Construction of a Kent Master Dendrochronological Sequence for Oak, A.D. 1158 to 1540

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A selection of houses in Kent of the period c. *1300–*c. *1550 has been dated by tree-ring techniques. As a result a master dendrochronological sequence for oak has been formed for the period* A.D. *1158 to 1540. The article contains a brief outline of how this is done. The master can be used to date oak from other houses in Kent of the period.*

INTRODUCTION

Over the past three years the Nottingham University Tree-Ring Dating Laboratory, in collaboration with the Royal Commission on the Historical Monuments of England, has been using dendrochronological techniques to date houses in Kent of the period *c.* 1300–*c.* 1550. At the start of the project no master chronology of the ring widths of oak existed for Kent. There are, of course, well-established national and regional master chronologies for oak covering this period. Of these the England,[1] the South of England[2] and the East Midlands[3] seem particularly relevant.

Our usual practice is to sample (usually by coring) about eight timbers from a building, or part of a building if one part is manifestly of a different date from that of another. If several sequences of ring widths match together well and result in an average sequence with 100 or more rings, then that can usually be dated by cross-matching with master chronologies from outside Kent and one may, with reasonable confidence, assert that the date is correct. However, whilst such an approach is useful initially, it is unsatisfactory in the long run because many houses may go undated, for example if the sequences of ring widths from their timbers have less than 100 rings, as is frequently found in Kent.

There are, it would seem, two ways of tackling this problem. The first would be to develop an absolute master chronology for the Kent area by sampling and cross-matching sequences from all periods, with a good deal of replication to ensure a sound result. This would, of course, involve sampling growing oaks or oaks whose

felling dates are known so that the dates of all the ring widths in the resulting master chronology were known.[4] Besides being extremely expensive and time-consuming, this has the drawback that the current research project does not involve dating buildings of later periods and so a great deal of time would have to be spent dating oak timbers from houses which were not of immediate interest to the researchers.

If, as in the British Isles, absolute master chronologies are available, then an alternative and equally valid approach is possible. This is to build a long, well-replicated, floating chronology, say with 200 or more ring widths, from purely local material, and then to cross-match this sequence with absolute master chronologies from neighbouring regions or areas of similar geography. There should be no problem in confidently dating such a floating chronology this way, and when done it will, of course, also date the shorter and less well-replicated sequences from the various houses which are its components. Once constructed this local chronology can be used to date other oak samples from the region and of the period.

The latter approach is the one adopted for the present research project in Kent. However, some important caveats should be mentioned. Firstly, since confidence in the dates of the components is to be obtained through the dating of the long and well-replicated floating chronology, this latter sequence must not itself be constructed by *first* dating its component sequences individually with the non-local masters — and then combining them into a master chronology on the basis of these dates. That is, the floating chronology for the locality must be built up by cross-matching the component sequences among *themselves* without reference to any other evidence.

Secondly, in order to obtain a sound floating chronology that will be useful for dating other timbers from Kent, only the best of the available material should be used. That is to say, all the sequences must be above a certain stated minimum length. Replication of these sequences from other timbers in the same houses is also highly desirable. Furthermore, since confidence in dating sequences with only small overlaps between them is generally low, a reasonable minimum overlap between the component sequences is necessary in the construction of the master sequence.

Finally, the level of cross-matching the component sequences should be high, that is to say, the *t*-values (see below) used to indicate a relative date must be above a certain level. The standards of length, replication and cross-matching required to date the component sequences of ring widths with confidence can be established to a great extent by experimenting with modern oak of known date.

A method of constructing a floating chronology from component sequences of ring widths which is objective and only dependent on the cross-matching of the components according to stated standards and satisfying certain necessary conditions has been developed.[5] This method, based upon the Method III of Litton and Zainodin, has been applied to the tree-ring data from Kent. The result is a well-replicated floating chronology of 383 ring widths, called Kent 88, which is unquestionably dated with all three of the chronologies mentioned above to the period A.D. 1158 to 1540. The *t*-values for this period are 8.3, 10.5 and 9.2 with the England, South of England and East Midland master chronologies, respectively. It is composed of sequences from 94 timbers from fifteen different houses. These houses

are spread unevenly from east to west across the county and are mainly in the mid-to-northern half.

The next section contains a few remarks on the Kent region which are relevant to tree-ring analysis in the area, the locations of the houses providing oak samples for the construction of Kent 88 and some details about the samples themselves. This is followed by a brief outline of the method used to construct the master chronology together with the results in the form of a Bar Diagram and a matrix of the *t*-values between the site chronologies. More details on the method used, together with a complete list of Kent 88, is to be published elsewhere (see below).

THE SOURCES OF TIMBER

In broad terms Kent can be divided into several separate zones which run in bands right across the country from the west-north-west to east-south-east (Fig. 1). In the northmost zone by the Thames Estuary, there are areas of Marshland among the Foothills which come up to the Chalk Hills of the Northern Downs. South of these lie, in succession, the Vale of Holmesdale, the Ragstone Hills (Chartland) and the Weald, Low and then High.[6] On the coast in the SE. corner lies Romney Marsh. Most of the county is drained to the north into the Thames and the North Sea largely by the rivers and tributaries of the Darent in the west, the Medway in the middle and the Stour in the east of the county. The temperature is fairly uniform over the whole area, ranging from about 5°C in January to about 16°C in July. The rainfall, on the other hand, is largely determined by the relief. In the northern zone and Romney Marsh it is less than 600 mm. In most of the other zones it is between 600 and 750 mm except on the highest grounds where it exceeds this.

The distribution of woodland in Kent is not uniform[7] but it is still one of the most heavily wooded regions of Britain. The Anglo-Saxons called the large tract of forest about a hundred miles long and forty miles broad lying between the Chalk Hills in the north and the South Downs, Andredsweald. The Domesday Book shows that the Weald was heavily wooded at the time,[8] but by Elizabethan times the forest had been cleared piecemeal for its timber and charcoal, and for cultivation. The coppice-with-standards must have been established in the Middle Ages and the felling of oak reduced the woodland to open canopy. There would, therefore, have been a plentiful supply of local oak for building throughout the period of interest here — *c.* 1300 to *c.* 1550 — and so it can be assumed that there would have been little need to import oak from outside the county for structural timbers. Interestingly, Kent had a system by which settlements round the coast enclosing the Weald held areas of wood within the Weald for grazing which were, no doubt, also used as sources of timber.[9]

Oak timbers suitable for making a master chronology were sampled from nineteen houses and the locations of these are shown on the map in Fig. 1. The largest of these houses, Ightham Mote, was sampled in three quite different parts: the Hall, Solar and Chapel and can, with justice, be regarded as three different sources of timber. Some details on these houses and on the samples of oak cored from

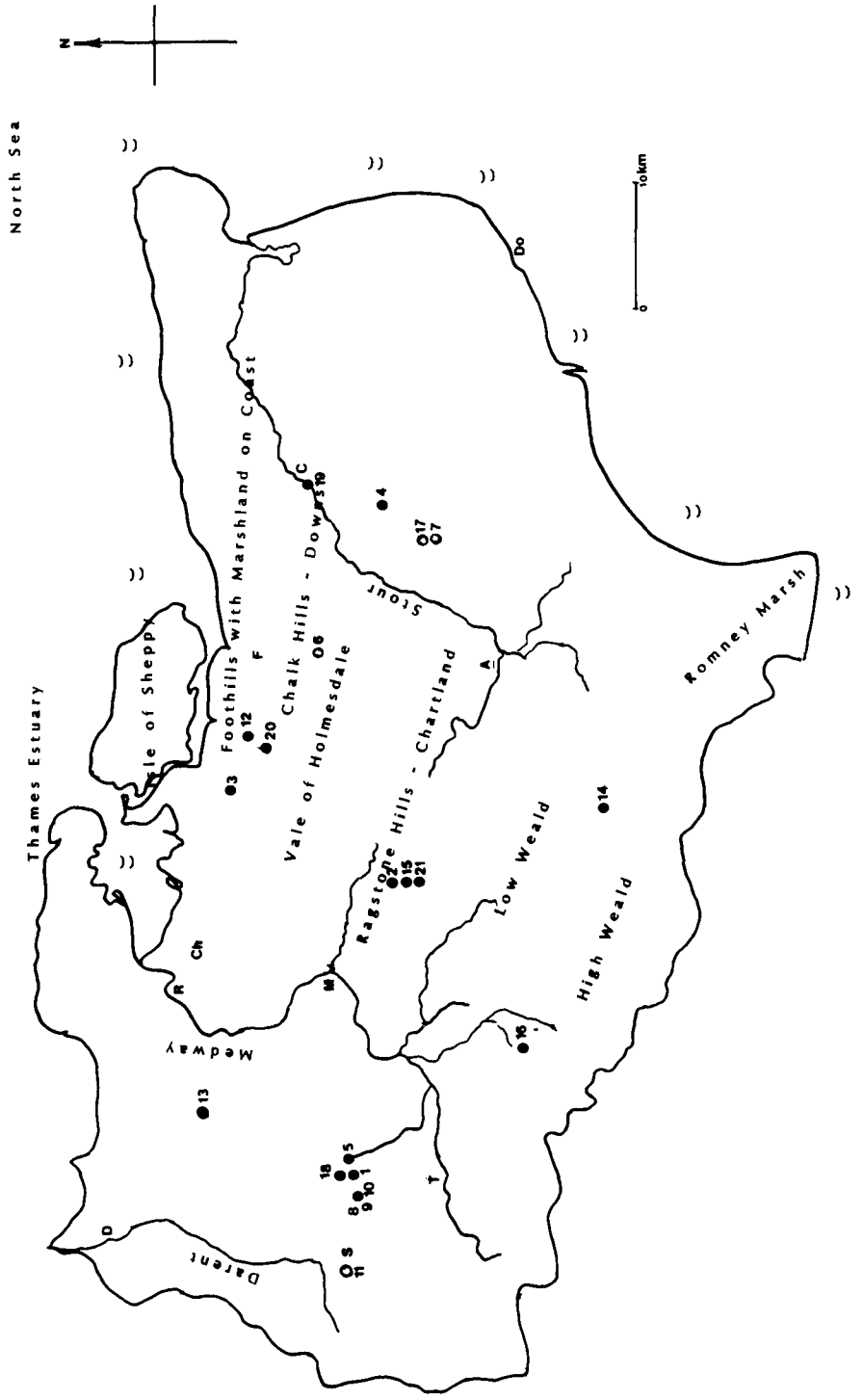

FIG. 1

Map of Kent giving the locations of all the sites sampled for use in the construction of the master chronological sequence Kent 88. ● signifies a site represented in Kent 88 whilst ○ signifies one used but rejected and not retained in the final master

KEY TO TOWNS

A Ashford; C Canterbury; Ch Chatham; D Dartford; Do Dover; F Faversham; M Maidstone; R Rochester; S Sevenoaks; T Tonbridge.

them are given in Table 1. No timber with less than 54 measured rings was considered suitable.

OUTLINE OF THE METHOD OF CONSTRUCTING KENT 88

The sequences of raw ring widths have not themselves been used for cross-matching; this has been done instead by using their corresponding sequences of ring-width indices.[5] The 'goodness' of a match at a relative position between two sequences is indicated by the *t*-value at that position.[10] The position of one sequence relative to another where the maximum *t*-value occurs is the strong candidate for their relative date, provided also that this value is sufficiently large (say, at least 4.5) and the amount of overlap between the two sequences at this position is adequate.

It is quite usual for timber in one building to come from a single locality, such as a local wood, or perhaps at most two woods close together. When this happens the sequences of ring widths from several samples are usually comparatively easy to cross-match with each other since the samples will have experienced almost identical weather, been grown on similar soils, etc. Of course, if a house had been built in two or more phases at different times, then several groups of well-matched sequences corresponding to the phases can be expected. This fact is exploited in the analysis by *first* cross-matching the sequences from a building, or separate parts of a building, among themselves. This groups them into sets of sequences in each of which some sequences cross-match with each other well, i.e. with high maximum *t*-values. From these matching sequences, which are now dated relative to each other in a consistent manner, a sequence of ring widths is made up by averaging. These sequences of averages, the *site sequences*, represent the year-by-year pattern of annual ring-growth for oak in a locality better than any sequence of widths obtained from one piece of timber alone. It is these site sequences which are then used to form a master sequence. For example, of the nine samples collected from Lower Newlands, Teynham, eight have at least 54 ring widths and are suitable for building a master. Of these, five cross-matched very well with each other at consistent relative positions and were averaged at these relative positions to form the site sequence Teynham LN-H1 with 89 rings (see Table 1). Two groups of well-matching samples were obtained from the parlour in a house at Lynsted to give rise to the two site sequences Lynsted TC-P1 and TC-P2, composed of five and two samples, respectively. Ightham Mote has three site sequences, one each for the Solar, Chapel and Hall. Most other houses have only one site sequence each.

Twenty-three site sequences from nineteen sites satisfied certain stringent conditions which were required in constructing the *master*.[5] The formal process of constructing the master by cross-matching these site sequences resulted in eighteen of them forming one long sequence of 383 ring widths — Kent 88. A Bar Diagram showing the relative positions of these sequences in the master chronology is contained in Fig. 2. As mentioned in the Introduction, Kent 88 is dated to the period 1158 to 1540 by cross-matching with other well-established absolute master chronologies. The resulting dates of the first and last rings in each of the site sequences are given in the Bar Diagram. The *t*-values between them at their relative positions

TABLE I

DETAILS OF SITES, SAMPLES AND SITE SEQUENCES USED IN CONSTRUCTING THE OAK MASTER CHRONOLOGY KENT 88

Details of site					*Details of site sequences*				
No.	*Name*	*Location*	*Grid ref*	*Total no. of samples*	*Code*	*No. of samples in seq*	*Length of seq. (rings)*	*Median no. of rings in components*	*In final master?*
1	Barton's Farm (Hall)	Plaxtol	TQ602540	7	BF-H1	5	125	89	YES
2	The Blue House	East Sutton	TQ831502	8	BH-H1	5	169	84	YES
3	Chilton Manor ("Secret Room")	Sittingbourne	TQ911628	7	CM-S1	6	153	76	YES
4	China Court	Petham	TR129515	8	CC-H1	2	117	108	YES
5	Clakkers Hall	Plaxtol	TQ612555	6	CH-H1	2	138	108	YES
6	Copton Manor	Sheldwich	TR017591	16	CM-H1	3	84	67	NO
7	Dennes House	Waltham	TR108487	8	DH-H1	2	96	90	NO
8	Ightham Mote (Chapel)	Ightham	TQ585535	12	IM-C1	9	147	79	YES
					IM-C2	3	89	70	NO
9	Ightham Mote (Hall)	–	–	12	IM-H1	11	151	82	YES
10	Ightham Mote (Solar)	–	–	12	IM-S1	11	155	100	YES
11	21–25 London Rd (Wing)	Sevenoaks	TQ529548	6	LR-W1	6	108	81	NO
12	Lower Newlands	Teynham	TQ971625	9	LN-H1	5	89	68	YES
13	Nurstead Court	Meopham	TQ640686	8	NC-H1	5	115	69	YES
14	Man's Shop	Tenterden	TQ885334	8	MS-H1	4	149	117	YES
15	Noah's Ark	East Sutton	TQ825467	10	NA-H1	8	110	81	YES
16	Rectory Park (Wing)	Horsmonden	TQ703388	8	RP-W1	2	114	102	YES
17	Sarness Farm (Barn)	Waltham	TR110490	7	SF-B1	2	94	86	NO
18	Spoute House (End)	Plaxtol	TQ611536	6	SH-E1	3	101	84	YES
19	Sun Inn	Canterbury	TR149578	8	SI-I1	2	70	62	YES
20	Tudor Cottage (Parlour)	Lynsted	TQ955622	9	TC-P1	5	98	74	YES
					TC-P2	2	95	82	YES
21	Walnut Tree	East Sutton	TQ837495	8	WT-H1	7	175	111	YES

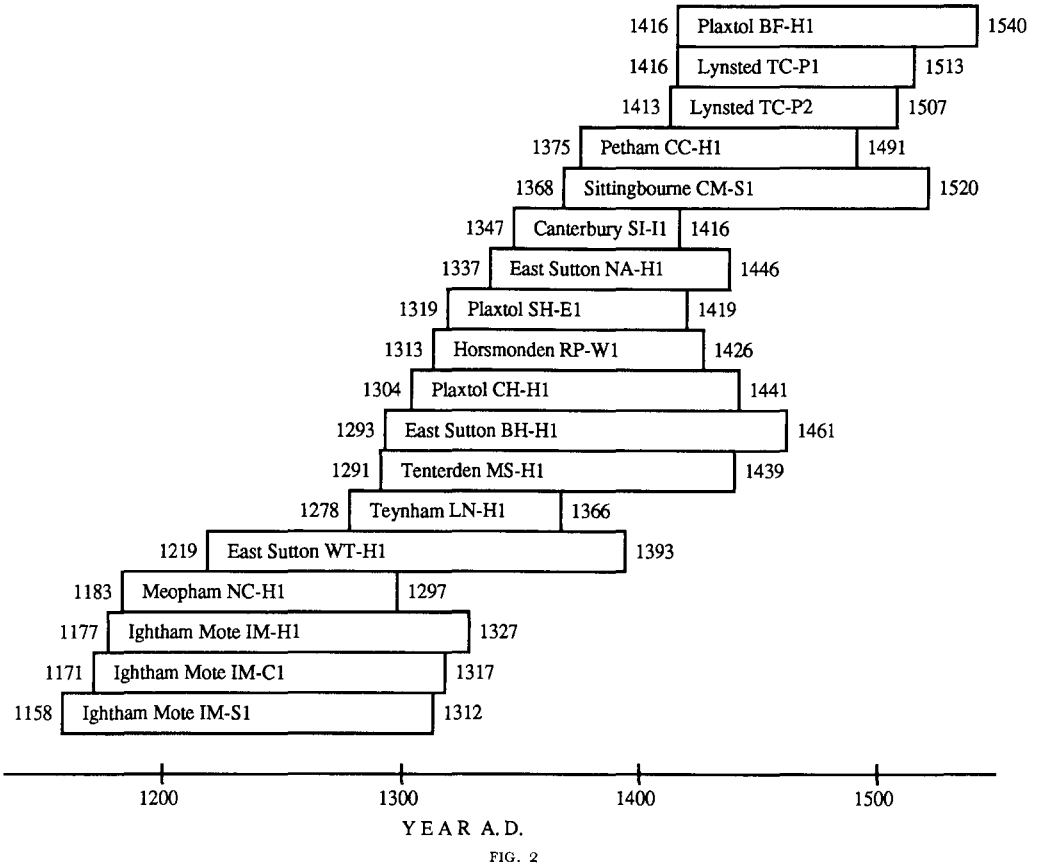

FIG. 2

Bar Diagram giving the relative positions of the site sequences forming Kent 88 (see Table 1) together with the dates of their first and last rings

in Kent 88 are given in Fig. 3. The first column in this figure contains the *t*-values between each site chronology and its corresponding 'Depleted Master'. For example, the 'depleted master' corresponding to the site chronology Plaxtol CH-H1 is the Kent 88 master with the component from Plaxtol CH-H1 omitted. The *t*-value between this and Plaxtol CH-H1 itself is 8.9, which indicates that the agreement between Plaxtol CH-H1 and the average of all the other site chronologies is very good indeed in the relative position it occupies in the master (in absolute dates, 1304–1441). It is to be noted that all the *t*-values in this column are maximum and at least 4.8; this indicates good agreement between all the site chronologies in the master at the relative dates given in Fig. 2.

DISCUSSION

Kent 88 is well replicated both in terms of sites and samples from about 1200 to 1500 and so can be used to date samples with confidence from this period in Kent

Depleted Master	Ightham Mote IM-S1 1158-1312	Ightham Mote IM-C1 1171-1317	Ightham Mote IM-H1 1177-1327	Meopham NC-H1 1183-1297	East Sutton WT-H1 1219-1393	Teynham LN-H1 1278-1366	Tenterden MS-H1 1291-1439	East Sutton BH-H1 1293-1461	Plaxtol CH-H1 1304-1441	Horsmonden RP-W1 1313-1426	Plaxtol SH-E1 1319-1419	East Sutton NA-H1 1337-1446	Canterbury SI-H1 1347-1416	Sittingbourne CM-S1 1368-1520	Petham CC-H1 1375-1491	Lynsted TC-P2 1413-1507	Lynsted TC-P1 1416-1513	Plaxtol BF-H1 1416-1540
13.9																		
11.6	12.5																	
15.1	16.8	13.6																
6.7	6.3	5.4	6.2															
9.0	4.0	4.1	3.7	3.8														
7.9			4.1		4.5													
5.7					4.2	2.0												
8.2					4.2	4.6	4.8											
8.9					6.0	5.6	2.2	4.8										
8.2					5.7	6.8	3.3	5.3	6.9									
4.8					3.7	3.0	2.9	3.5	2.7	2.4								
6.6					5.6		3.0	4.8	4.0	5.1	2.1							
6.4					4.3		2.6	3.4	5.0	3.7	2.7	3.9						
12.7							3.3	4.9	5.0	3.1	3.8	6.0	5.6					
4.9							3.6	3.0	2.3	2.5	1.9	2.0		3.4				
5.1								2.9						4.4	3.0			
7.4								2.7						6.6	3.1	3.9		
7.8								1.8						7.0	3.2	3.6	6.2	

FIG. 3

The *t*-values between the component site sequences (of ring-width indices) at the relative positions in the master chronology Kent 88. An underlined number is one which is a maximum *t*-value between the two sequences concerned. The term 'Depleted Master' heading the first column is explained in the text

and the surrounding areas. Indeed it has been used to date further samples of Kent oak since its construction. The two end periods are not well replicated at present but it is hoped that eventually they will be strengthened.

No attempt has been made in this article to estimate the felling dates of the samples from each of the houses, since this is not immediately relevant to its purpose. These estimates, and so estimates of the dates of construction of the houses concerned, are contained in a recent issue of *Vernacular Architecture*.[11] (More details on the method of construction of Kent 88 together with a complete listing is in a University of Nottingham publication.[12])

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NOTES

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