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Summary

The analysis of 43 oak timbers from the river gravels near the River Trent resulted in the production of tree-ring chronologies spanning 4232-4021 BC, 2979-2858 BC, and 2637-2125 BC. Some of the trees were from a river jam and were associated with human remains. Tree-ring dates for these trees are compatible with a radiocarbon date for a human rib, and indicate that both trees and bones date to the early 3rd millennium BC.

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TREE-RING ANALYSIS OF OAKS FROM LANGFORD QUARRY, NEWARK-ON-TRENT, NOTTINGHAMSHIRE

INTRODUCTION

This document is a technical archive report on the tree-ring analysis of oak timbers from Langford quarry (Fig 1; NGR SK818608). It is beyond the dendrochronological brief to describe the site in detail or to undertake the production of detailed drawings. As part of a multidisciplinary study of the site, 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. The conclusions presented here may therefore have to be modified in the light of subsequent work.

The site is adjacent to the modern River Trent and is within the sands and gravels of the valley floor (Howard *et al* forthcoming). Quarrying had exposed the remains of large trees, similar to those found elsewhere in the Trent valley at Colwick (Salisbury *et al* 1984). What made Langford unique was the discovery of four human skulls in the same area. This led to an area 2m by 2m being excavated by the Trent and Peak Archaeological Trust (Howard and Garton 1996).

Three groups of tree-ring data are included in this study (Fig 2). Samples were taken by the Trent and Peak Archaeological Trust from the trees in and immediately adjacent to the excavation (ES09-ES27). Two of these trees appeared to have felling scars. The second group of samples (100-122) came from trees exposed elsewhere in the quarry. The third group (samples 1-10) were from trees in an adjacent area which had been sampled prior to this study and their tree-rings measured by the Nottingham University Tree-Ring Dating Laboratory. The area from which they came had been landscaped and the trees destroyed at the time of the Sheffield sampling trip, but the original ring-widths were kindly made available by colleagues in Nottingham.

The Langford analysis forms part of a larger project to construct a prehistoric tree-ring chronology for the southern half of England. The tree-ring analysis was therefore undertaken primarily as a chronology building exercise. The provision of precise dates for the trees and associated archaeological remains was a secondary, albeit important, consideration.

METHODS

Since the tree trunks had almost dried out, their cross-sections were prepared by paring with a Stanley knife. Samples unsuitable for dating purposes were rejected at this stage. These included non-oak samples, samples with unmeasurable ring patterns due to knots or narrow rings, and those with less than about 50 rings. Where ring widths were measured across two radii, the two sets of measurements were averaged to produce a single sequence. The ring widths were measured to an accuracy of 0.01mm on a

travelling stage connected to a microcomputer which uses a suite of dendrochronology programs written by Ian Tyers (1997). The ring width data were plotted as graphs. Crossmatching was carried out first visually by comparing the graphs on a light box, and then using a computer program to measure the amount of correlation between two ring sequences. The program uses crossmatching routines which are based on the Belfast CROS program (Baillie and Pilcher 1973; Munro 1984). This calculates the correlation coefficient *r* between two ring sequences, and then tests the significance of the results using Student's *t* test. Generally *t*-values of 3.5 or above indicate a match provided that the visual match between the tree-ring graphs is acceptable (Baillie 1982, 82-5). *t*-values over *c.* 10 usually indicate an origin in the same tree, although *t*-values less than 10 may be produced when different radii are measured on the same trunk (Hillam forthcoming). This is particularly true for young trees. Visual matching can sometimes aid the decision as to whether timbers come from the same tree but inevitably some same-tree samples will go undetected by dendrochronology.

The data from matching ring sequences are averaged to produce a structure or site master curve. Unmatched sequences are then compared to the master. Matching is accepted if the sequence to be dated matches visually and statistically with the working master and with the individual components of that master. The data from the newly matched sequences are then incorporated into the master and the process repeated until no more samples can be crossmatched. The site master is tested for similarity against dated reference chronologies. Master curves are used for dating whenever possible because they enhance the general climatic signal at the expense of the background noise from the growth characteristics of the individual samples. Any unmatched sequences are tested individually against the reference chronologies.

Once tree-ring dates have been obtained, calendar dates can be assigned to each of the annual rings within the sample, but the date of the outer ring is not necessarily equivalent to the year of death. If a sample has bark or bark edge, the date of the last measured ring is the date in which the tree died or was felled. A complete outer ring indicates that the tree was felled during its period of dormancy between autumn and early spring (referred to as "winter felled"). A partially formed ring indicates that the tree died in late spring or summer (known as "summer felled") or, if the springwood is just beginning to form, in spring (Baillie 1982, fig 2.1). Partially formed rings are not measured so, for spring- and summer-felled trees, there will be a one-year discrepancy between the date of the measured ring sequence and the felling date. It is not always possible to distinguish between an incomplete ring and a complete narrow ring and therefore the season of felling may be indistinguishable. Sometimes the outer edge of a sample may be damaged because of the delicate nature of sapwood and, whilst it is known that bark edge was originally present, a few outer rings may have been lost or become so compressed that they are unmeasurable. In cases such as these, the felling dates are precise to within a few years. Where bark edge is absent, felling dates are calculated using the sapwood estimate of 10-46 rings. This is the range of the 95% confidence limits now

thought to represent the number of sapwood rings in British oak trees over 30 years old (Tyers pers comm). It replaces the estimate of 10-55 rings previously used at Sheffield (Hillam *et al* 1987). Where sapwood is absent, felling dates are given as *termini post quem* (*tpq*) by adding 10 years, the estimated minimum number of missing sapwood rings, to the date of the last measured heartwood ring. This is the earliest possible felling date but the actual felling date could be much later depending on how many heartwood rings have been removed during conversion of the trunk into its component timbers.

The above gives a brief introduction to dendrochronology. Further information about the history, principles, and methodology of dendrochronology can be found in Baillie (1982) and Hillam (forthcoming).

THE TREES

During the excavation, samples were taken from any trees which appeared likely to be oak (*Quercus* spp.). Examination in the laboratory showed that ES12 and ES25 were not oak and these were rejected. ES10 and ES21 were also rejected since they had less than 50 rings, the minimum number required for reliable dating. ES16, ES17, ES19, and ES24 proved unsuitable because their rings could not be measured accurately either because their rings were too narrow or because of the presence of knots. The remainder had 64 to 205 rings. Many of the samples from this area had very narrow rings with average ring widths well below 1.0mm (Table 1), although ES11, one of the trees with felling scars, had very wide rings averaging 3.98mm.

The sampling strategy for the remaining trees was to sample as diverse a range from as large an area as possible. Some of the larger trees were too big to sample safely with a chain saw but often fragments had broken off and these were sampled instead. Most trees had quite narrow rings but others, eg 108, were from faster-grown trees and, although these had fewer rings and were therefore less suitable for chronology building, they were sampled because they extended the range of trees.

Initial appearances suggested that the tree remains came from a few large trees. These had broken, possibly on deposition, leaving smaller fragments lying around the larger trunks. A sample was obtained from tree E and a fragment from tree A. The other samples came from pieces of timber lying around them. Samples not listed are from smaller trunks, branches, or fragments.

Tree	Length (m)	Diameter (m)[1]	Grain	Associated samples
A (115)	12.5	1.8	straight	113, 114
B	24.0	1.4	straight	106, 109, 112
C	5.0	0.5	straight	105, 107, 108
D	8.4	0.5	straight	116, 117, 118
E (121)	7.0	1.3	very twisted	-

[1] Note this does not include bark or sapwood, none of which had survived.

The dimensions of the tree trunks indicate that most of the trees were tall and straight-grained, probably originating in a closed canopy which caused them to grow up towards the light. Tree E is the exception. It had very twisted grain giving the trunk the appearance of a cork screw. What caused this type of growth is unknown.

No information about the size and age of tree is available for the third group of trees which produced samples 1-10.

THE TREE-RING RESULTS

The data from the Nottingham samples were first compared against each other. Two groups of matching ring sequences were obtained: 2, 4, 5, 6, and 8 formed one group (Fig 3 and Table 2), whilst 9 and 10 made up the second (Fig 4). The data from each group were combined to produce two site masters, Langford 1 (Table 3) and Langford 9/10 respectively. Sample 7 matched Langford 1 with a *t*-value of 4.4 over the period 4136-3994 BC; it also matched the Old Loop 1 chronology at the same date (t=6.1). Samples 1 and 3 remain undated.

When samples 100-122 and ES09-ES27 were measured, many were found to be broadly contemporary with Langford 9/10 (see below) but nothing else matched with Langford 1. The latter was tested against dated reference chronologies. It matched several chronologies over the period 4232-4021 BC (Table 4), but was particularly similar to Old Loop 1, a chronology constructed from tree remains at Colwick just south of Nottingham (Fig 1; Salisbury *et al* 1984).

Of the remaining samples, 105 and 108 matched each other with a *t*-value of 6.2. The data were combined to give the 122-year chronology, Langford 2 (Fig 4 and Table 5). This chronology was dated to 2979-2858 BC because of its similarity to chronologies from Colwick and East Anglia over this period (Table 6).

The data from twenty-two samples matched Langford 9/10 (Fig 4 and Table 7). These produced Langford 3, a chronology of 513 years (Table 8), which dated to 2637-2125 BC (Table 9). The Langford chronology was very similar to another chronology from Colwick, Para Trent 1, and to chronologies from East Anglia.

The only other match was between samples 106 and 109 which gave a *t*-value of 4.3. No date has yet been obtained for 106/109, but a sample from 106 has been submitted for radiocarbon dating.

THE CHRONOLOGY OF THE LANGFORD TREES

Although a total of 32 samples were dated, these proved to represent fewer trees. The six samples taken by Nottingham and dating to the late fourth-early fifth millennium BC are probably mostly from the same tree with only sample 7 definitely from a different tree (Table 2). Without the actual tree-ring samples, it is not possible to be certain of this and therefore the ring width data were not averaged before inclusion in the site master. The sample 7 tree died after 3984 BC; the tree which produced samples 2, 4, 5, 6, and 8 died after 4011 BC (Fig 3).

After a gap of over one thousand years, two dated trees are represented, 105 and 108. These, along with 107, were initially grouped together as tree C, but 107 proved to be younger by about 500 years and is clearly not from the same tree. 105 and 108, which match with a *t*-value of 6.2, are also from different trees, although they may have died at the same time. 105 died after 2880 BC, and 108 after 2848 BC.

Langford 3, 2637-2125 BC, contains the largest number of samples (Fig 4). 113-115 proved to be from tree A (Table 7). Samples 100-104, just to the north of 113-115 and the large unsampled trunk are also probably from tree A. More surprisingly, the visual matching and the *t*-values suggest that sample 107, originally thought to be from trunk C, could be from tree A. A date of death after 2372 BC was obtained for tree A. Samples 9 and 10, which died after 2416 BC and 2481 BC respectively, are broadly contemporary, but lack of sapwood makes it impossible to determine their exact chronological relationship.

The twisted trunk E (sample 121) died after 2329 BC. Although definitely from a different tree, its ring pattern is similar to those from tree A, suggesting perhaps that it originated in the same woodland. The samples from the remaining dated tree trunks are probably younger. 110 and 111 died after 2294 BC and 2284 BC; 122 after 2207 BC, and 119 after 2172 BC. The youngest dated tree is D, from which samples 116-118 are derived. This died after 2115 BC.

The timbers sampled during the excavation are a more diverse group than those described above and no same tree groups were identified. They date to the younger end of Langford 3 with felling dates after 2266 BC for ES09 and after 2133 BC for ES11. ES13, ES20, and ES26 have *tpq* in between these dates.

In addition to the dated samples, there is the 2-timber master made up from 106 and 109. These two samples are not from the same tree, but are broadly contemporary. A more precise date will be available for these once the radiocarbon results for 106 is known.

The date of the Langford trees are summarised as follows:

Samples	Dates of death/felling dates (BC)
2, 4, 5, 6, 8	4011+
7	3984+

105, 108 (not same tree)	2880+, 2848+
100-104, 113-115, 107	2372+
121 (tree E)	2329+
110, 111 (probably not same tree)	2284+
ES09	2266+
119	2172+
ES11	2133+
116-118	2115+
106, 109 (probably not same tree)	awaiting radiocarbon result

LANGFORD AND OTHER TREES FROM THE TRENT VALLEY

This wide range of dates for trees from the River Trent gravels was also found at Colwick, near Nottingham (Fig 1). Although the original work at Colwick suggested that all the dated trees belonged to fourth or fifth millennium BC (Salisbury *et al* 1984; Morgan *et al* 1987), more recent work has indicated otherwise (Brown and Baillie 1992). The dated timbers from Colwick are from three pits: Colwick Hall (CH), Old Loop (OL), and Para Trent (PT). Samples were also taken from the pits, Swans Nest and Trout Pond (Salisbury *et al* 1984), but these remain undated. Figure 5 shows the temporal relationship between the Langford oaks and those from Colwick. The dates of the chronologies are summarised below:

Site	Chronology	Date span (BC)
Colwick	Old Loop 2	4852-4426
Langford	Langford 1	4232-4021
Colwick	Old Loop 1	4186-3833
Colwick	Colwick Hall 1	3045-2697
Langford	Langford 2	2979-2858
Colwick	Colwick Hall 2	2792-2583
Langford	Langford 3	2637-2125
Colwick	Para Trent 1	2563-2258

The trees in Langford 1 are broadly contemporary with some of those in Old Loop 1; Langford 2 spans part of the period covered by Colwick Hall 1, and Langford 3 is broadly contemporary with Para Trent 1. It is possible that the death of some of the trees may have been caused by the same event at the both Langford and Colwick. As more trees are examined from other sites in the Trent Valley, it may be possible to throw light on the precise dates and the causes of these events.

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also provided unpublished tree-ring chronologies; further data were made available through the EU Environmental Research Programme, contracts EV5V-CT94-0500 and ENV5-CT95-0127.

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Table 1: Details of tree-ring samples. The data from samples 1-10 were supplied by the Nottingham University Tree-Ring Dating Laboratory; 100-122 are from fallen trees adjacent to the excavation; ES9-27 are from the excavation site.

Sample no	Context no	Total no of rings	ARW[1] (mm)	Date span (BC)	Felled (BC)	Comments
1	-	51	2.97	undated	-	
2	-	130	1.49	4215-4086	4076+	
3	-	100	1.07	undated	-	
4	-	130	1.45	4199-4070	4060+	
5	-	128	1.57	4215-4088	4078+	
6	-	212	1.48	4232-4021	4011+	
7	-	143	0.88	4136-3994	3984+	
8	-	136	1.64	4194-4059	4049+	
9	-	160	1.36	2585-2426	2416+	
10	-	113	1.71	2603-2491	2481+	
100	-	184	0.80	2593-2410	2376+	100-104 same tree
101	-	165	1.00	2550-2386	2376+	100-104 same tree
102	-	230	1.26	2637-2408	2376+	100-104 same tree
103	-	188	0.84	2623-2436	2376+	100-104 same tree
104	-	162	0.94	2570-2409	2376+	100-104 same tree
105	-	65	3.06	2954-2890	2880+	
106	-	61	1.44	undated	-	matches 109; radiocarbon sample taken
107	-	158	1.46	2539-2382	2372+	
108	-	122	2.89	2979-2858	2848+	
109	-	129	1.20	undated	-	matches 106
110	-	57	1.87	2360-2304	2394+	
111	-	76	1.54	2369-2294	2284+	

[1] ARW - average ring width

112	-	104	0.88	undated	-	
113	-	94	2.38	2547-2454	2438+	113-115 same tree
114	-	134	2.99	2591-2458	2438+	113-115 same tree
115	-	+183	2.61	2630-2448	2438+	113-115 same tree; +14 inner rings
116	-	140	2.10	2296-2157	2115+	116-118 same tree?
117	-	135	1.93	2276-2142	2115+	116-118 same tree?
118	-	132	1.80	2256-2125	2115+	116-118 same tree?
119	-	72	3.61	2253-2182	2172+	
120	-	88	2.85	undated	-	
121	-	279	1.65	2617-2339	2329+	
122	-	123+	0.77	2364-2242+	2207+	+25 heartwood rings
ES09	0110	149	1.47	2424-2276	2266+	
ES11	0113	64	3.98	2206-2143	2133+	log with felling scar
ES13	0109	205	0.66	2405-2201	2191+	
ES14	0111	97 (inc 30 sapwood	0.65	undated	-	bark edge?; radiocarbon sample taken
ES18	CCL	68	0.94	undated	-	
ES20	CDX	107	0.62	undated	-	
ES22	CEF	56+	0.61	undated	-	more narrow outer rings
ES23	CEG	+111	0.53	undated	-	more inner rings
ES26	BGA	153	2.10	2420-2268	2258+	
ES27	0107	108+	1.36	undated	-	log with felling scar; more narrow outer rings with sapwood

Table 2: *t*-value matrix for ring sequences from the fourth-fifth millenium BC timbers. Values less than 3.0 are not printed.

		2	**4**	**5**	**6**	**7**	**8**
	date span (BC)	4215-4086	4199-4070	4215-4088	4232-4021	4136-3994	4194-4059
2	4215-4086	*	9.92	**16.61**	**14.47**	-	**12.37**
4	4199-4070	*	*	9.39	**10.86**	3.30	8.34
5	4215-4088	*	*	*	**14.88**	-	**10.27**
6	4232-4021	*	*	*	*	4.13	**13.23**
7	4136-3994	*	*	*	*	*	-
8	4194-4059	*	*	*	*	*	*

Table 3: Langford 1, 4232-4021 BC.

Date	Ring widths (0.01mm)										No of samples									
4232 BC									49	68									1	1
-	46	33	37	62	47	35	53	30	68	44	1	1	1	1	1	1	1	1	1	1
-	94	112	79	75	102	140	103	103	121	67	1	1	1	1	1	3	3	3	3	3
-	158	65	47	79	168	249	158	138	158	99	3	3	3	3	3	3	3	3	3	3
4200 BC	114	128	111	131	222	146	190	171	229	205	3	4	4	4	4	4	5	5	5	5
-	205	210	229	216	177	137	101	110	131	170	5	5	5	5	5	5	5	5	5	5
-	226	190	192	196	248	171	317	273	196	140	5	5	5	5	5	5	5	5	5	5
-	207	216	220	220	195	174	167	147	164	192	5	5	5	5	5	5	5	5	5	5
-	193	170	147	154	97	149	176	161	205	164	5	5	5	5	5	5	5	5	5	5
4150 BC	91	111	209	158	157	106	204	105	154	120	5	5	5	5	5	5	5	5	5	5
-	151	142	136	136	151	138	135	163	182	113	5	5	5	5	5	5	5	5	5	5
-	128	161	172	187	205	185	237	115	124	145	5	5	5	5	5	5	5	5	5	5
-	148	113	157	93	242	175	135	181	190	146	5	5	5	5	5	5	5	5	5	5
-	132	80	108	109	115	92	171	128	111	73	5	5	5	5	5	5	5	5	5	5
4100 BC	123	94	143	103	181	93	90	159	152	141	5	5	5	5	5	5	5	5	5	5
-	191	107	153	135	168	194	180	150	169	113	5	5	5	4	4	3	3	3	3	3
-	120	177	190	138	154	161	165	115	139	174	3	3	3	3	3	3	3	3	3	3
-	195	198	165	130	140	159	133	170	185	128	3	2	2	2	2	2	2	2	2	2
-	164	181	104	90	91	95	109	105	96	89	2	2	1	1	1	1	1	1	1	1
4050 BC	130	86	53	129	78	112	106	84	93	120	1	1	1	1	1	1	1	1	1	1
-	144	94	64	129	92	88	107	128	88	121	1	1	1	1	1	1	1	1	1	1
-	118	152	131	96	127	125	111	119	105	130	1	1	1	1	1	1	1	1	1	1

Table 4: Dating Langford 1, 4232-4021 BC. *t*-values with dated reference chronologies.

Chronology	Date span (BC)	*t*-value
ENGLAND		
Ashton 13, Lancs (Brown and Baillie 1992)	4465 -3929	4.08
Beverley, Long Lane (Hillam *et al* 1990)	4197 -3891	4.21
Old Loop 1, Notts (Brown and Baillie 1992)	4186 -3833	8.20
Sweet Track, Somerset (Hillam *et al* 1990)	4202 -3807	7.14
IRELAND		
Garry Bog 3, Co Antrim (Brown *et al* 1986)	5252 -3822	4.58

Table 5: Langford 2, 2979-2858 BC.

Date	Ring widths (0.01mm)										No of samples									
2979 BC		199	221	377	499	317	311	352	376	221		1	1	1	1	1	1	1	1	1
-	278	328	289	330	239	343	358	341	304	474	1	1	1	1	1	1	1	1	1	1
-	375	454	290	267	363	424	485	390	434	403	1	1	1	1	1	1	2	2	2	2
2950 BC	317	297	279	425	449	390	462	376	357	306	2	2	2	2	2	2	2	2	2	2
-	233	323	335	329	384	431	370	303	240	252	2	2	2	2	2	2	2	2	2	2
-	278	398	277	279	227	179	217	270	389	198	2	2	2	2	2	2	2	2	2	2
-	368	295	192	321	291	306	285	254	295	270	2	2	2	2	2	2	2	2	2	2
-	225	294	271	200	240	161	205	333	272	229	2	2	2	2	2	2	2	2	2	2
2900 BC	247	295	233	211	209	179	205	370	319	362	2	2	2	2	2	2	2	2	2	2
-	282	302	309	191	187	258	225	201	229	268	2	1	1	1	1	1	1	1	1	1
-	302	280	226	249	217	252	254	339	257	216	1	1	1	1	1	1	1	1	1	1
-	205	258	253	209	258	238	175	233	182	189	1	1	1	1	1	1	1	1	1	1
-	319	258	181								1	1	1							

Table 6: Dating Langford 2, 2979-2858 BC. *t*-values with dated reference chronologies.

Chronology	Date span (BC)	*t*-values
ENGLAND		
Colwick Hall 1, Notts (Brown and Baillie 1992)	3045-2697	5.95
Holme Fen, Cambs (Brown and Baillie 1992)	3141-1868	3.58
Wicken Sedge Fen, Cambs (Brown and Baillie 1992)	3088-2585	5.07
Wood Walton Fen, Cambs (Brown and Baillie 1992)	3196-2307	4.09

Table 7: *t*-value matrix for ring sequences from for the third millenium BC timbers. Values less than 3.0 are not printe

	10	**100**	**101**	**102**	**103**	**104**	**107**	**110**	**111**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**121**
9	7.67	-	4.81	4.85	-	4.85	4.03	\	\	4.94	6.86	8.92	\	\	\	\	6.37
10	*	3.90	4.62	5.34	3.77	5.13	4.94	\	\	7.37	7.14	8.48	\	\	\	\	7.41
100	*	*	**10.06**	**12.20**	**11.33**	**10.24**	7.74	\	\	5.09	5.21	5.88	\	\	\	\	6.32
101	*	*	*	**11.10**	8.97	**15.59**	9.75	\	\	6.63	9.35	8.56	\	\	\	\	9.26
102	*	*	*	*	9.09	**11.80**	8.60	\	\	6.37	7.23	7.85	\	\	\	\	6.01
103	*	*	*	*	*	9.81	6.71	\	\	5.45	6.02	6.11	\	\	\	\	3.09
104	*	*	*	*	*	*	9.77	\	\	8.02	**12.35**	9.99	\	\	\	\	7.59
107	*	*	*	*	*	*	*	\	\	9.63	9.75	9.73	\	\	\	\	5.86
110	*	*	*	*	*	*	*	*	6.43	\	\	\	\	\	\	\	-
111	*	*	*	*	*	*	*	*	*	\	\	\	\	\	\	\	-
113	*	*	*	*	*	*	*	*	*	*	**12.36**	**13.09**	\	\	\	\	6.20
114	*	*	*	*	*	*	*	*	*	*	*	14.50	\	\	\	\	7.09
115	*	*	*	*	*	*	*	*	*	*	*	*	\	\	\	\	6.08
116	*	*	*	*	*	*	*	*	*	*	*	*	*	**10.12**	6.84	4.01	\
117	*	*	*	*	*	*	*	*	*	*	*	*	*	*	8.65	5.12	\
118	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	3.29	\
119	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	\
121	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
122	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
es09	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
es11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
es13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
es20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Table 8: Langford 3, 2637-2125 BC.

Date	Ring widths (0.01mm)										No of trees[2]									
2637 BC				185	105	128	142	90	186	140				1	1	1	1	1	1	1
-	363	335	386	403	320	335	369	235	298	359	2	2	2	2	2	2	2	2	2	2
-	243	326	392	378	268	254	239	169	246	219	2	2	2	3	3	3	3	3	3	3
-	188	220	204	269	292	281	174	138	141	191	3	3	3	3	3	3	3	4	4	4
2600 BC	187	223	183	213	253	264	206	166	251	197	4	4	4	4	4	4	4	4	4	4
-	244	179	195	143	209	278	181	180	232	282	4	4	4	4	4	5	5	5	5	5
-	210	263	181	215	267	294	210	284	238	250	5	5	5	5	5	5	5	5	5	5
-	189	164	199	151	168	240	159	205	217	233	5	5	5	5	5	5	5	5	5	5
-	279	176	163	151	189	256	286	228	204	221	5	5	5	5	5	5	5	5	5	5
2550 BC	129	128	219	217	232	167	196	136	202	164	5	5	5	5	5	5	5	5	5	5
-	196	122	127	171	238	275	238	132	154	159	5	5	5	5	5	5	5	5	5	5
-	187	159	145	148	192	189	194	192	182	203	5	5	5	5	5	5	5	5	5	5
-	159	168	132	164	156	179	138	158	147	179	5	5	5	5	5	5	5	5	5	5
-	215	158	122	174	175	210	256	205	174	199	5	5	5	5	5	5	5	5	5	5
2500 BC	188	162	112	159	107	161	194	171	129	118	5	5	5	5	5	5	5	5	5	5
-	140	104	102	160	175	132	141	165	146	103	4	4	4	4	4	4	4	4	4	4
-	157	100	92	81	138	188	158	151	145	142	4	4	4	4	4	4	4	4	4	4
-	177	126	80	100	135	138	104	148	165	159	4	4	4	4	4	4	4	4	4	4
-	118	101	161	117	121	156	126	148	158	159	4	4	4	4	4	4	4	4	4	4
2450 BC	109	127	143	124	111	124	117	87	86	71	4	4	4	3	3	3	3	3	3	3
-	73	64	87	109	97	124	113	109	87	74	3	3	3	3	3	3	3	3	3	3
-	120	143	133	110	116	135	185	154	101	203	3	3	3	3	3	2	3	3	3	3
-	236	130	192	141	161	122	143	120	112	106	4	4	4	4	4	4	4	4	4	4
-	123	140	118	83	93	94	131	107	104	160	4	4	4	4	4	5	5	5	5	5
2400 BC	153	119	130	81	92	109	130	103	86	101	5	5	5	5	5	5	5	5	5	5
-	124	124	117	126	81	133	137	164	162	207	5	5	5	5	5	4	4	4	4	4
-	166	130	93	104	121	105	86	94	132	139	4	5	5	5	5	5	5	5	5	5
-	101	173	90	103	86	138	121	81	121	110	5	6	6	6	6	6	7	7	7	7
-	145	137	174	143	170	151	115	83	117	130	8	8	8	8	8	8	8	8	8	8
2350 BC	104	100	148	106	82	83	98	100	84	92	8	8	8	8	8	8	8	8	8	8
-	76	93	84	97	132	101	124	144	160	128	8	8	7	7	7	7	7	7	7	7
-	98	140	141	116	77	98	71	94	99	135	7	7	7	7	7	7	7	7	7	7
-	160	108	152	126	131	178	157	156	126	132	7	7	7	7	7	7	7	7	7	7
-	122	98	79	77	125	126	157	81	108	130	7	7	7	7	7	7	7	6	6	6
2300 BC	135	126	165	140	197	210	219	197	212	247	6	6	6	6	7	7	7	6	6	6
-	220	146	182	145	170	186	186	208	179	169	6	6	6	6	6	6	6	6	6	6
-	136	172	204	214	203	194	198	211	184	123	6	6	6	6	6	5	5	5	4	4
-	191	110	187	152	161	164	125	123	121	91	4	4	4	3	3	3	3	3	3	3
-	91	107	108	123	156	124	116	201	215	189	3	3	3	3	3	3	3	4	4	4
2250 BC	190	216	183	191	204	231	204	217	186	183	4	4	4	4	4	4	4	4	4	3
-	200	218	192	229	253	193	248	170	220	252	3	3	3	3	3	3	3	3	3	3
-	196	191	210	249	171	185	181	144	162	237	3	3	3	3	3	3	3	3	3	3

[2] Data from ring sequences believed to be from the same tree have been averaged before inclusion in the master.

-	195	238	225	263	191	168	193	172	151	170	3	3	3	3	3	3	3	3	3	3
-	130	146	148	223	201	180	117	204	292	284	3	3	3	3	4	4	4	4	4	4
2200 BC	379	348	302	258	280	305	328	373	279	357	3	3	3	3	3	3	3	3	3	3
-	282	233	302	307	358	330	307	305	388	382	3	3	3	3	3	3	3	3	3	2
-	335	257	335	370	312	359	265	168	219	239	2	2	2	2	2	2	2	2	2	2
-	312	276	171	243	308	415	307	150	90	84	2	2	2	2	2	2	2	2	2	2
-	110	118	161	184	223	274	190	206	166	158	2	2	2	2	2	2	2	2	2	2
2150 BC	288	258	402	337	251	351	201	148	113	114	2	2	2	2	2	2	2	2	1	1
-	127	129	110	108	97	119	118	144	149	140	1	1	1	1	1	1	1	1	1	1
-	127	164	119	134	110	104					1	1	1	1	1	1				

Table 9: Dating Langford 3, 2637-2125 BC. *t*-values with dated reference chronologies.

Chronology	Date span (BC)	*t*-values
ENGLAND		
Beverley Rising Main, E Yorks (Hillam unpubl)	2698-2443	5.57
Coveney, Cambs (Brown and Baillie 1992)	2371-2110	5.38
Croston 1, Lancs (Brown and Baillie 1992)	3198-1682	4.72
Holme Fen, Cambs (Brown and Baillie 1992)	3141-1868	8.38
Para Trent 1, Notts (Brown and Baillie 1992)	2563-2258	9.55
Rainham 21, Greater London (Tyers unpubl)	2262-2139	4.01
Sawtry Fen, Cambs (Brown and Baillie 1992)	2585-1745	8.25
Wood Walton Fen, Cambs (Brown and Baillie 1992)	3196-2307	4.59
IRELAND		
Belfast Long Chronology (Brown *et al* 1986)	3938-949	3.70
GERMANY		
South (Becker pers comm)	2875-650	3.92

Fig 1: Location of Langford and other sites mentioned in report.

Fig 2: Sketch showing the approximate positions of the sampled trees in relation to the excavation and the location of the Nottingham trees. Not to scale.

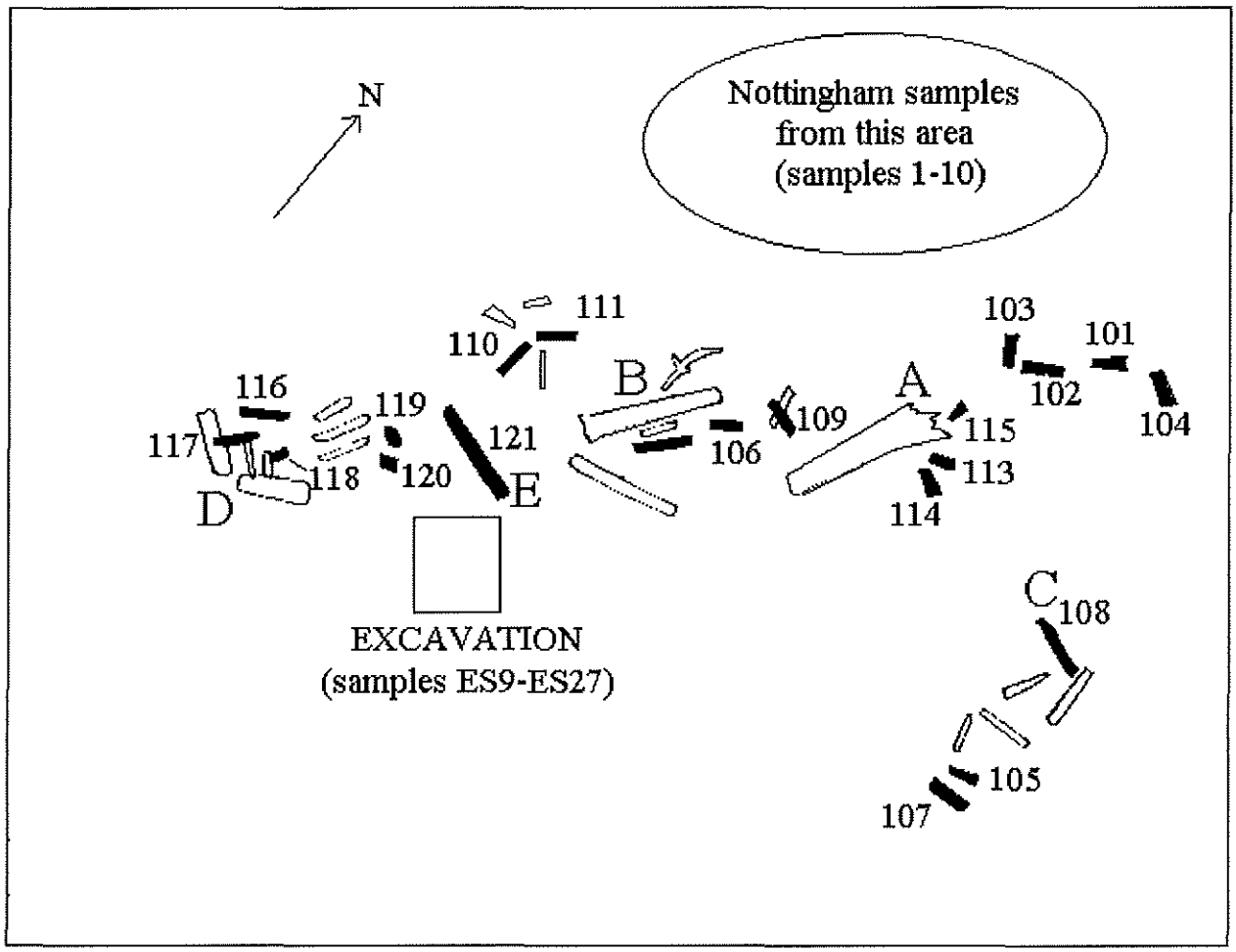

Fig 3: Bar diagram showing the relative positions of the ring sequences in Langford 1. White bars - heartwood rings; + - felled after.

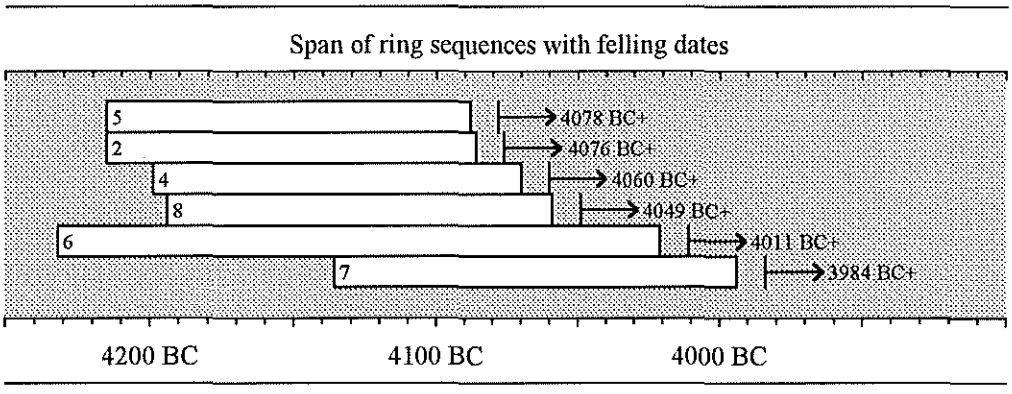

Fig 4: Bar diagram showing the relative positions of the ring sequences in Langford 2 and 3. Thick bars - heartwood rings; thin bars - unmeasured rings; + - felled after. Shading and letters after the sample numbers indicate probable same tree groups.

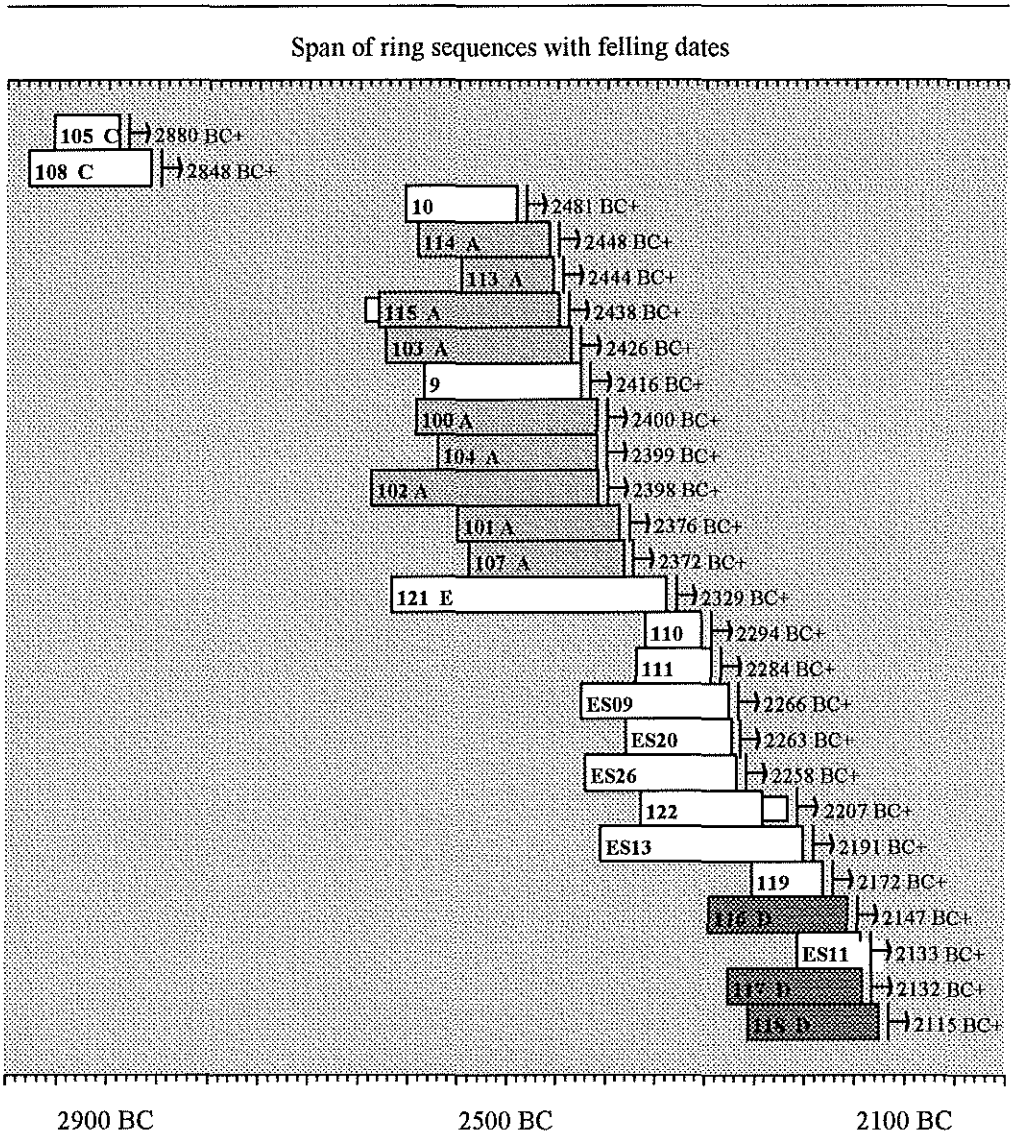

Fig 5: Bar diagram showing the relative positions of the ring sequences from the dated River Trent gravel oaks. White bars - tree-ring chronologies; LF - Langford; CH - Colwick Hall; P Trent - Para Trent.