Ancient Monuments Laboratory
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TREE-RING ANALYSIS OF TIMBERS FROM THE STAVE CHURCH AT GREENSTED, ESSEX

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Summary

Dendrochronological analysis of staves from the church of St Andrew's, Greensted, has demonstrated that the building is later than has hitherto been thought. The analysis presented here provides a terminus post quem for the construction of the building of AD 1063. The balance of evidence suggests that construction probably occurred between c 1063 and c 1100. Despite the new date Greensted remains Britain's oldest known standing timber building and one of the earliest standing timber buildings in Europe.

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TREE-RING ANALYSIS OF TIMBERS FROM THE STAVE CHURCH AT GREENSTED, ESSEX

Introduction

The 'log church' of St Andrew's, Greensted, Essex (NGR TL540030), is one of the most famous buildings in England and is reputed to be a temporary resting place of the body of St Edmund in AD 1013. The stave construction used in its walls is a unique survival for this country, although there are around 30 other 'stave churches' still extant in Scandinavia and archaeological evidence indicates that the construction technique was formerly widespread both here and abroad. As it now stands, Greensted church consists of a small nave incorporating vertically set oak posts, a small brick chancel, a timber framed belfry with weather-boarding, and a south porch which is similar in style to the current nave roof. A comprehensive description of the structure is beyond the scope of this report. Readers seeking more detail are referred to Christie *et al* (1979) and Hewett (1980, 5-13). Hewett provides the most recent attempt at a reconstruction of the original structure (reproduced here as Fig 1).

English Heritage and Essex County Council have proposed a dendrochronological investigation carried out in conjunction with new drawings of the surviving structure. Tree-ring analyses undertaken primarily on buildings in Essex (eg Tyers 1993a), and on archaeological timbers from Greater London (eg Tyers forthcoming) in recent years have produced sufficiently strong tree-ring sequences covering all the likely construction periods of the structure. As a result of this work modern dendrochronological techniques can now be applied to Greensted for the first time. The purpose of the study was to carry out dendrochronological analyses of some of the staves as part of an integrated recording programme by Essex County Council of the surviving fabric of the church.

Historical Background

In the eighteenth and early nineteenth centuries several independent sets of descriptions and drawings show views of the church and timbers. These are the only documentary and pictorial evidence for the structure before a major restoration undertaken around 1848, which provided new brick sills and wall top plates, shortened every stave by some unknown extent (estimates vary between a few inches and a few feet), and replaced all the earlier roof. Virtually all subsequent survey work has involved trying to reconcile these various descriptions with the surviving fabric and identifying the pre-1848 structure and its layout.

In 1960 a small archaeological investigation was made in the chancel aimed at determining if the chancel was also originally wooden and whether there had been earth-fast timbers or timbers supported by a horizontal sill (Christie *et al* 1979, Appendix II). This excavation concluded that there had been an early small wooden chancel of earth-fast upright logs, and then a second wooden chancel with a wooden sill presumed to be similar to the existing nave.

Also in 1960 there was an unpublished report of a new scientific date for the structure, apparently based on an otherwise unknown technique of 'dendro-magnetism'. This suggested the building dated from AD 845. A letter relating to this report was located during the course of the work reported here and is presented in Appendix 1. Prior to the production of this 'scientific date' an eleventh-century date for the structure seems to have been widely assumed. Although the AD 845 result was rapidly adopted by many commentators, not everybody seems to have accepted it, notably Christie *et al* (1979; 95, 106) who include two pleas for fresh scientific determinations on the age of the timbers.

Methodology

The church was visited and all the accessible timbers were assessed. Many of the timbers were suitable for analysis and therefore sampling was recommended. Standard dendrochronological samples were removed using a 15mm diameter corer. There was some concern over the removal of samples from such an important building, especially as the construction method made discreet sampling difficult. Discussion of these issues took place with English Heritage, the church architect, the parish, and the County historic building advisers. These discussions produced the conclusion that the coring should be undertaken below the level of the internal panelling so as to be invisible internally, and that each hole should be plugged to be as unobtrusive as possible. For that purpose plugs were turned from some redundant bog-oak sections from the laboratory. These are both an extremely good colour match and a good surface texture match to the surviving outer surface of the staves. The bog-oak is from Rustington, West Sussex, and dates from 2835-2620 BC (Cathy Groves pers comm). The plugs are derived from the outermost section of the timber. They are a loose fit and have been lightly attached using 'Evostik'.

Sampling was undertaken on two separate sampling trips. The first group of samples were taken from the timbers that appeared to have the best tree-ring sequences for dating purposes. The subsequent trip widened the sampling programme to include examples of most of the potentially different types of timbers existing within the nave. The stave numbering scheme utilised in this report is based on Christie *et al* (see Fig 2).The cores were taken at positions which maximised the numbers of rings obtained and, where possible, included the outermost heartwood rings. Only one timber was located with surviving sapwood (N9). The ring sequences in the cores were revealed by sanding.

Samples with less than 50 annual rings were rejected at this stage. The complete sequences of growth rings from the remaining samples were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition cross-correlation algorithms (Baillie and Pilcher 1973; Munro 1984) were employed to search for positions where the ring sequences were highly correlated. These positions were checked using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences. The *t*-values reported below are derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position must be obtained from a range of independent sequences, and that these positions are supported by satisfactory visual matching.

All the measured sequences from this assemblage were compared with each other and those that were found to cross-match were combined to form a site master curve. This master curve and the remaining unmatched ring sequences were then tested against a range of reference chronologies, using the same matching criteria: high *t*-values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found, these provide calendar dates for the ring-sequence.

These tree-ring dates are the dates of the rings present in the sample. Their interpretation relies upon the nature of the final rings in the sequence. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings that may be missing. This *tpq* may be many decades prior to the real felling date. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. If bark-edge had survived on any datable timber then the felling date would have been the date of the last surviving ring. The sapwood estimate applied throughout this report is a minimum of 10 and maximum of 55 annual rings, where these figures indicate the 95% confidence limits of the range. These figures are applicable to oaks from the British Isles (Hillam *et al* 1987). The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the reuse of timbers and the repairs of structures before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of phases within the structure.

A further aspect of the analysis is the linking, or failure to link, pairs of samples together as being derived from a single parent tree. These 'same tree' links are made on the basis of a combination of high levels of matching between samples, extremely similar longer term growth trends, and individual anatomical anomalies within the timbers. High *t*-values are not by themselves necessarily indicative of two series being derived from a single tree. Conversely low *t*-values do not exclude the possibility. It is the balance of a range of information that provides the evidence.

Results

No attempt was made to sample any of the timbers that appear to belong to the 1848 restoration, since these are reasonably well understood and do not fall within the aims of the project. There are 53 probably original timbers, all of oak (*Quercus* spp.). A total of 20 timbers were selected for sampling (Fig 2; Table 1). Of the remaining 33 at least another ten are unsuitable for coring, either because of the gross disfigurement that would result (eg N7 which has the 'lepers squint' hole in it, and S8 which is the entrance door post) or because there is clearly too few rings in the timber (e.g. S14, S17, S18, and N22). Nineteen of the samples proved to contain enough rings to be suitable for tree-ring dating techniques. The sample from S1, one of the timbers without a chamfered upper edge, contained less than 50 rings. The diversity of the dimensions of the sampled timbers and the diversity of ring numbers and average growth rates (see Table 1) suggests that the aim of sampling a comprehensive and representative group of timbers has been achieved.

Most of the staves are half-round in cross-section. (ie D-shaped). The only exceptions to this within the original timbers are N8, N9, N10, and SW4. Therefore it was assumed from inspection, and largely borne out during sampling, that the timbers are half-trees split through the centres. It was also assumed during sampling that most of the rounded outer surfaces were formed from the loss of the outer sapwood from the trunks and that the outer edges of most of the samples were therefore going to be complete to the original heartwood/sapwood boundary zone of the trees. This assumption was not necessarily borne out during the analysis and will be discussed in greater detail below.

The measured tree-ring sequences were compared with each other and of these twelve were found to match together to form a single continuous sequence (Table 2; Fig 3). Overall, the dated material is characterised by slow average growth rates, cyclic and extreme sequences of narrow rings, and relatively poor quality of the cross-matching between staves. Somewhat unexpectedly, especially considering 19 useful samples were obtained from 53 probably original timbers, there were no pairs of timbers located which were apparently derived from the same tree. The master sequence formed by averaging the sequences from the twelve matching samples was found to date to an extensive range of chronologies (Table 3), and is dated AD 878 to AD 1053 inclusive. The remaining measured samples have failed to produce any visually and statistically acceptable matches and are thus undated by tree-ring techniques. The site master chronology GREENSTD, dating from AD 878 to AD 1053 inclusive, is listed in Table 4.

Fig 3 shows the relative positions of the dated ring sequences. The absence of sapwood on any of these dated samples means that a *tpq* date is strictly all that can be produced from the analysis. Assuming that the material is contemporary a date of after AD 1063 is obtained by addition of the minimum likely number of sapwood rings (10) to the latest surviving ring in the samples (AD 1053). However as discussed below this result may be refined.

Interpretation

Refining the date

The outermost measured rings on the dated samples are typically at the curved weathered outer surfaces of the staves. When analysing buildings of thirteenth-century date, or later, such outer surfaces often still bear the trace of the eroded sapwood or occasionally retain small sections of very friable sapwood. This allows the outer surfaces to be categorised as the heartwood/sapwood boundaries and allows standard estimates of the minimum number (10) of missing sapwood rings to be applied to the dates of the outermost rings. The timbers at Greensted are rather more problematic from this point of view. Firstly we have no comparable assemblages of timbers that are of similar date and that have been exposed to the elements all their life. Thus we have no idea what the normal behaviour of sapwood and indeed exposed heartwood is under these conditions. We are therefore entirely reliant upon observations that can be made at Greensted.

It is quite clear that the sapwood on the staves has long since disintegrated. There is some evidence to suggest that the only timber with sapwood in the nave (N9) was put in its present exposed position as recently as AD 1848 (Christie *et al* 1979, 101). Sapwood is notoriously friable. It disintegrates steadily upon exposure, usually aided by insect and fungal attacks. It is extremely rare to find sapwood in exposed positions on thirteenth-century buildings, and the Greensted evidence suggests that it is even rarer in timbers of the eleventh century. What is critical to the interpretation of the tree-ring dating evidence at Greensted is that there is clearly the possibility that oak heartwood can also be lost over such an extended period, most probably by disintegration of the more friable outermost heartwood band which can often be differentiated from the inner heartwood of older archaeological material (see Hillam 1987, 147).

There is some evidence that the southern nave wall has lost more rings than the northern wall. Examination of the bar diagram (Fig 3) shows that the majority of the latest rings obtained by the sampling programme come from the north side, while the majority of the southern staves have sequences that end a couple of decades earlier. Possible causes of this could be either increased stress from continual expansion and contraction in those staves exposed to the sun, or increased erosion in those staves exposed to the prevailing wind. Either mechanism could result in some loss of the outer surfaces. A subsequent examination of the material showed no consistent differentiation between the slightly earlier group and the later group in terms of outer surfaces, sizes, or patina, and thus all the dated material seems most likely to be a group of contemporary timbers.

Thus, the interpretation of the results that appears to make most sense on present evidence is that the building contains 53 staves of one original date. Only one of these retains any sapwood (and this is unfortunately undatable) and some appear to have lost some heartwood, probably by climatic attrition. The timber with the latest date has a final heartwood ring of AD 1053. However there is a clustering of heartwood end-dates for the timbers in the AD 1040's (Fig 3). Such a clustering may suggest that the standard 10-55 year sapwood range could be applied to this group to provide a possible felling date range for the entire assemblage (Baillie 1982, 57). This process yields a range of *c* 1063 to *c* 1100.

<u>Discussion</u>

The AD 845 'date'

The results presented above clearly refute the AD 845 date produced for the timbers during the 1960's. The techniques employed by Jack E Crawford Stringer to provide this ninth century date, described in Appendix 1, are typical of a number of attempts made during the 1950's and 1960's in the UK to provide so called 'tree-ring dates'. These early methods have been shown over the past two decades to be generally unreliable. Published examples of attempts to provide dates for tree-ring sequences by the use of a series of weather records include Schove and Lowther (1957) and Schove (1979). A summary of such attempts is provided by Baillie (1982, 43). It should also be noted that despite extensive bibliographic searches no other report by Crawford Stringer, on any subject, has been located. There are several basic problems with his approach. Firstly, reliable tree-ring chronologies extending back to the period in question did not become available for Britain until the early 1980's. Secondly, an unspecified 'detailed sequence of climatic events of historical record such as famines, plagues, crop-failures, great frosts, floods, etc' was used. Even ignoring the problem of the reliability of accurately dating such events at the time of this early analysis, modern experience shows that the relationship between such events and contemporary tree-ring sequences is extremely complex (Baillie 1995 135-7). Finally, the new samples show that despite the Greensted staves having exposed end grain they have bands of very narrow rings in which the boundaries are difficult to distinguish even using modern techniques. It seems likely that any attempt to measure them by 'rubbings' would have been extremely unlikely to produce reliable ring width sequences. Prior to Crawford Stringer's work the church was usually regarded as being of the eleventh century and with the benefit of hindsight it seems remarkable that such a radical redating of this important building was so widely accepted on such poor evidence.

St Edmund

The earliest published reference to a link with St Edmund is Lethieullier (1789). Christie *et al* (1979, 110) observe 'The earliest authority for the returning of St. Edmund's body in 1013 from London to Norfolk was written about the end of the eleventh century. It does not record that the body rested in a wooden chapel near Ongar'. The tree-ring analysis demonstrates the surviving timbers are from after AD 1013, although there remains the possibility that there was an earlier structure on the site. The scanty archaeological remains found in the chancel by Christie *et al* (1979 Appendix II) suggests that the chance of determining whether this is the case by archaeological excavation in the nave is remote.

Woodland Type

The timbers that are currently surviving in the church are mostly less than 2m in length. This restricts the observations that can be made upon tree-types, for these normally require relatively long sections before different types of woodland origin can be distinguished. The majority are fairly straight-grained, although a few have a slight corkscrew habit (eg N7, N23, N24, S5, and S17). The corkscrewing is in different directions on different trees. A few have large knots visible (eg N16, N24, NWC, S17, and S18). The most unusual macro-characteristic is that of apparent epicormic type knots (eg N4, N5, N17, N20, N24, and S16). These may indicate periods when the woodland canopy was more open thus encouraging new growth on the stems.

The samples obtained show some diversity of average growth-rates (see Table 1), but most are growing between 1.0 and 2.0mm/year on average. Some of the unsampled staves were growing faster than this. The staves also show a fair diversity of the ages of the trees when they were felled. Several unsampled staves appeared to have less than 50 annual rings surviving and, even allowing for the missing centres and the missing outermost rings, were probably derived from trees of less than 100 years total age. Other samples had more rings, and the total length of the chronology produced by all the dated samples (176 years) gives a minimum estimate of the maximum tree age exploited for the construction. Allowing for the missing centres and the lost outermost rings it is suggested that 200-250 years is the likely maximum age of the trees used. Average growth rates and maximum ages such as these are extremely common for oak.

There is no evidence from this analysis to support popular assertions such as the use of 600 year old trees or that the trees used were growing when Christ was alive.

The tree-ring sequences derived from the samples can be characterised as containing numerous rapid changes from normal to extremely restricted growth. It is not possible to determine precisely the woodland type involved except that the timbers came from an uneven aged oak stand. The periodic changes in growth rate may be caused by anthropogenic factors. The material is quite different from the timbers analysed from the majority of buildings in Essex.

How Many Trees

The apparent absence of pairs of samples derived from the same tree was a surprise. This finding refutes another common assertion about the church which is that one enormous tree was used in its construction. There are only around 40 original timbers in the church with enough rings in them and more than a third of these have been sampled. It was assumed that the timbers were originally half logs, and prior to sampling it was assumed that both halves were originally in the structure. The surviving lengths are clearly shorter than original so it is not clear if two half-logs were derived from fairly 'stumpy' trees or 4 or 6 half-log lengths were derived from rather taller trees. The absence of 'same tree' pairs from 19 useful samples probably indicates that either both halves of one tree did not end up in the building routinely, or, that many more timbers were originally present and have not survived. An alternative suggestion (D Goodburn pers comm) is that the staves were originally of complete round trunks (ie O-shape sections), and they have been subsequently cut back on the inside surfaces to provide a flat inner wall to the nave. Such a proposal is supported by the tool-mark evidence on the inner surfaces of the staves, which shows that they were plastered on the inner side at some stage. If this is the case then the absence of same tree matches between individual sampled timbers is less problematic.

Other stave structures

Stave construction techniques were widespread. Christie *et al* (1979, 103-6) distinguish between the Norwegian and the southern Scandinavian stave churches on the basis of a technological distinction: flanged and grooved joints in the former and inserted tongues in the latter. From a wood specialist viewpoint the distinction is more fundamental: the former group are exclusively constructed of pine (*Pinus sylvestris* L.), whilst the latter are built of oak (*Quercus* spp.). The newest data available for the standing Norwegian pine structures is that they are all primarily twelfth century or later, whilst the southern oak material is both eleventh century and twelfth century in date. Few of this latter group are complete and the majority are only known from reused material in later structures. The earliest standing oak church is at

Hedared in Sweden, dated by dendrochronology to the early thirteenth century (Niels Bonde pers comm).

Stave structures have been recorded on the London waterfront excavations in contexts ranging in date from the eleventh to the fourteenth centuries, the dating for these structures being primarily by dendrochronological methods. It is suggested by Milne (1992, 81) that 'the vernacular stave building tradition represented by these waterfront structures was one of considerable longevity and showed much variety in London, coexisting with both the earthfast post and framed building techniques'.

Hewett (1980) notes the similarity between the grave chamber on the Gokstad ship, excavated in the Oslo fjord in 1880, and the Greensted material. Recent dendrochronological analysis of the Gokstad timbers demonstrates that this dates from the early tenth century (Bonde and Christensen 1993).

Conclusion

The dendrochronological evidence clearly refutes the 'dendro-magnetic' date of AD 845 since it indicates the trees were felled after AD 1063 and probably before *c* AD 1100. From the available evidence it seems possible that the church was originally built as the private chapel for a new lord of the manor immediately after the Conquest (D Andrews pers comm). The widely accepted link with the temporary resting place of St Edmund's body in AD 1013 cannot refer to the present structure, although it does not prevent this reference being to an earlier building on the same site.

No other standing timber building from the UK that has been dendrochronologically examined comes close to providing dates of similar vintage to those obtained for Greensted. Of course this does not preclude the possibility that some future work may identify similarly early timbers, although it seems most likely this will be as reused timbers employed in a later building. However, Greensted seems assured of its pre-eminent position as the oldest standing timber building in the UK, despite being at least two centuries more recent than many have hitherto imagined.

Dendrochronological dating of the Scandinavian standing structures has been undertaken but is currently being reassessed. The majority of the Norwegian pine churches now appear to date from the twelfth century or later, whilst at least some reused fragments of similar buildings in Sweden and Denmark appear to be contemporary with Greensted. It seems likely that Greensted can maintain its claim to be the earliest timber building in northern Europe.

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References

Baillie, M G L, 1982 *Tree-ring Dating and Archaeology*, London

Baillie, M G L, 1995 *A slice through time*, London

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

Bonde, N, and Christensen, A E, 1993 Dendrochronological dating of the Viking Age ship burials at Oseberg, Gokstad and Tune, Norway, *Antiquity*, **67**, 575-83

Christie, H, Olsen, O, and Taylor, H M, 1979 The Wooden Church of St Andrew at Greensted, Essex, *The Antiquaries Journal*, **59**, 92-112

Hewett, C A, 1980 *English Historic Carpentry*, Phillimore

Hibberd, H, 1992 *Dendrochronology Spot-dates; Vintry and Vintners, City of London*, MoL EAS Dendrochronology Rep, **SPT09/92**

Hillam, J, 1987 Problems of Dating and Interpreting Results from Archaeological Timbers, in *Applications of tree-ring studies: current research in dendrochronology and related areas* (ed R G W Ward), BAR Int Ser, **333**, 141-55

Hillam, J, Morgan, R A, and Tyers, I, 1987 Sapwood estimates and the dating of short ring sequences, in *Applications of tree-ring studies: current research in dendrochronology and related areas* (ed R G W Ward), BAR Int Ser, **333**, 165-85

Lethieullier, S, 1789 unpubl letter (British Museum, Stowe MS, **754,** 42), quoted in *The Builder*, **87**, 351 (8 October 1904)

Milne, G, 1992 *Timber Building Techniques in London c 900-1400,* LAMAS Special Paper **15**

Munro, M A R, 1984 An improved algorithm for crossdating tree-ring series, *Tree Ring Bulletin*, **44**, 17-27

Nayling, N T, 1991 *Dendrochronology report on timbers from Thames Exchange, City of London*, MoL EAS Dendrochronology Rep, **DEN07/91**

Schove, D J, 1979 Dark Age Tree-ring Dates, AD 490-850. *Medieval Archaeology*, **23**, 219-223

Schove, D J, and Lowther, A W G, 1957 Tree-rings and Medieval Archaeology, *Medieval Archaeology*, **1**, 78-95

Tyers, I, 1988a *Dendrochronology Spot date report; Dowgate Hill, City of London*, MoL EAS Dendrochronology Rep, **SPT02/88**

Tyers, I, 1988b *Dendrochronology Spot date report; Old Bailey, City of London*, London MoL EAS Dendrochronology Rep, **SPT06/88**

Tyers, I, 1991 *Interim Dendrochronology Report on timbers from the Horsefair site, Kingston*, MoL EAS Dendrochronology Rep, **DEN06/91**

Tyers, I, 1993a Tree-ring dating at Cressing Temple, and the Essex curve, in *Cressing Temple. A Templar and Hospitaller Manor in Essex* (ed D Andrews), 77-83

Tyers, I, 1993b *Project 53a; medieval London Bridge. Dendrochronology research archive, assessment report and updated project design*, MoLAS Dendrochronology Rep **DEN07/93**

Tyers, I, 1994a *Bull Wharf and the east side of Queenhithe. BUF90, BLL79 and UPT90, City of London. Dendrochronology, assessment of potential, and summary of earlier work*, MoLAS Dendrochronology Rep, **DEN01/94**

Tyers, I, 1994b *Preliminary results of the tree-ring analysis of the Guildhall coffins*, MoLAS Dendrochronology Rep, **DEN16/94**

Tyers, I, forthcoming Dendrochronological analyses in Greater London and Essex, in *The tree-ring dating of buildings. Proceedings of the Presidents Session of the 1993 conference of British Association or the Advancement of Science* (ed G Merion-Jones)

Tyers, I, and Hibberd, H, 1993 *Dendrochronology, wood identification and wattle analysis for the Fleet Valley developers report*, MoLAS Dendrochronology Rep, **DEN03/93**

Figure 1

Reconstruction of the original Greensted nave (after Hewett 1980).

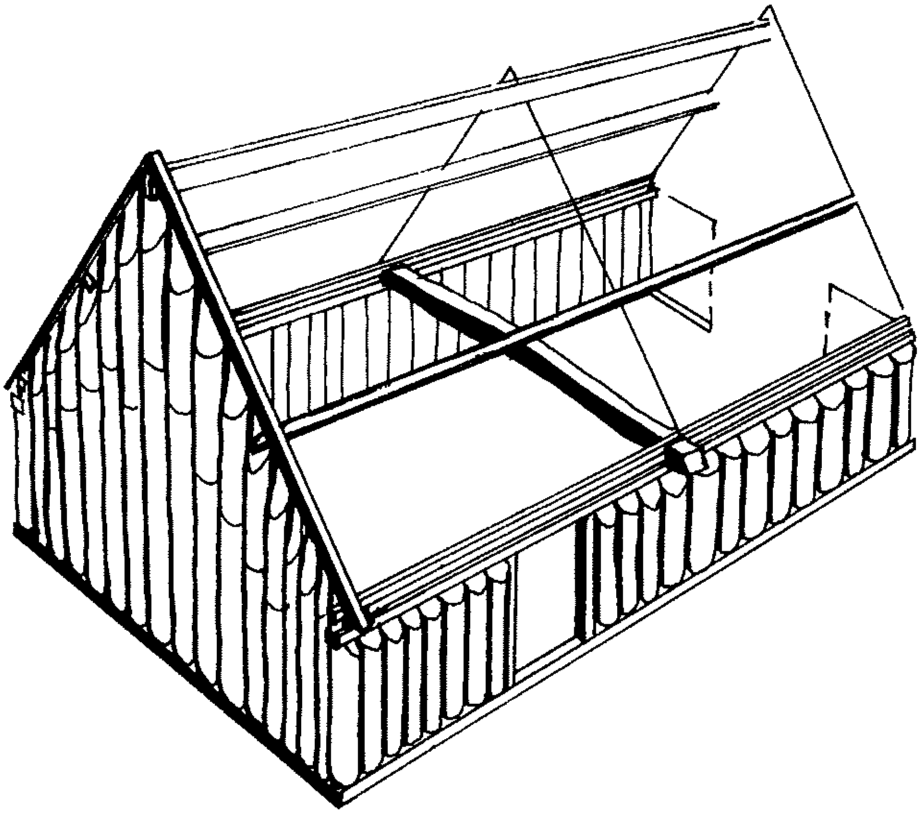

Figure 2

Plan of the Greensted staves, showing the numbering scheme used in the report (after Christie *et al* 1979).

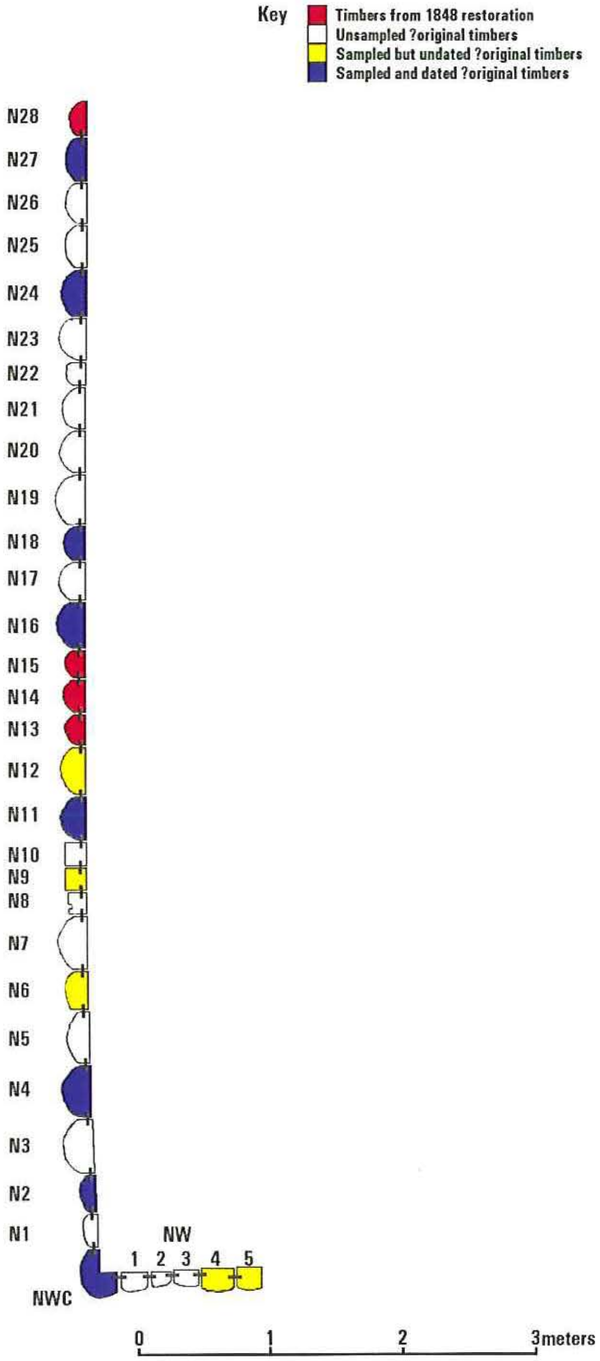

Figure 3

Bar diagram showing the relative positions of the dated ring sequences from St Andrews Church, Greensted, Essex. The numbers for each bar are as shown in Figure 2.

White bars - heartwood rings

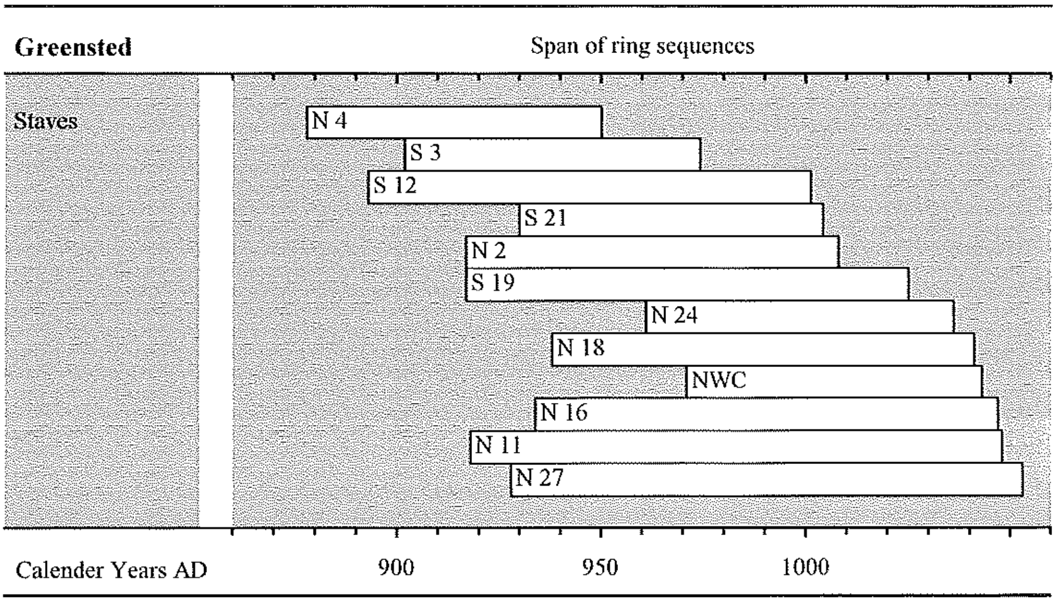

Table 1

List of samples

Origin of core	Analysis undertaken	Wood type	Total Rings	Sap Rings	mm/year	Result	Date of sequence
North side post 2	Tree-ring sequence measured	Oak	92	0	1.54	Dated	AD917 - AD1008
North side post 4	Tree-ring sequence measured	Oak	73	0	2.02	Dated	AD878 - AD950
North side post 6	Tree-ring sequence measured	Oak	85	0	1.59	Undated	-
North side post 9	Tree-ring sequence measured	Oak	122	12	1.30	Undated	-
North side post 11	Tree-ring sequence measured	Oak	131	0	1.38	Dated	AD918 - AD1048
North side post 12	Tree-ring sequence measured	Oak	90	0	1.00	Undated	-
North side post 16	Tree-ring sequence measured	Oak	114	0	1.86	Dated	AD934 - AD1047
North side post 18	Tree-ring sequence measured	Oak	104	0	1.54	Dated	AD938 - AD1041
North side post 24	Tree-ring sequence measured	Oak	76	0	1.68	Dated	AD961 - AD1036
North side post 27	Tree-ring sequence measured	Oak	126	0	1.33	Dated	AD928 - AD1053
North-west corner post	Tree-ring sequence measured	Oak	73	0	2.02	Dated	AD971 - AD1043
North-west side post 4 lower	Tree-ring sequence measured	Oak	64	0	0.97	Undated	-
North-west side post 5	Tree-ring sequence measured	Oak	50	0	1.09	Undated	-
South side post 1	Species Identification only	Oak				-	-
South side post 3	Tree-ring sequence measured	Oak	73	0	1.46	Dated	AD902 - AD974
South side post 6	Tree-ring sequence measured	Oak	94	0	1.07	Undated	-
South side post 12	Tree-ring sequence measured	Oak	109	0	1.26	Dated	AD893 - AD1001
South side post 16	Tree-ring sequence measured	Oak	67	0	2.08	Undated	-
South side post 19	Tree-ring sequence measured	Oak	109	0	1.19	Dated	AD917 - AD1025
South side post 21	Tree-ring sequence measured	Oak	75	0	1.78	Dated	AD930 - AD1004

Table 2

Correlation between the dated material from the staves of St Andrews, Greensted, near Ongar, Essex. (- = *t*-values less than 3.0, \ = overlap less than 15 years)

***t*-values**

sample	**samples**										
	N4	*N11*	*N16*	*N18*	*N24*	*N27*	*NWC*	*S3*	*S12*	*S19*	*S21*
N2	-	4.49	3.24	-	-	-	5.48	3.66	-	3.20	4.62
N4		4.62	-	\	\	3.89	\	4.72	6.67	4.06	-
N11			3.48	3.61	3.02	4.73	6.34	4.83	3.21	3.12	3.08
N16				3.42	5.10	5.23	4.80	-	4.03	-	-
N18					-	4.37	3.54	-	-	4.26	3.28
N24						-	4.88	\	-	-	-
N27							5.24	3.38	4.30	3.71	3.98
NWC								\	3.15	-	3.55
S3									3.17	3.75	-
S12										5.96	3.67
S19											-

Table 3

Dating of the master curve from the staves of St Andrews, Greensted, near Ongar, Essex. *t*-values with dated reference chronologies. All the reference curves are independent.

Area	Reference chronology	*t*-values
Essex	Fyfield Hall (Pilcher pers comm)	3.67
London	Billingsgate (Hillam pers comm)	6.90
	Dowgate Hill (Tyers 1988a)	5.82
	Fleet Valley (Tyers and Hibberd 1993)	6.18
	Fennings Wharf (Tyers 1993b)	6.50
	Guildhall Yard (Tyers 1994b)	6.26
	Kingston Horsefair (Tyers 1991)	5.71
	Old Bailey (Tyers 1988b)	8.66
	Thames Exchange (Nayling 1991)	6.48
	Upper Thames Street (Tyers 1994a)	6.93
	Vintry House (Hibberd 1992)	7.71
Humberside	Beverley Dominican Priory (Hillam pers comm)	6.12

Table 4

Ring-width data of the site master curve for oaks from the staves at St Andrew's church, Greensted, Essex, dated AD 878-AD 1053 inclusive.

year	ring widths (0.01mm).										number of trees per year									
AD 878								374	477	319								1	1	1
	360	434	385	373	390	410	278	295	251	326	1	1	1	1	1	1	1	1	1	1
	275	216	330	345	245	282	209	250	136	200	1	1	2	2	2	2	2	2	2	2
AD 901	195	202	222	295	224	248	209	179	175	163	2	3	3	3	3	3	3	3	3	3
	146	179	160	146	174	153	148	179	156	152	3	3	3	3	3	3	5	6	6	6
	173	202	198	171	132	79	74	94	138	108	6	6	6	6	6	6	6	7	7	8
	111	146	107	208	175	173	172	168	147	125	8	8	8	9	9	9	9	10	10	10
	98	78	79	121	162	172	227	197	161	178	10	10	10	10	10	10	10	10	10	10
AD 951	126	111	99	66	81	99	98	127	142	147	9	9	9	9	9	9	9	9	9	9
	161	162	169	168	171	168	173	131	148	117	10	10	10	10	10	10	10	10	10	10
	138	140	156	124	132	129	171	113	161	174	11	11	11	11	10	10	10	10	10	10
	122	149	175	124	140	209	186	126	168	167	10	10	10	10	10	10	10	10	10	10
	173	188	189	152	149	179	190	191	216	181	10	10	10	10	10	10	10	10	10	10
AD 1001	185	187	202	174	158	163	180	178	174	130	10	9	9	9	8	8	8	8	7	7
	151	167	161	138	139	106	114	112	142	117	7	7	7	7	7	7	7	7	7	7
	164	153	160	143	108	180	160	141	159	170	7	7	7	7	7	6	6	6	6	6
	165	125	136	122	165	151	228	159	146	170	6	6	6	6	6	6	5	5	5	5
	149	135	116	126	139	126	130	105	79	90	5	4	4	3	3	3	3	2	1	1
AD 1051	101	144	175								1	1	1							

Appendix 1. The 'dendro-magnetic' date of AD 845

The following text is a copy of a letter from Jack E Crawford Stringer to the Bishop of Chelmsford dated 31st August 1960 kindly made available by the Rev Tom Gardiner.

For the Furtherance of Archaeological Dating Studies.
DENDROMAGNETIC
RESEARCH

Telephone:-
North Shields 611

Lincluden,
Preston Park,
North Shields,
Northumberland

31st August, 1960.
The Rt. Rev. Bishop of Chelmsford,
Chelmsford,
Essex.

My dear Lord Bishop,

Greensted Church.

During the past two years I have been conducting a survey on a wide scale of very ancient timbers, both as trees, typical of which are the giant oaks of Sherwood Forest and Ampthill and also in the form of structural timbers typical of which are those in old manor houses, Norman keeps, tithe barns, etc., and also in some churches. The first part of the research is to establish dates for the timber, later, examination of physical properties, including magnetic effects, is planned.

The survey thus involves firstly a study of annual growth rings. I was very taken with the beautiful and excellent presentation of the end grain of the nave timbers of Greensted Church and by kind permission of the Caretaker, Mrs. Poole I took traces of some of the external wall timbers, in the manner of taking rubbings from old manorial brasses.

Later examination at leisure of these grain rubbings showed tree-ring analysis was possible so I carried out dating research by linking up the sequences of narrow and wide rings with a detailed sequence of climatic events of the historical record, such as notable famines, plagues, crop-failures, great frosts, floods, etc.

A revelation I had not dared to expect was the reward; the 17th Century date, when the belfry was added to the Church, appeared in a newish looking wall timber,- there must have been some church repairs effected at this time. Next an 11th Century date emerged from two older looking timbers, evidently associated with the church date commonly accepted. Lastly, three timbers of ancient appearance gave mutually confirming date of c.845 A.D. I take it this indicates what possibly may be the earliest (or, at least, a very early) building of the nave. There are two other timbers having the appearance of extreme age, but formed in a different manner of construction so that the end grain is not exposed. It might not be unreasonable to think we have here the evidence for the date of an even earlier building of the Church; but, this is only a supposition. In the literature available to me there is no mention of date earlier than 11th Century, it is possible this new dating evidence will prove of interest and value to the Ecclesiastical Authority?

Before starting my field study at the Church, I enquired for the Rector but was informed he was convalescing in Devon from a shoulder injury and in the strictly limited time available (one day only) I could not contact him for permission in my usual manner of procedure; hence my approach to Mrs. Poole. I trust that in this occasion I shall be deemed, in Your Lordship's opinion, to have acted quite properly.

Archaeological colleagues are of the opinion that I should make a written Communication of these dating findings to a suitable scientific journal; my own choice would be "Antiquity", if the Editor, Mr. Glyn Daniel, is agreeable, as this journal has in the past, carried articles on Churches, such as the plate of St. Ninian's.

May I ask permission, therefore, Sir, to make such a Communication, if Your Lordship is agreeable?

I sign myself,
Your Lordship's Servant
Jack E. Crawford Stringer

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