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ST MARY'S CHURCH, KING'S PYON, HEREFORDSHIRE
TREE-RING ANALYSIS OF TIMBERS

SCIENTIFIC DATING REPORT

Dr Martin Bridge

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Tree-Ring Analysis of Timbers

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Summary

Only seven timbers from the nave roof were assessed as being potentially suitable for tree-ring dating. These seven timbers were cored, but three of the samples were found to contain too few rings for reliable dating, and these samples were not analysed further. Two of the measured series were found to have come from the same tree, and these cross-matched a third series, producing a site chronology 113 years long. The site chronology contained some marked declines in growth and failed to give consistent acceptable matches against the dated reference material. The nave roof therefore remains undated.

Keywords

Dendrochronology
Standing Building

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Introduction

St Mary's Church is a grade-I listed parish church (NGR SO 438 506; Fig 1) which has elements from the twelfth, thirteenth, and fourteenth centuries, and which was restored in AD 1872. The nave roof consists of four bays with moulded tie beams and cusped raking struts (Figs 2–5). There are three rows of purlins, and intermediate trusses are collared, but lack the raking struts. Stylistically, it is dated to the fourteenth century, but grant-aided repairs in mid-2006 allowed access to the timbers, and confirmation of the dating by dendrochronology was sought by the Historic Buildings Architect Chris Miners, of English Heritage's Birmingham office.

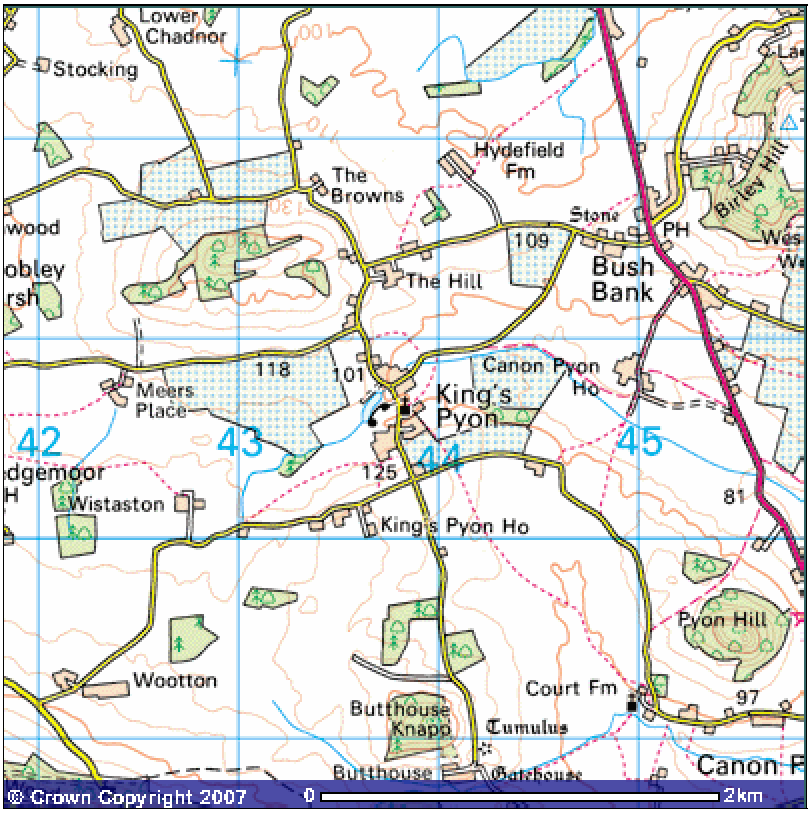

Figure 1: Map showing the location of St Mary's Church, King's Pyon, Herefordshire (centre).

Methodology

The site was visited in August 2006. In the initial assessment, accessible oak timbers with more than 50 rings and traces of sapwood were sought, although slightly shorter sequences are sometimes sampled if little other material is available. Those building timbers judged to be potentially useful were cored using a 15mm auger attached to an electric drill. The cores were glued to wooden laths, labelled, and stored for subsequent analysis.

The cores were prepared for measuring by sanding, using an electric belt-sander with progressively finer grit papers down to 400 grit. Any further preparation necessary, eg where bands of narrow rings occurred, was done manually. Suitable samples had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). Cross-matching and dating was accomplished by a combination of visual matching and a process of qualified statistical comparison by computer. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted to allow visual comparisons to be made between sequences on a light table. This method provides a measure of quality control in identifying any errors in the measurements when the samples cross-match.

In comparing one sequence or site sequence against another, *t*-values over 3.5 are considered significant, although in reality it is common to find *t*-values of 4 and 5 which are demonstrably spurious because more than one matching position is indicated. For this reason, it is necessary to obtain some *t*-values of 5, 6, and higher, and for these to be well replicated with different, independent chronologies and with local and regional chronologies well represented, unless the timber is imported. Where two individual sequences match with a *t*-value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have been derived from the same parent tree.

When cross-matching between samples is found, their ring-width sequences are averaged to form an internal 'working' site mean sequence. Other samples may then be incorporated after comparison with this 'working' master until a final site sequence is established. This is then compared with a number of reference chronologies (multi-site chronologies from a region) and dated individual site masters in an attempt to date it. Individual long series which are not included in the site mean(s) are also compared with the database to see if they can be dated.

The dates thus obtained represent the time of formation of the measured rings in each sample. These dates require interpretation for the construction date of the phase under investigation to be determined. An important aspect of this interpretation is the estimate of the number of sapwood rings missing. The sapwood estimates used here are based on those proposed for this area by Miles (1997), in which 95% of oaks contain 11–41 rings. Where complete sapwood or bark is present, the exact date of tree felling may be determined

The dates derived for the felling of the trees used in construction do not necessarily relate directly to the date of construction of the building. However, evidence suggests that, except in the reuse of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965).

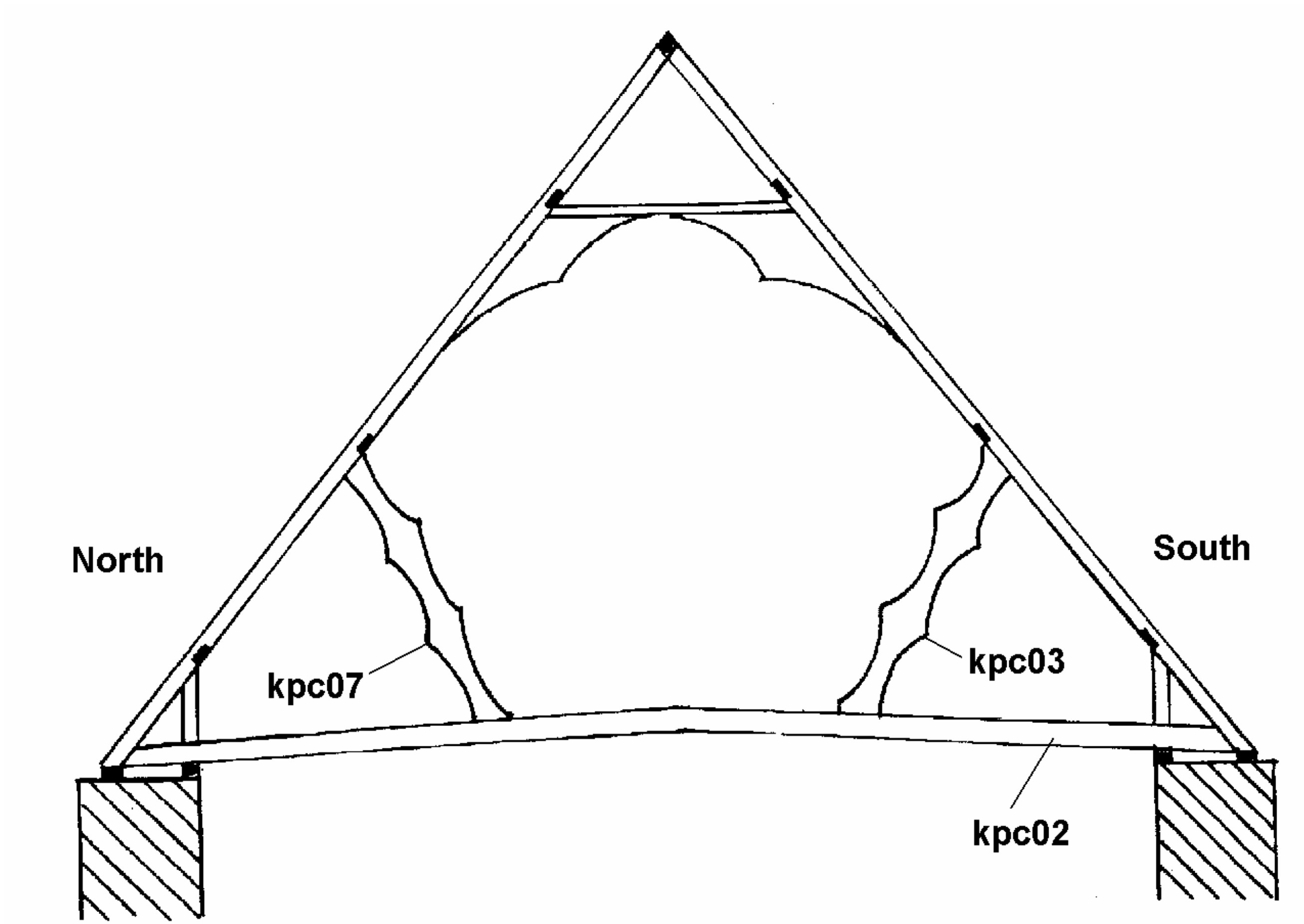

Figure 2: Truss 2 showing the timbers sampled for dendrochronology, adapted from original drawings supplied by Hook Mason Architects

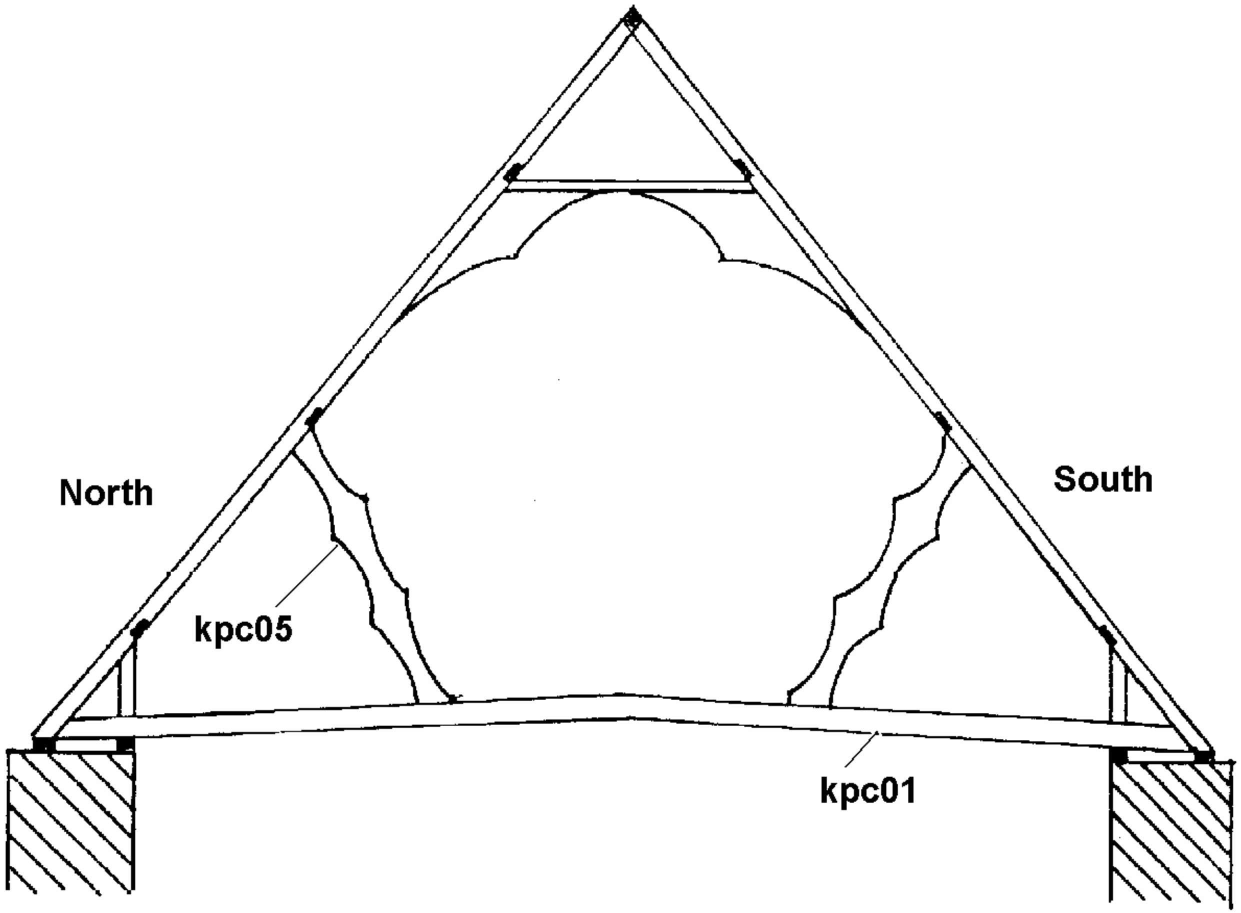

Figure 3: Truss 3 showing the timbers sampled for dendrochronology, adapted from original drawings supplied by Hook Mason Architects

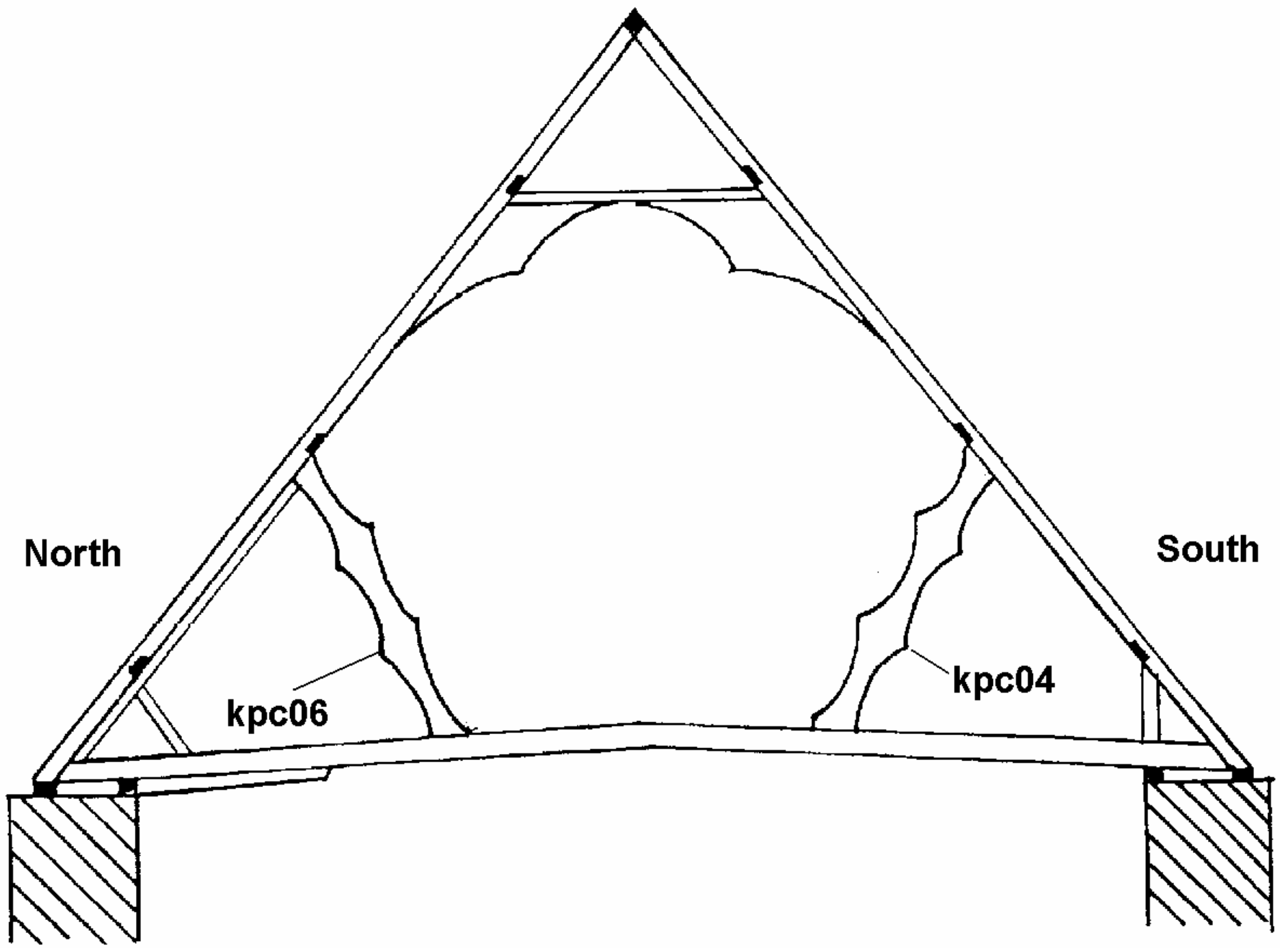

Figure 4: Truss 4 showing the timbers sampled for dendrochronology, adapted from original drawings supplied by Hook Mason Architects

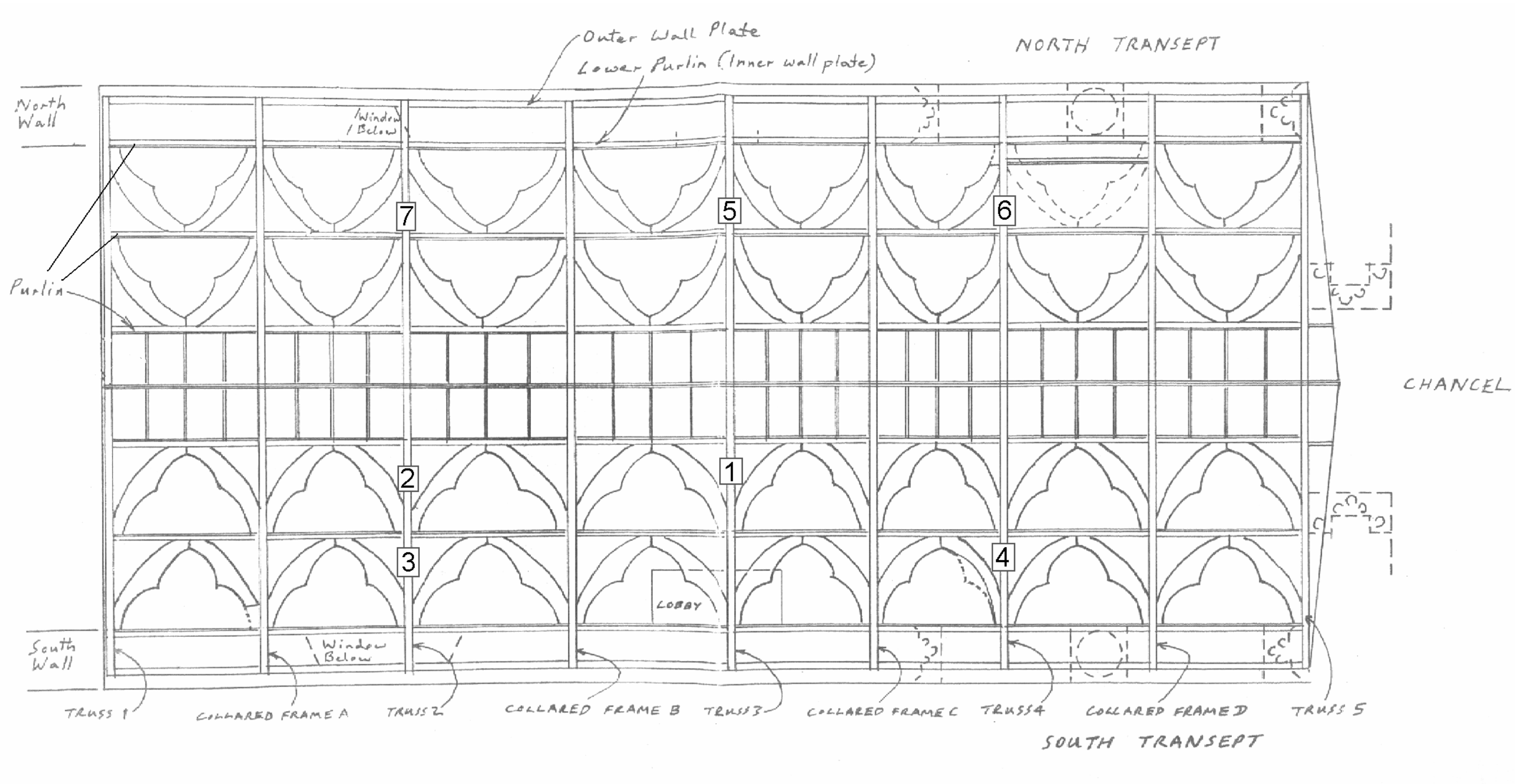

Figure 5: Layout plan of the nave roof (seen from above) with the approximate positions of the samples indicated, based on an original drawing by Hook Mason Architects

<u>Results and Discussion</u>

The majority of the roof was found to be unsuitable for dendrochronological analysis, containing mostly timbers derived from young fast-grown trees. However, although it was difficult to find timbers with sufficient rings and traces of sapwood, seven timbers were cored. Three of these (Table 1) were found to have too few rings to analyse further, and a fourth had only 46 rings, less than ideal, although it was measured as it was thought possible that it may cross-match with the remaining timbers.

Three timbers did yield potentially useful series, containing 89, 94, and 109 rings respectively, and each retaining the heartwood-sapwood boundary. Cross-matching between these series revealed that series kpc05 and kpc06 matched each other well (t = 10.4 with 89 years overlap; Figs 6 and 7), and, despite the 5-year difference in heartwood-sapwood boundary date, the two were considered to be from the same tree. They were combined to form a new series, kpc56m. This series matched with the other long series, kpc04 (t = 4.8 with 90 years overlap), but the other measured sequence (kpc02) with only 46 rings did not give consistent matches with either of these sequences. The two long series were combined into a site sequence, KPYONCH1. The data for this series are given in Table 2. Neither this nor any of the individual series gave consistent acceptable matches when compared with dated reference material. The nave roof timbers therefore remain undated.

The nave roof at King's Pyon yielded measurable series from only three different trees (kpc56m, kpc04, and kpc02), but each showed marked declines in their growth patterns (two are illustrated in Fig 7), which may have prevented dating, despite the abundance of local reference chronologies. It is not possible to determine the cause of these declines, though their gradual onset over the space of a few years suggests health issues in the trees rather than direct silvicultural practices on the trees themselves, which would usually result in more rapid growth declines.

Although this is a region of the country in which tree-ring dating is generally successful, two other studies in Kings Pyon (Groves and Hillam 1993; Nayling 1999) have had only mixed success, suggesting that there may be something unique relating to timber supplies in this immediate area.

Table 1: Details of oak (*Quercus* spp.) timbers sampled from St Mary's Church, King's Pyon. Trusses are numbered from the west end to be consistent with the architect's drawings

Sample Number	Timber and position	No of rings	Mean width (mm)	Mean sens (mm)	Sapwood complement
kpc01	Tiebeam, truss 3	<40	NM	-	-
kpc02	Tiebeam, truss 2	46	2.51	0.15	H/S
kpc03	South cusped brace, truss 2	<40	NM	-	-
kpc04	South cusped brace, truss 4	109	1.30	0.16	H/S
kpc05	North cusped brace, truss 3	89	1.31	0.18	H/S
kpc06	North cusped brace, truss 4	94	1.41	0.19	H/S
kpc07	North cusped brace, truss 2	<40	NM	-	-

NM = not measured; H/S = heartwood/sapwood boundary

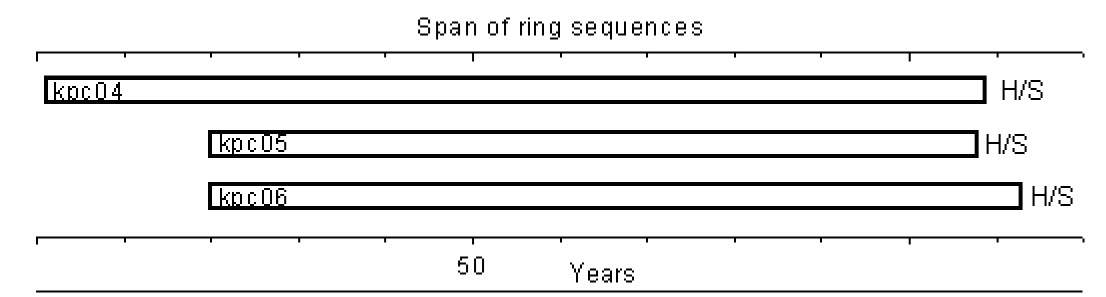

Figure 6: Bar diagram showing the relative positions of overlap of the three cross-matching samples

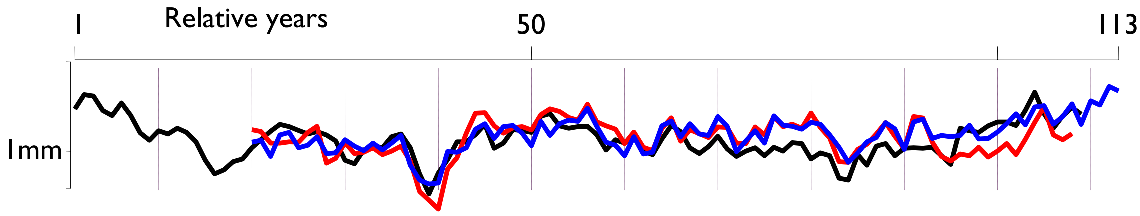

Figure 7: The three cross-matching curves plotted on the same axis showing their similarity in growth pattern and the declines in growth around years 37–40 and 83–85 in the site chronology. The y axis is the width in mm on a logarithmic scale. The black line is kpc04, red is kpc05 and blue is kpc06

Table 2: Ring width data for the undated site chronology **KPYONCH1**

Ring widths (0.01mm)										no of trees									
210	271	264	205	187	234	188	138	121	143	1	1	1	1	1	1	1	1	1	1
135	150	139	118	85	67	72	83	87	118	1	1	1	1	1	1	1	1	1	2
127	122	142	141	127	130	141	110	106	102	2	2	2	2	2	2	2	2	2	2
91	100	110	102	118	127	93	60	48	57	2	2	2	2	2	2	2	2	2	2
86	105	119	152	169	122	130	150	144	133	2	2	2	2	2	2	2	2	2	2
182	182	168	163	162	187	147	119	125	109	2	2	2	2	2	2	2	2	2	2
131	100	96	138	166	132	130	115	118	149	2	2	2	2	2	2	2	2	2	2
128	99	108	127	108	146	128	137	131	134	2	2	2	2	2	2	2	2	2	2
126	110	78	71	97	96	120	139	115	104	2	2	2	2	2	2	2	2	2	2
140	141	114	101	92	131	134	127	131	143	2	2	2	2	2	2	2	2	2	2
152	150	173	237	207	148	169	199	176	243	2	2	2	2	2	2	2	2	2	1
225	313	289								1	1	1							

Acknowledgements

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