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Summary

Tree-ring analysis of forty oak timbers from two wells at Slough House Farm near Maldon indicated that the timber shafts were Saxon in date rather than Roman as originally thought. Precise felling dates were obtained for the two shafts, and a tree-ring chronology covering the period AD406-602 was produced. The implications of the results are discussed with reference both to Slough House Farm and to Saxon timbers in general.

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TREE-RING ANALYSIS OF WELL TIMBERS FROM SLOUGH HOUSE FARM, GREAT TOTHAM PARISH, ESSEX

Introduction

Excavations in 1988/89 at Slough House Farm near Maldon (Fig 1), revealed features ranging in date from the Neolithic to the medieval periods. The two wells which contained waterlogged timbers (F130, F2957) were located after about 1m of subsoil had been removed.

Well F130 was a deep circular pit into which a square timber shaft had been inserted (Wallis 1989, Fig 5). Three courses of the shaft had survived but the presence of other timbers inside the shaft suggested that there had originally been more than three courses. All the twelve *in situ* timbers were sampled for dendrochronology - N1 is the highest timber on the north side, S3 is the lowest on the south and so on (Table 1). An extra sample from S1 was also sampled, plus two planks and two other associated timbers, 175 and 176.

Well F2957 was also a circular pit containing a square timber shaft. The latter was less substantial than that of F130 and had collapsed. Eighteen samples were taken from the collapsed shaft (Table 1, samples 1-28). A stake X, found in the packing of the shaft, was also sampled. The collapsed shaft was replaced by a shaft consisting of a hollowed out tree trunk A. During the hollowing out process one side of the trunk was cut away. After the trunk had been inserted into the well, four timbers were placed upright over the gap. Three of these timbers (B, C, D) were sampled for dendrochronology.

Associated finds suggested that the wells were Roman in date. The packing of the collapsed shaft of F2957 contained 1st century Roman pot, and pottery of 1st-2nd century date came from the silting of the replacement shaft. F130 contained several residual prehistoric and Roman sherds in the lining and silting of the shaft, and there was also a vegetable-tempered sherd of approximately 6th century date in the lowest fill of the shaft. The dendrochronological study was undertaken to confirm the Roman origin of the

wells and to provide a precise date for the timbers.

Methods

The samples were prepared by freezing them for at least 48 hours and then cleaning their cross-sections with a surform plane. The ring widths of those samples with more than 50 rings were measured on a travelling stage connected to an Apple II microcomputer (Hillam 1985, Fig 4). (Ring patterns with less than 50 rings are unlikely to be unique and might not produce reliable dates - see Hillam *et al* 1987 for further details.) The ring sequences were plotted as graphs using a graphing program on the Prime mainframe (Okasha 1987). The graphs were then compared with each other on a light box to check for any similarities between the ring patterns which might indicate contemporanity. For crossmatching purposes, the ring width data were also transferred to an Atari ST microcomputer with hard disk. The tree-ring software for the Atari was written and developed by Ian Tyers of the Museum of London. The crossmatching routines are based on the Belfast CROS program (Baillie & Pilcher 1973; Munro 1984), and all the *t* values quoted in this report are identical to those produced by the first CROS program (Baillie & Pilcher 1973). 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).

Dating is achieved by crossmatching ring sequences within a site or structure, combining the matching sequences into a site master, and then testing that master for similarity against dated reference chronologies. A site master is used for dating whenever possible because it enhances 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.

If a sample has bark or bark edge, the date of the last measured ring is the date in which the tree was felled. A complete outer ring indicates that the tree was felled during its dormant period in winter or early spring. This is

referred to as "winter felled". If the ring is incomplete, felling took place during the growing season in late spring or summer (referred to as "summer felled"). In the absence of bark edge, felling dates are calculated using the sapwood estimate of 10-55 rings. This is the range of the 95% confidence limits for the number of sapwood rings in British oak trees over 30 years old (Hillam *et al* 1987). Where sapwood is absent, felling dates are given as *termini post quem* by adding 10 years, the minimum number of missing sapwood rings, to the date of the last measured heartwood ring. The actual felling date could be much later depending on how many heartwood rings have been removed.

At this stage of the study, factors such as reuse, stockpiling, or repairs have also to be taken into account. Thus whilst the tree-ring dates for the measured rings are precise and independent, the interpretation of these dates often requires other archaeological evidence.

Results

Well F130

All the timbers from this well were oak (*Quercus* spp). The timbers from the three surviving courses were tangentially split planks (Table 1). The planks sometimes used the full diameter of the tree trunk (eg E2, S2); others used less than half the diameter (eg E1). The thickness of the planks increased from the bottom course to the top one on each side. The average ring width ranged from 0.9mm to 2.1mm and the number of rings from 86 to 161. The timbers probably came from trees of 0.5m to 1.0m diameter and often aged over 200 years old. The samples were straight-grained with no knots, and had come from fine quality timbers. The other timbers associated with this shaft were of similar type and quality and were probably originally part of the shaft.

The ring widths of all the samples except N1, E3 and W1 were selected for measurement. (E3 had fewer rings than the others; N1 and W1 were big and heavy and less suitable for the measuring equipment.) All the ring sequences except 176 crossmatched (Fig 2). The ring patterns of E1 and 175 were almost

identical and probably came from the same tree. It was also noticeable that the sequences from each layer were very similar, more so than the sequences from different layers, which might indicate that a single tree was used for each layer of timbers (Table 2). Planks 1 and 2 were also very similar (t = 12.6), which again suggests that they belonged to a higher course.

The ring widths of E1 and 175 were averaged before being incorporated into the structure master so as to avoid bias. The final F130 master chronology is 197 years in length (Table 3). It was tested against reference chronologies of Roman date but no consistent dating was found. However when the search for crossmatching was extended to include reference data from other periods, a startlingly good match was found for the period AD406-602 (Table 4). As well as being very similar to Saxon chronologies from relatively local areas such as Barking Abbey in Greater London or Mersea Island in Essex, the F130 sequence showed good correlation with chronologies from Tamworth, Carlisle and even Whithorn in south-west Scotland.

There can therefore be no doubt that the timbers from well F130 are Saxon in origin. A more precise date can be obtained because four of the samples had sapwood, including two which had probable bark edge (Fig 2). The slight uncertainty is due to the possibility that one or two outer rings were lost due to damage during sampling. In fact E2 ends in 602 and plank 1 in 601 so it is safe to assume that the two timbers were felled in 602 or 603 (Table 5). The heartwood-sapwood transitions or outer rings of the other timbers are very close in date (see also Baillie 1982, 56-7). This plus the similarity in ring pattern suggests that all the timbers were felled in 602/603 but that some had lost or had their sapwood removed (Fig 2). Since green timber was generally used for structures such as wells, the construction date for the well shaft is 602/603 or just after.

No reliable dating has been found for the 191 ring sequence from 176. (All the data are stored at the Sheffield Dendrochronology Laboratory where they

can be consulted on request.)

Well F2957

The timbers from this well were also oak except possibly for 24. This was knotty, gnarled piece of wood with no identifiable wood structure. It could possibly be a piece of root. The timbers from the collapsed shaft were generally very inferior in quality, especially when compared to those from F130. Many of the samples contained knots (Table 1). Some of the timbers were from relatively young oak trees. 17, for example, was 18 years old when felled and showed no evidence of having been worked. Three timbers (9, 10, 21) were radially split planks which had 70-123 rings and probably came from trees about 150 years old. Other timbers were sections which had been hewn into rectangular or other shapes (eg 8, 12). Eleven samples were rejected as unsuitable for dating because of knots or too few rings (Table 1).

The stake X from the packing was a radial segment split from a tree of approximately 160mm in diameter and about 72 years old when felled. It had bark edge, although the measured ring sequence is only 66 years because the outer 6 rings could not be measured accurately.

Only a section of the hollowed out trunk A was available for study. It contained 78 rings but had no sapwood. Timbers B-D had 71-90 rings and like A, were from the outer part of a tree trunk. The timber from the replacement shaft was of better quality than that it replaced but did not reach the quality of the F130 timbers.

The ring sequences from B-D crossmatched to give a 125 year master sequence. Timber A was found to match this master. A group of sequences from the collapsed shaft also matched each other. The ring sequences, and the samples themselves, of 9 and 10 were so similar that they must have come from the same tree. Samples 5, 12, 21 and 25 also matched 9/10 (Table 2). When a master sequence was made from these five sequences (the ring widths of 9 and 10 were first averaged to avoid undue bias), it was found to crossmatch the sequence

from X. 8 did not match with any of the other sequences but this may be because it is relatively short.

The sequences from the collapsed shaft and its replacement did not match each other particularly well, so they were next tested against the F130 chronology. The master from the collapsed shaft gave a t value of 8.8 when its ring sequence spanned the period 415-539, and that from the replacement a t of 8.4 for the period 481-589. Comparison with other Saxon chronologies confirmed these dates, and the matching ring sequences from F2957 and F130 were combined into a single Slough House Farm master chronology of 197 years dating to 406-602. This sequence (Table 6) will be used in the future as a reference chronology for dating new Saxon timbers.

The precise dating of F2957 is more complex than that for F130 (Table 5). Five of the samples from the collapsed shaft had sapwood, including two which definitely were complete to the bark edge (Fig 2). 10, and hence 9, was felled in 539/540, and 25 in 507/508. The felling date ranges for 5 and 21 are 508-549 and 502-534 respectively. The range for 21 therefore covers the felling date of 25 but not that of 9/10, whilst 5 is more likely to be of a similar date to 9/10. The remaining sample (12), which did not have sapwood, was felled some time after 527, and is also likely to be contemporary with 9/10.

Stake X from the packing of the shaft also had bark edge. It was felled in 504/505. The collapsed shaft therefore has structural and associated timbers which were felled in 504/505, 507/508 and 539/540. One interpretation is that the shaft was constructed in 504-508 or just after and repaired in 539/540. This seems more feasible than a construction in 539/540 using or reusing timbers which had been felled 30 years previously.

The timbers from the replacement shaft are obviously later than those of the collapsed shaft but since none of them had sapwood, a precise felling date cannot be obtained. A and C were felled after 568 and 565 respectively,

whilst B and D were felled after 599 and 595. Assuming that they are contemporary, a *terminus post quem* of 599 is obtained for the construction of the replacement shaft. This is similar to some of the *termini post quem* for the F130 timbers without sapwood, so it may be that the replacement shaft of F2957 was inserted at the same time as the F130 shaft.

Discussion

The results from the Slough House Farm wells add to the data already collected on timbers from early-mid Saxon sites (Tyers *et al* 1990). The timber shaft from F130 and the two from F2957 illustrate that different quality timber was available and was selected for whatever reason. In terms of quality the timber from F130 is most similar to that from the well found at the Six Dials site in Hamwic (Hillam 1984), whilst the timbers from F2957 are more akin to those from the wells at Odell in Bedfordshire (Hillam 1981).

All the timbers for these Saxon wells, whatever their quality and regardless of when they were felled, came from trees which started life just after AD400. (The replacement timbers from F2957 seem to be later but they are from the outer part of a tree trunk.) The reason for this profusion of Saxon structures with timbers which started growing just after 400 is still being explored and a full discussion on the subject can be found elsewhere (Tyers *et al* 1990). It seems to be related to the decline of the Roman Empire and the departure of the Romans, since the tree-ring record shows no evidence of trees which either started or stopped growing in the 4th century.

Conclusion

The study clearly illustrates the importance of dendrochronology to archaeology. Well timbers which were thought to be of Roman origin, are in fact Saxon. It raises the question of how many "Roman" wells which have not had the benefit of dendrochronological analysis, are actually Saxon in date.

The timbers for well F130 which were of very high quality, were felled in 602/603 and probably used almost immediately. The collapsed shaft of F2957

contained timbers of inferior quality felled in 507/508 and 539/540 with a packing timber that was felled in 504/505; it was probably constructed in the first decade of the 6th century and repaired in 539/540. It was replaced by timbers felled after 599, possibly at the same time the F130 shaft was inserted.

Acknowledgements

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SLOUGH HOUSE FARM, ESSEX

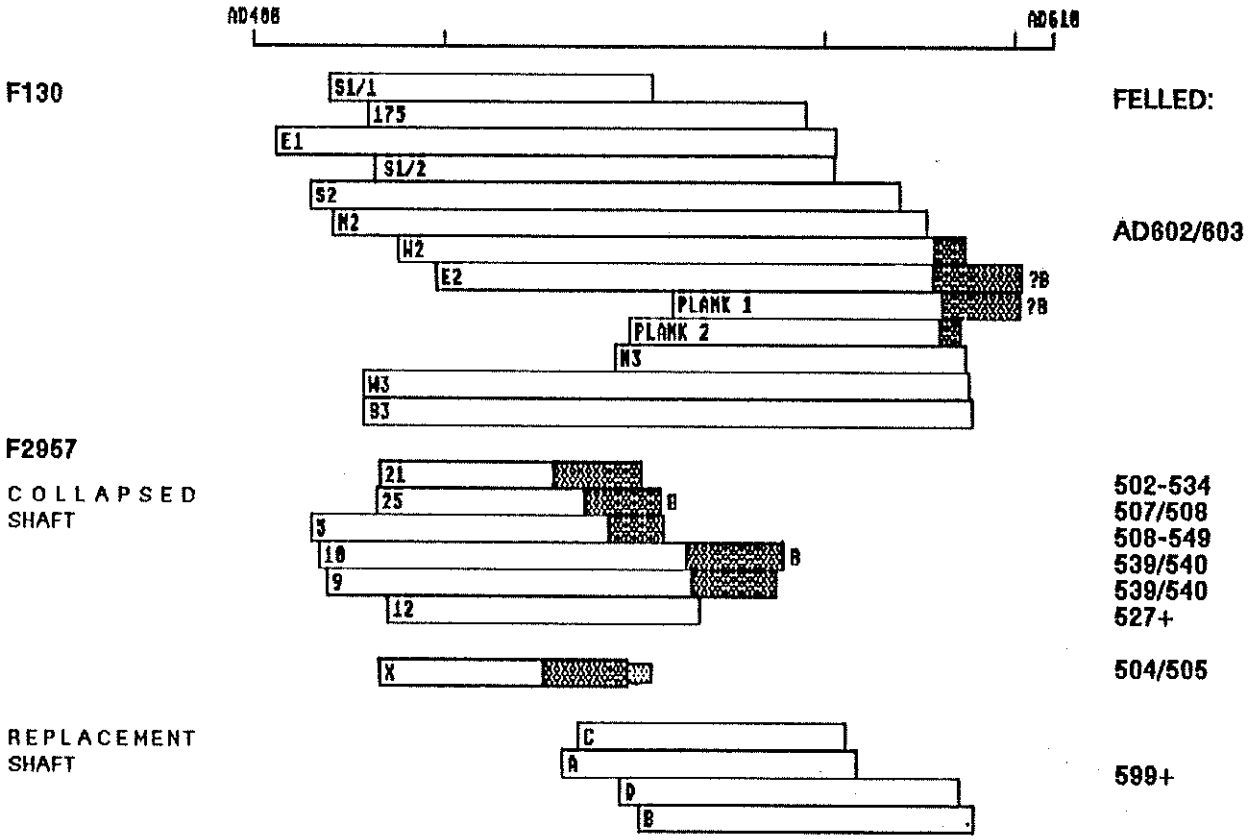


FIGURE 2: Bar diagram showing the relative positions of the dated ring sequences from Slough House Farm. White bars - heartwood rings; hatching - sapwood; B - bark edge.

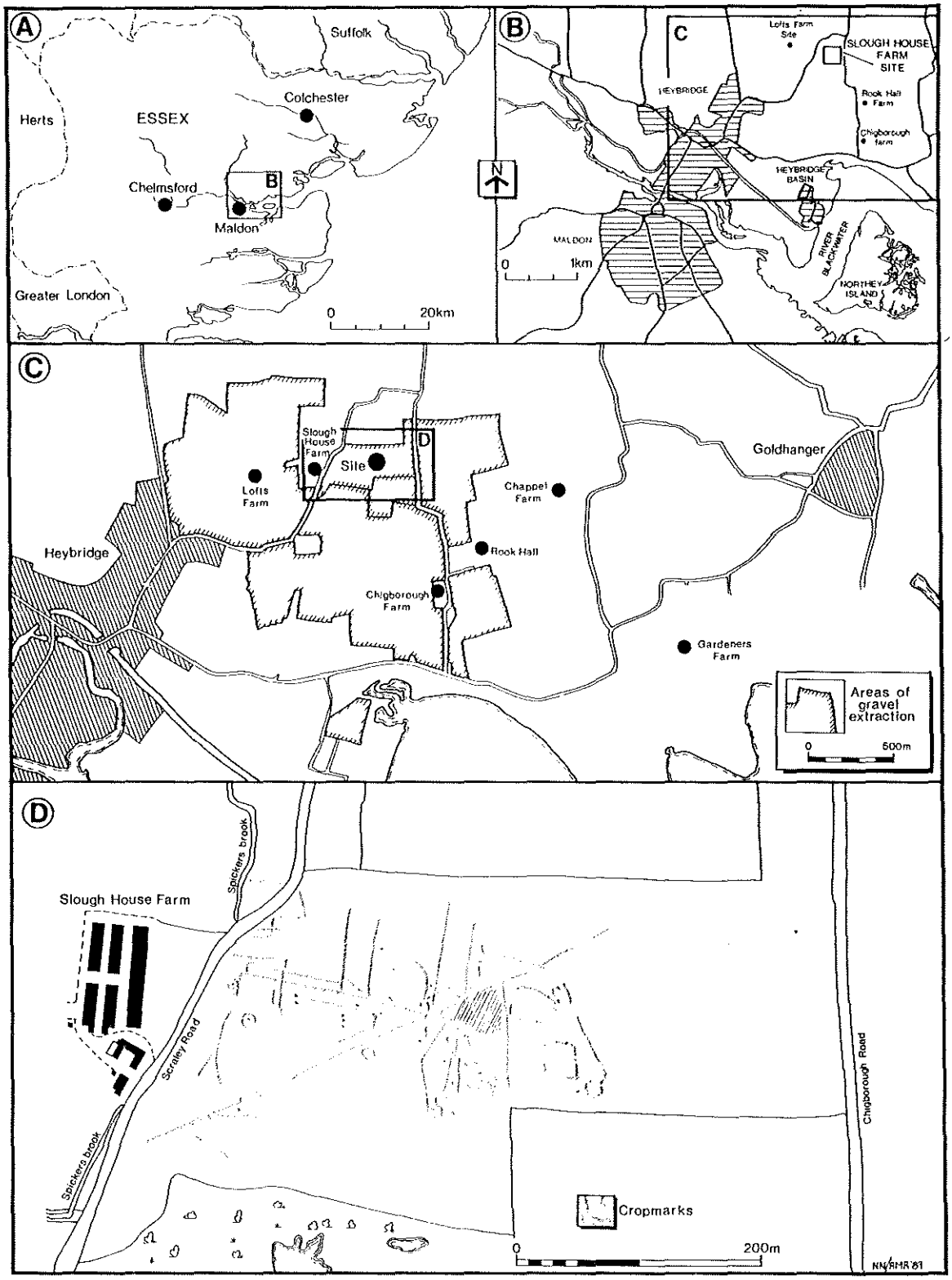


FIGURE 1: Location of site (Drawing - R Massey-Ryan & N Nethercoat)

Table 1: Details of the tree-ring samples. Sketches are not to scale; shading on sketches indicates sapwood.

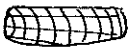
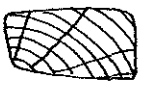
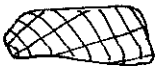
number	total no of rings	sapwood rings	average width(mm)	sketch	dimensions (mm)	comments
Well F130						
N1	-	-	-		510x115	not measured
N2	157	-	1.10		305x90	
N3	93	-	1.82		175x55	
S1/1	86	-	2.37		280x130	
S1/2	121	-	1.83		295x105	
S2	156	-	1.08		310x100	
S3	161	-	1.61		305x70	
E1	148	-	2.05		345x160	
E2	155	23	0.85		305x100	bark edge?
E3	-	-	-		305x65	not measured
W1	-	-	-		580x150	not measured
W2	150	8	1.04		310x120	
W3	160	-	1.79		310x65	
175	116	-	1.66		240x130	
176	191	-	1.36		255x110	undated
plank 1	92	20	0.89		155x40	bark edge?

Table 1/cont

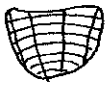
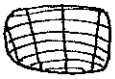
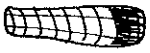
number	total no of rings	sapwood rings	average width(mm)	sketch	dimensions (mm)	comments
plank 2	88	5	0.97		160x35	
Well F2957						
1	39	9	2.69		220x200	rejected; knotty
5	94	14	1.83		265x130	knotty
7	22	-	8.18		200x180	rejected; insufficient rings
8	50	-	1.70		135x95	
9	119	22	1.95		235x80	
10	123	25	1.71		225x70	bark edge; same tree as 9
12	83	-	1.18		130x115	knotty
15	65	24	-		270x115	rejected; knotty; narrow band
17	18	13	2.13		80x75	rejected; bark
17A	18	14	2.22		75x70	same tree as 17
18	-	-	-		180x110	rejected; knotty
18A/B	-	-	-		210x115	rejected; knotty
21	70	23	2.93		230x45	
22	-	-	-		130x120	rejected; knotty
24	-	-	-		200x110	rejected; knotty

Table 1/cont

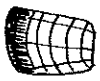
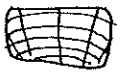
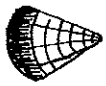
number	total no of rings	sapwood rings	average width(mm)	sketch	dimensions (mm)	comments
25	76	20	1.48		120x85	bark edge
27	35	-	-		165x80	rejected; knotty
28	24	-	-		335x175	rejected; insufficient rings
A	78	-	1.30		120x100	
B	89	-	2.23		300x165	
C	71	-	1.56		235x105	
D	90	-	1.28		65x45	
X	66+	22+	1.04		80x70	6 unmeasured rings to bark edge

Table 2: t value matrix showing the degree of correlation between the ring sequences from Slough House Farm. Values of less than 3.0 are not printed; overlaps of less than 15 years are indicated by a backslash. P1, P2 - planks 1 & 2.

						P130										P2957						
	B2	N2	N3	S1/2	S2	S3	W2	W3	P1	P3	175	5	9	10	12	21	25	X	A	B	C	D
B1	6.6	4.5	4.5	13.9	5.0	4.4	5.9	4.0	8.2	6.2	23.6	6.1	8.2	8.1	5.7	3.5			4.8	6.7	3.2	
B2		5.1	5.9	6.3	7.7	7.4	10.0	7.2	7.0	5.3	5.6	3.4	5.0	5.5	4.1					5.2		4.7
N2			3.9	4.9	11.1	7.8	6.8	6.1			5.3	4.3	4.1	4.5	5.4					3.5		
N3				4.7	6.7	10.3	6.6	8.0	5.8	4.6	3.5	\	4.0		3.5	\	\	\	3.0	5.4		6.4
S1/2					4.0	4.2	5.1	3.4	7.4	5.8	12.4	4.0	6.4	5.9	4.7				4.8	5.9	4.1	4.1
S2						8.6	10.9	8.7	4.6		4.8	4.5	3.4	4.8	5.1	3.1	4.4			7.1		4.9
S3							8.1	9.9	5.4	3.9	3.8	3.7	3.3	3.2	4.5				4.5	5.4		6.0
W2								8.6	7.5	6.5	6.4	5.1	3.8	4.1	3.8			3.1		6.7	3.1	5.0
W3									5.2	3.3	3.8	3.8	3.1	3.9	4.1		3.0		3.8	5.7		7.8
P1										12.6	8.5	\	6.0	5.5	\	\	\	\	3.3	6.5	3.3	5.6
P2											5.1	\	5.8	6.6		\	\	\	3.5	5.9		4.7
175												5.8	6.2	6.1	4.2	3.2		3.5	3.4	5.4		
5													6.5	7.3	7.8	7.2	5.4	4.6		\		\
9														19.5	5.5	7.7	3.4	3.3		6.5		
10															5.5	8.3	4.1	3.3	3.5	6.1		3.3
12																4.5	3.3	3.1	3.1			3.9
21																	5.1	3.7		\		\
25																				\		\
X																				\	\	\
A																				3.4	4.9	3.9
B																					4.7	7.2
C																						4.2

Table 3: Ring width data of F130 master chronology, AD406-602.

year	ring widths (0.02mm)										no of samples									
AD406						238	183	123	167	179						1	1	1	1	1
	147	150	177	159	147	120	109	82	116	105	1	1	1	1	2	2	2	2	2	3
	131	172	133	92	128	144	139	141	154	134	3	3	3	3	3	3	3	3	5	5
	113	103	98	84	128	141	98	108	81	103	5	5	6	6	6	6	6	7	7	7
	106	109	82	103	102	114	89	78	58	47	7	7	7	7	7	7	7	8	8	8
AD451	70	80	83	68	101	91	66	84	72	86	8	8	8	8	8	8	8	8	8	8
	48	63	59	68	52	109	86	71	88	73	8	8	8	8	8	8	8	8	8	8
	55	53	70	77	117	102	75	82	72	57	8	8	8	8	8	8	8	8	8	8
	54	73	74	82	63	60	64	66	74	55	8	8	8	8	8	8	8	8	8	8
	65	53	77	86	89	97	75	55	88	99	8	8	8	8	9	9	9	9	10	10
AD501	79	89	73	61	56	63	77	83	65	73	10	10	10	10	10	9	9	9	9	10
	70	64	41	66	79	75	83	80	62	57	10	10	10	10	10	10	10	10	10	10
	53	59	67	81	53	60	69	72	52	42	10	10	10	10	10	10	10	10	10	10
	69	71	63	80	69	75	78	59	39	41	10	10	10	10	10	10	10	10	10	10
	41	52	73	74	61	61	66	47	73	89	10	10	10	10	10	10	10	10	10	10
AD551	73	84	95	80	59	41	48	67	81	94	10	10	10	8	8	8	8	8	8	8
	64	66	50	53	52	55	63	71	75	83	8	8	8	8	8	8	8	8	8	8
	58	53	36	48	58	60	50	72	84	66	7	7	7	7	7	7	7	7	7	7
	55	53	58	71	70	77	91	72	56	48	7	7	7	7	7	7	6	4	3	2
	33	34	48	41	35	40	42	32	35	34	2	2	2	2	2	2	2	2	2	2
AD601	49	36									2	1								

Table 4: Dating Slough House Farm. t values between the F130 master chronology and other Saxon reference chronologies.

chronology	F130
Barking Abbey, Greater London (Tyers 1988)	8.7
Brandon, Suffolk (Groves & Hillam 1986)	5.3
Carlisle (Baillie & Pilcher pers comm)	4.6
Hamwic, Six Dials (Hillam 1984)	5.2
Ipswich, Smart Street (Groves 1987)	5.8
London, York Buildings (Tyers pers comm)	6.8
Mersea, Essex (Hillam 1981)	7.6
Odell, Bedfordshire (Hillam 1981)	6.4
Old Windsor (Fletcher pers comm)	9.6
Portchester Castle (Fletcher pers comm)	5.7
Tamworth (Hillam 1981)	4.5
Whithorn, SW Scotland (Hillam unpubl)	4.0

Table 5: Details of the tree-ring dates. Dates of heartwood-sapwood transitions, if present, are given in brackets. Sapwood estimate used is 10-55 rings (Hillam et al 1987).

number	structure	date span of rings	felling date	structure date
N2	F130	421-577	587+	602/603
N3		495-587	597+	
S1/1		420-505	515+	
S1/2		433-553	563	
S2		415-570	580+	
S3		429-589	599+	
E1		406-553	563+	
E2		448-602(580)	602/603?	
W2		438-587(580)	589-634	
W3		429-588	598+	
175		430-545	555+	
plank 1		510-601(582)	601/602?	
plank2		499-586(582)	591-636	
5	F2957 collapsed	415-508(495)	508-549	504-508 with repairs 539/540?
9	shaft	419-537(516)	539/540	
10		417-539(515)	539/540	
12		435-517	527+	
21		433-502(480)	502-534	
25		432-507(488)	507/508	
X	F2957 stake	433-498(457)+	504/505	
A	F2957 replacement	481-558	568+	599+ (same date as
B	shaft	501-589	599+	F130?)
C		485-555	565+	
D		496-585	595+	

Table 6: Slough House Farm master chronology, AD406-602.

year	ring widths (0.02mm)										no of samples									
AD406						239	184	124	168	180						1	1	1	1	1
	148	151	178	160	152	135	153	123	154	111	1	1	1	1	3	3	4	4	4	5
	146	188	145	109	123	134	124	128	140	123	5	5	5	5	5	5	5	5	7	7
	108	106	116	107	140	168	133	131	105	136	7	7	10	10	11	11	11	12	12	12
	140	131	94	123	117	138	102	87	66	62	12	12	12	12	12	12	12	13	13	13
AD451	81	76	93	76	104	92	70	73	78	84	13	13	13	13	13	13	13	13	13	13
	54	77	62	64	52	96	83	69	80	66	13	13	13	13	13	13	13	13	13	13
	50	55	68	71	111	93	68	84	69	55	13	13	13	13	13	13	13	13	13	13
	58	75	75	78	61	57	62	62	65	52	13	13	13	13	14	14	14	14	14	14
	63	50	74	88	85	89	81	56	94	106	14	14	14	14	15	16	16	16	16	16
AD501	88	97	82	63	57	64	79	78	72	74	17	17	16	16	16	15	15	15	14	15
	76	66	45	69	86	81	88	88	70	66	15	15	15	15	15	15	15	14	14	14
	59	69	76	90	64	76	82	80	54	45	14	14	14	14	14	14	14	14	14	14
	75	73	70	80	66	72	81	60	40	45	14	14	14	14	14	14	14	14	14	13
	42	53	75	80	63	60	70	52	74	96	13	13	13	13	13	13	13	13	13	13
AD551	76	85	96	87	71	51	51	80	91	111	13	13	13	11	11	10	10	10	10	10
	68	70	54	53	52	53	65	72	78	89	10	10	10	10	10	10	10	10	10	10
	61	60	37	49	60	60	48	77	89	64	9	9	9	9	9	9	9	9	9	9
	56	58	63	77	83	85	97	88	77	49	9	9	9	9	9	8	7	5	4	2
	34	35	49	42	36	41	43	33	36	35	2	2	2	2	2	2	2	2	2	2
AD601	50	37									2	1								