unsuitable for tree-ring dating. 148 contained knots which obscured the pattern of the annual rings and 506 had only c 35 rings which is insufficient for reliable crossdating. The remaining timbers contained between 57 and 170 annual rings (Table 1). Frequently, the whole ring sequence was not measured (eg 305, 314) because of the presence of knots in the cross-section or because the wood was degraded by fungal attack.

The measured ring widths were plotted as graphs, known as tree-ring curves, in order to represent visually the pattern of wide and narrow rings. These were compared one with the other by sliding one graph over another until the position of best fit was found. Many of the ring patterns were synchronous; some (eg 304 and 308 or 335 and 352) were almost identical,

indicating that the timbers had come from the same tree. Where this occurred, the ring widths of samples from the same tree were meaned to give a single curve, eg 304/308. The relative time-spans of the matching curves are indicated in Figure 1.

The Group 6 and Group 7 timbers appeared to be contemporary, ie they were felled at the same time. However, estimation of the felling dates of the timbers was made difficult by the fact that only samples 307 and 604 had any sapwood. The remainder had had their sapwood removed when they were converted for use in the revetments. This was a common practice as sapwood tends to be more susceptible to decay and insect attack than does the heartwood. An estimated felling date was calculated for the Group 7 timbers by establishing the date of the heartwood-sapwood transition of 604. This was year 185 on the arbitrary scale (Figure 1). Assuming the number of sapwood rings in oak to be 32 ± 9 (see Baillie, 1973; Hillam, 1979), the felling date for 604 is between years 208 and 226. However, the date of the heartwood-sapwood transition on timber 337 must be year 196 or slightly later, which would give a felling date between years 219 and 237. It can therefore be postulated that the timbers were felled in c year 219. This is also true of the Group 6 timbers since the date of the heartwood-sapwood transition of 305/306 is year 183 or slightly later, giving a felling date between years 206 and 224.

The only timber not to conform to this felling date was 307, the second sample to contain any sapwood rings. Its heartwood-sapwood transition dated to year 109 on the arbitrary scale (Figure 1). This would suggest a felling date of 131 ± 9. Since 307 was not considered by the excavator to be re-used, the dating of the timber was re-checked. A computer program which

calculates the degree of correlation between two curves (Baillie & Pilcher, 1973) was used to assess the agreements between 307 and the other samples. All the crossmatches were visually good and the computer comparisons gave, for example, a $\underline{t}$-value of 4.81 for the match between 307 and 306. A site master curve was made using the data from all matching samples except 307. The latter was tested against the master and a $\underline{t}$-value of 4.36 was obtained for the position illustrated in Figure 1. The evidence from tree-ring analysis therefore indicates that timber 307 was felled earlier than the other timbers. How the timber came to be incorporated into a revetment, which was constructed some 90 years later, is not known, unless 307 was in fact re-used.

A master chronology for Thames Street Tunnel was constructed using the data from the samples shown in Figure 1. Samples considered to be from the same tree were first meaned together before being incorporated into the master curve so as not to bias the master in their favour. All the Thames Street Tunnel ring width data, including that from the unmatched samples such as 353, can be found appended to the end of the report. The final chronology is presented in index values (Table 2) for reasons given in Baillie (1977). A computer program (Fritts et al, 1969) was used to convert the ring widths from the individual samples into indices and then to calculate the mean index values of the master chronology.

The Thames Street Tunnel chronology was compared with other Roman tree-ring sequences from London. Good visual correlations were found with curves from Milk Street, New Fresh Wharf/Seal House (a chronology produced by Ruth Morgan) and Watling Court. This crossmatching, an example of which is illustrated in Figure 2, was confirmed by computer comparisons:

the Thames Street Tunnel curve gave t-values of 4.98 with Milk Street, 6.02 with New Fresh Wharf/Seal House and 10.56 with Watling Court. t-values were also obtained for comparisons between the ring patterns of individual Thames Street Tunnel timbers and the chronologies from Watling Court and New Fresh Wharf/Seal House. The agreement values with Watling Court were consistently high (including $t = 3.06$ for the anomalous 307), whilst those with New Fresh Wharf/Seal House varied from $t = 0.00$ to $t = 5.54$ (Table 3). These results firmly dated the Thames Street Tunnel sequence in relation to the other Roman London tree-ring chronologies (Figure 3). Exact absolute dating is not yet possible because no dated reference curves from England exist for the Roman period and attempts at crossdating with Irish and German reference chronologies have so far produced no reliable results. However, approximate calender dates can be assigned to the floating chronologies because the felling date of the Watling Court timbers is known, from historical and archaeological evidence, to be c AD 100. The Thames Street Tunnel chronology therefore covers the period c 140BC - 60AD and the timbers, with the exception of 307, were felled in c AD 80-90. These results provide provisional dating until exact calender dates can be obtained by crossmatching the chronology with tree-ring sequences of known age.

References:

Baillie M.G.L. 1973, A recently developed Irish tree-ring chronology. Tree Ring Bulletin 33, 15-28.

---------- 1977, The Belfast oak chronology to AD 1001. Tree Ring Bulletin 37, 1-12.

Baillie M.G.L. & Pilcher J.R. 1973, A simple crossdating program for tree-ring research. Tree Ring Bulletin 33, 7-14.

Fritts H.C., Mosimann J.E. & Bottorff C. 1969, A revised computer program for standardizing tree-ring series. Tree Ring Bulletin 29 (1-2), 15-20.

Hillam J. 1979, Tree-rings and archaeology: some problems explained. J. Archaeol. Science 6, 271-8.

Morgan R.A., Tree-ring dating of the medieval waterfronts at the Seal House site. In Schofield J., Excavations at Seal House, City of London, 1974-6. LAMAS special paper (forthcoming).

Jennifer Hillam, July 1980.

Legends to tables and figures

Table 1: Details of the Thames Street Tunnel timbers; sketches are not drawn to scale. A '+' before or after the number of rings indicates that the complete ring sequence has not been measured. Samples 148 and 506 were not measured at all.

Table 2: The 198-year Thames Street Tunnel index chronology, dating to c 140BC - 60AD.

Table 3: Results of comparisons between the ring sequences from the individual Thames Street Tunnel timbers and the chronologies from Watling Court and New Fresh Wharf/ Seal House.

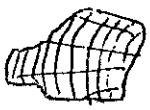
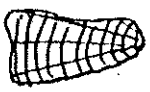
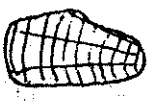
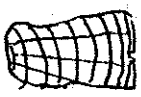
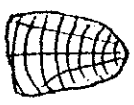
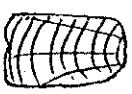
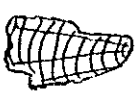
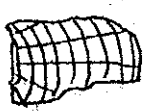
Figure 1: Bar diagram illustrating the years spanned by the matching Thames Street Tunnel ring sequences. Sapwood is represented by hatching and arrows indicate the approximate felling dates. A '+' shows that the complete ring sequence has not been measured. The scale in years is an arbitrary one.

Figure 2: Crossmatching between the Thames Street Tunnel curve and Morgan's chronology from New Fresh Wharf/Seal House. Only a section of the overlap between the two sequences is illustrated.

Figure 3: Bar diagram showing the relative dating of ring sequences from sites in Roman London. The provisional calender

Legends (cont.)

dates are based on the felling date of the Watling Court timbers being equal to c AD 100. Estimated felling dates for the various sites are indicated by arrows.
NFW/SH - New Fresh Wharf/Seal House; CUS'73 - Custom House; WAT'78 - Watling Court; TST'78 - Thames Street Tunnel; MLK'76 - Milk Street.

sample no.	no.of rings	sapwood rings	average width(mm)	sketch	dimensions (m)
148	-	-	-		0.16 x 0.18 x 1.00
303	115	-	1.34		0.21 x 0.09 x 0.25
304	95	-	1.47		0.17 x 0.11 x 0.42
305	+ 151	-	1.24		0.24 x 0.09 x 0.40
306	170	-	1.32		0.21 x 0.11 x 0.30
307	88	18	1.55		0.20 x 0.12 x 0.60
308	114	-	1.24		0.15 x 0.11 x 0.60
312	70	-	2.14		0.16 x 0.15 x 0.82
314	66 +	-	2.22		0.19 x 0.11 x c2.00
315	57	-	2.47		0.20 x 0.14 x 1.30
335	+ 126	-	1.72		0.37 x 0.38 x c3.00
336	+ 108	-	1.47		0.19 x 0.18 x 1.75
337	107	-	1.93		0.25 x 0.17 x 1.81
352	+ 113	-	1.71		0.39 x 0.36 x 1.35

(Table 1)

(Table 1, cont.)

sample no.	no.of rings	sapwood rings	average width(mm)	sketch	dimensions (m)
353	156	-	1.10		0.40 x 0.36 x 1.40
354	134	-	1.59		0.31 x 0.24 x 0.95
506	c 35	-	-		0.21 x 0.09 x 1.50
507	151	-	1.64		0.29 x 0.25 x 2.00
604	+147	14	1.72		0.30 x 0.47 x 2.00
605	147+	-	1.23		0.40 x 0.39 x 2.00

year	index									
	0	1	2	3	4	5	6	7	8	9
0		78	125	105	149	125	52	97	107	59
10	123	92	215	126	91	102	104	84	96	105
20	173	139	163	132	112	160	81	91	91	104
30	83	99	94	104	87	56	77	89	92	122
40	84	121	126	91	91	81	64	72	90	97
50	76	77	90	88	80	91	111	95	105	110
60	130	121	117	98	95	127	111	118	91	78
70	123	89	123	95	119	113	82	119	102	142
80	104	106	93	71	93	91	92	111	130	105
90	99	80	72	80	96	100	95	74	104	93
100	100	87	93	90	118	113	76	103	92	118
110	125	117	92	117	86	117	111	102	109	79
120	110	123	123	95	124	101	110	89	71	80
130	102	106	89	118	130	136	85	80	92	71
140	73	68	103	109	97	123	118	98	103	73
150	87	122	97	122	125	103	99	93	91	82
160	83	128	125	96	78	97	93	67	111	88
170	91	91	83	83	86	89	102	124	108	121
180	102	125	119	133	85	80	106	107	135	112
190	77	109	98	125	124	103	72	111	78	

number of trees										
0	1	2	3	4	5	6	7	8	9	
	1	1	1	1	1	1	1	1	1	
1	1	1	2	2	2	2	2	2	2	
3	3	3	3	3	3	3	3	3	3	
3	3	4	4	4	4	4	5	6	7	
7	8	8	8	8	8	8	8	8	8	
8	8	9	9	9	9	9	9	9	9	
9	9	9	9	9	9	9	9	9	9	
9	9	9	9	9	9	9	9	9	10	
10	10	10	10	10	10	10	11	11	11	
12	12	12	12	12	12	12	12	12	12	
12	12	12	12	12	12	12	12	12	12	
12	12	12	12	12	12	12	12	12	12	
12	12	12	12	12	12	12	11	11	11	
11	11	11	11	11	11	11	11	11	11	
11	11	11	11	10	10	10	10	9	9	
9	9	9	9	9	9	8	8	7	7	
7	7	6	6	6	6	6	6	6	6	
6	4	4	4	4	4	4	4	4	4	
4	4	4	4	3	3	3	2	2	2	
2	2	2	2	2	2	2	1	1		

Table 2

sample no.	t-values	
	Watling Court	New Fresh Wharf/ Seal House
303	4.59	0.00
304	3.75	short overlap
305	6.89	3.90
306	8.10	3.64
307	3.06	short overlap
308	3.59	0.78
315	4.20	3.39
335	5.69	4.45
336	4.20	0.11
337	5.23	5.06
352	6.17	2.29
354	6.07	5.54
507	7.63	4.49
604	7.75	3.16
605	3.94	3.55

Table 3

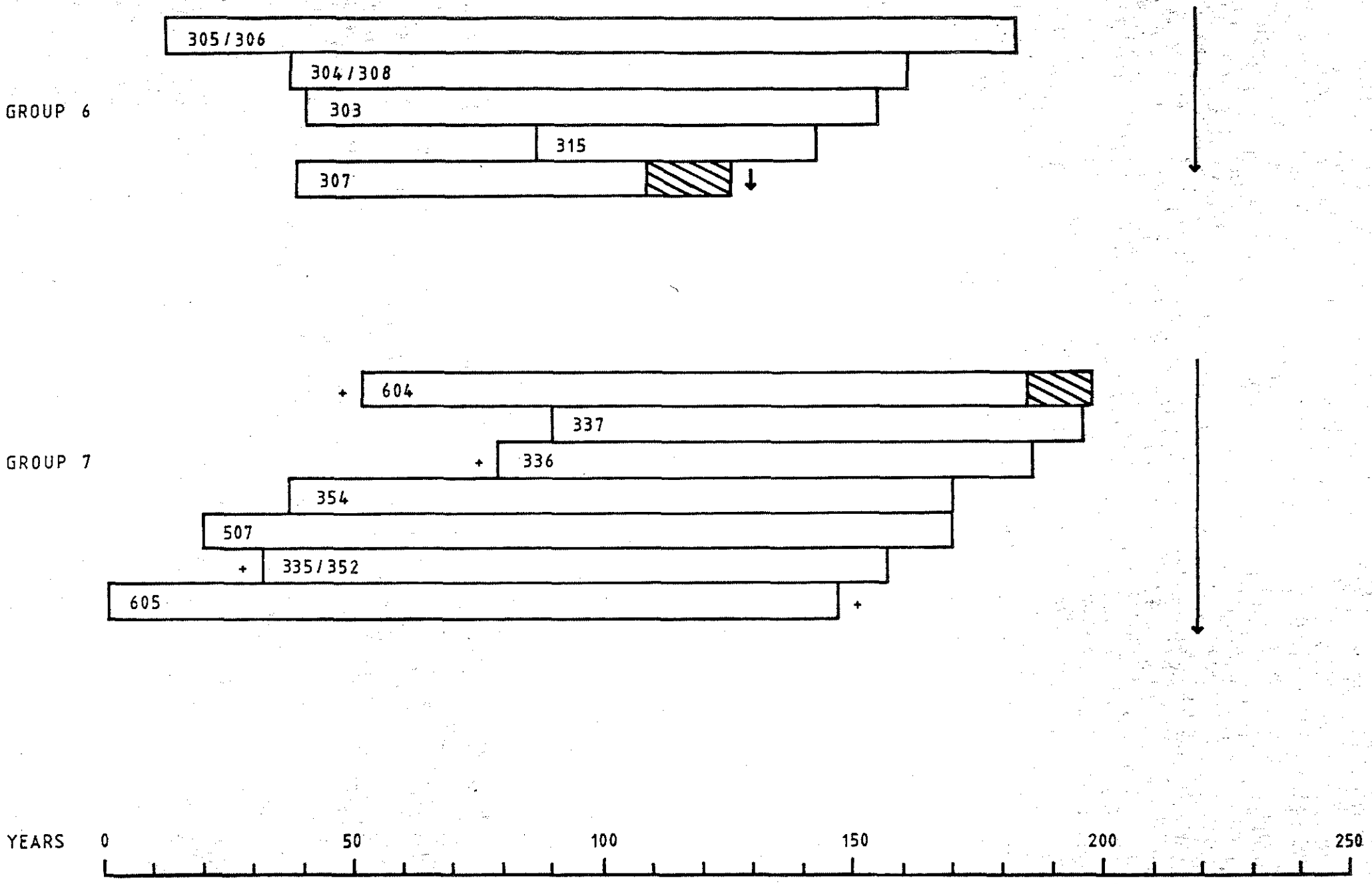
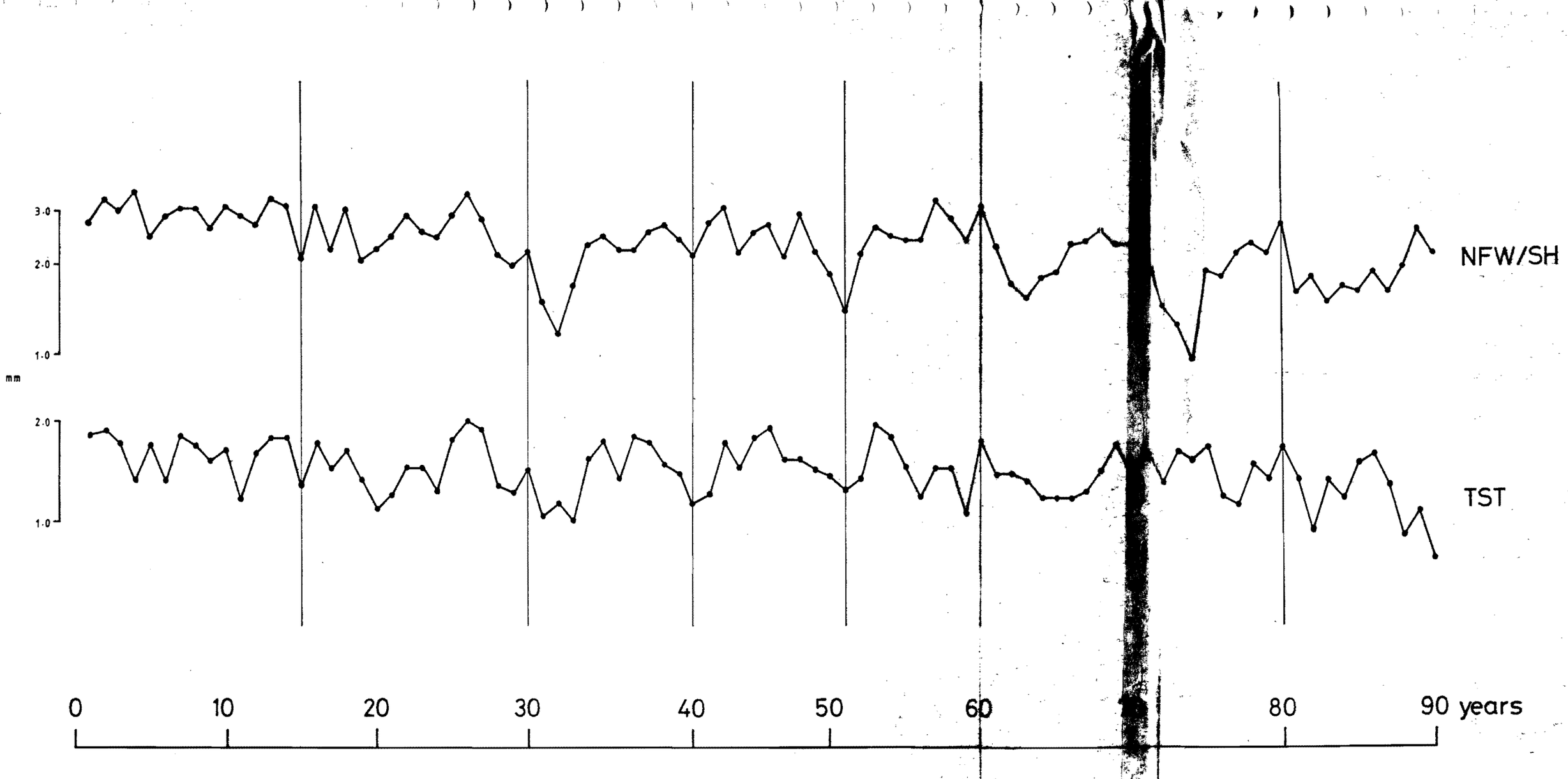

GROUP 6
305/306
304/308
303
315
307
GROUP 7
604
337
336
354
507
335/352
605
YEARS
0
50
100
150
200
250

FIGURE 1

FIG. 2



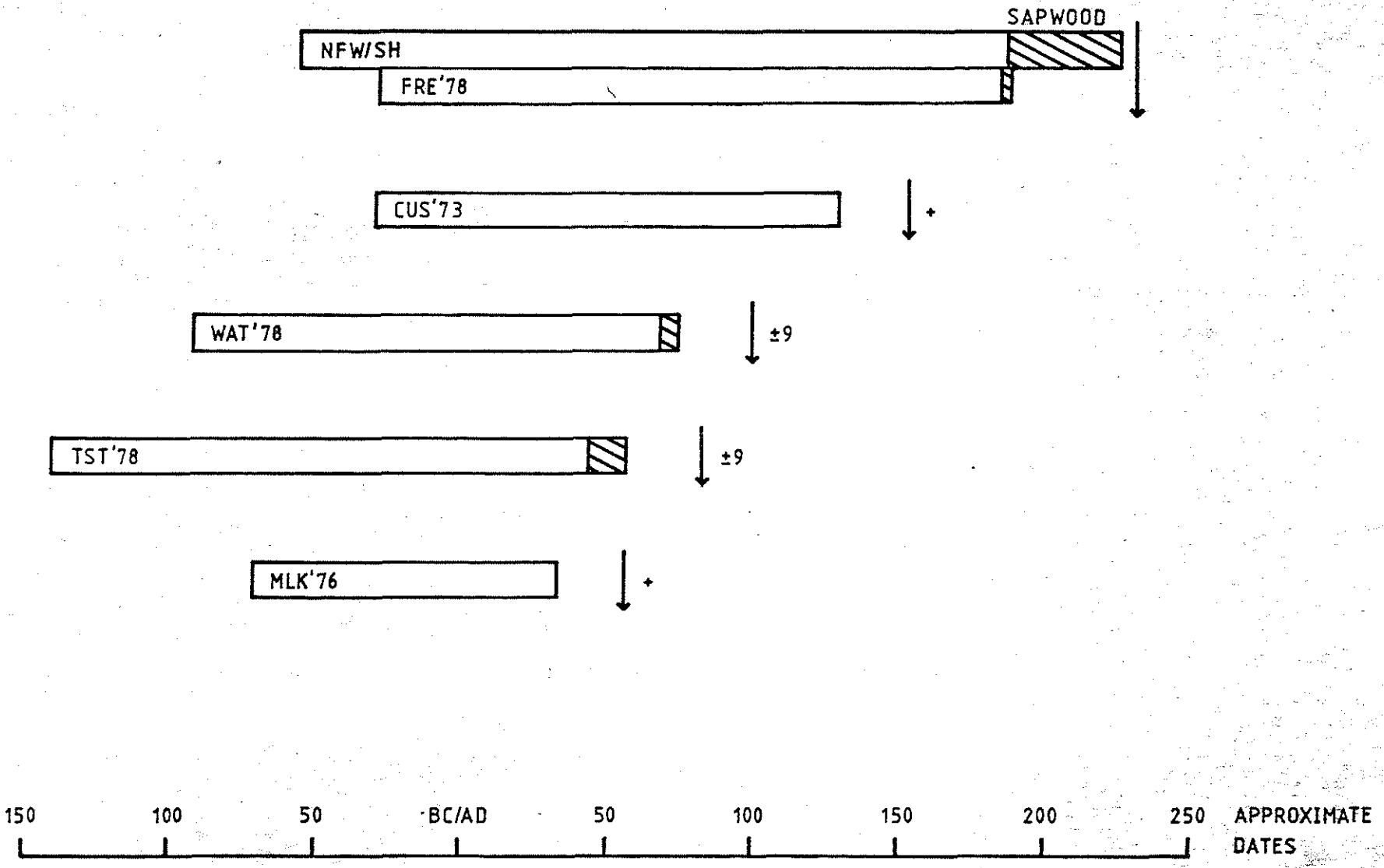

SAPWOOD
NFW/SH
FRE'78
CUS'73
+
WAT'78
±9
TST'78
±9
MLK'76
+
150
100
50
BC/AD
50
100
150
200
250
APPROXIMATE
DATES

FIGURE 3