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TREE-RING ANALYSIS OF OAK TIMBERS FROM THE "BREWHOUSE AND "REFECTORY" AT NOSTELL PRIORY, NEAR WAKEFIELD, WEST YORKSHIRE

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Summary

Tree-ring analysis was undertaken on samples from 42 structural timbers from two buildings forming part of the Home Farm complex at Nostell Priory, West Yorkshire. The results contribute significantly to the interpretation of the buildings. The 'Brewhouse', thought to be a single-phase structure, dates from early AD 1481. However the building has a series of intermediate roof trusses inserted circa AD 1536/7 which may mark a major remodelling of the structure. The 'Refectory', interpreted as parts of two buildings, is instead shown to be a single phase structure dating from AD 1509/10. Some inserted timbers in the 'Refectory' are also just pre-Dissolution in date, one at least of which is clearly re-used in its present position. Both buildings include later modifications or repairs from the mid-eighteenth century.

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TREE-RING ANALYSIS OF OAK TIMBERS FROM THE 'BREWHOUSE' AND 'REFECTORY' AT NOSTELL PRIORY, NEAR WAKEFIELD, WEST YORKSHIRE

Introduction

This document is a technical archive report on the tree-ring analysis of timbers from two buildings on the former estates of Nostell Priory, near Wakefield, West Yorkshire (NGR SE406172). It is beyond the dendrochronological brief to describe the buildings in detail or to undertake the production of detailed drawings. As part of a multifaceted and multidisciplinary study of the buildings, elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the buildings. The conclusions presented here may therefore have to be modified in the light of subsequent work.

Nostell Priory lies on the eastern outskirts of Wakefield, West Yorkshire. The Priory was established by the twelfth century and surrendered to the Crown in AD 1540. The fine Palladian villa on the estate was built from the AD 1730s and includes a later wing by Adam (Pevsner and Radcliffe 1967). This is opened to the public. The tree-ring dating of two buildings which are within the area of the Priory's Home Farm or domestic grange is the subject of this report. The 'Brewhouse' (NGR SE40611723) and the 'Refectory' (NGR SE40681728) both appear to have been erected as stores for farm produce, either from the Priory's demesne farms or from the tithes. Their current names are not thought to reflect their original functions. They are believed to date from the late-fifteenth or early-sixteenth centuries and both are Scheduled Ancient Monuments. Both buildings have recently been the subject of a comprehensive building survey (Prudhoe and Wrathmell 1996) and archaeological evaluation (Wheelhouse 1996) in advance of a planned reorganisation of the site for estate offices and other facilities. The dendrochronological analysis was requested by John Etté, English Heritage Inspector of Ancient Monuments, Yorkshire and Humberside Region, as part of this survey and evaluation, specifically to assist the interpretation of this rare class of monument.

A short description of both buildings following the nomenclature and numbering scheme of Prudhoe and Wrathmell 1996 is incorporated here to assist clarity, further details should be sought in Prudhoe and Wrathmell 1996. The nomenclature and numbering scheme of Prudhoe and Wrathmell 1996 are followed throughout this report. The buildings are perhaps most notable for their remarkably complete series of carpenters' numbering marks.

The 'Brewhouse'.

The 'Brewhouse' lies on the southern side of the Home Farm area, aligned east-west and parallel with the A638 Wakefield to Doncaster road (Fig 1). The original structure consists of a series of trusses with principal posts, a king-post roof, bracing and integral girding beams (Fig 2). There are intermediate roof trusses of more or less identical structure between the main trusses. Many of the timbers below roof-truss level have been replaced by stone infill. The extant main trusses have a series of carpenters numbers running from 10 in the western wall to 14 near the eastern end (Fig 3). Prudhoe and Wrathmell 1996 hypothesise from both the numbering scheme and a map of *c* AD 1730 (Prudhoe and Wrathmell 1996, Photo 12) that the building originally extended much further westwards.

The roof trusses in bays 10 - 12 were accessible, although the surviving principal posts at first-floor level tended to be inaccessible behind various items stored on this floor. The timbers in bays 13 - 14 show extensive signs of disturbance and modern replacement and the condition of the timbers was noticeably poorer than elsewhere. The floor in bays 10 - 12 shows a mixture of timber; there are modern circular saw-cut timbers as well as some timbers apparently similar to the main truss timbers. All the extant main truss and intermediate truss timbers in bays 10 - 12 appear similar: there is widespread presence of sapwood and bark-edge in all these areas.

The 'Refectory'

This building is north-east of the 'Brewhouse', and its true alignment is south-east/north-west (Fig 1), although for compatibility with Prudhoe and Wrathmell 1996 the alignment used below is east-west. The truss types are similar to those from the 'Brewhouse', although at the east end there is a surviving aisle to the north side (Fig 4). The surviving fragment is of ten bays (Fig 5), and has a curious carpenters numbering sequence. The west end of the building has an early-modern dairy unit that precludes easy access to the trusses labelled, according to Prudhoe and Wrathmell 1996, as 8 and 7 (Fig 5). Truss 6 and bay 5 have clearly suffered fire damage in the past: truss 6 is a complete replacement, whilst the wall plates are heavily charred; truss 5 has been replaced by a brick wall. Trusses 4 through to 1 are not aisled. The carpenters' marks suggest a single coherent structure. The numbering sequence survives on every element of every truss, and even extends to the wall plates which are marked with the appropriate truss number. Unfortunately the stone infill has removed many of the vertical elements, and thus apart from trusses 1 and 2, it is not clear whether this section was originally floored over. No jowls for supporting girding beams are identifiable (except in trusses 1 and 2). The current floor from bays 2-5 includes softwood and elm timbers for the posts, girding beams, and joists,

and has a very hard gypsum or plaster layer laid over straw on top of the joists. All this structure appears to be a later insertion; the posts do not respect the trusses as far as positioning is concerned. The non-oak timbers probably indicate a later phase. A similar gypsum/plaster floor with straw survives at Sinai Park, near Burton upon Trent, where it is perhaps in a seventeenth-century context (Morriss 1995, 69-71) . Next comes trusses 11 through to 9 which are aisled to the north, and the principal posts are jowled to support a floor. A cut brace in the east wall, extending eastwards from truss 9, clearly suggests the building extended further to the east. The truss 11 girding beam is a clearly re-used, highly decorated timber, whilst the truss 10 girding beam appears to be a later replacement. There are no other extant floor elements in this eastern area. The differences between trusses 1 - 4 and 9 - 11 have led to suggestions that these are two separate abutted buildings (Prudhoe and Wrathmell 1996). Archaeological evaluation of the surrounding area (Wheelhouse 1996) and the estate map of *c* AD 1730 suggest the aisled section of the building extended much further east (Prudhoe and Wrathmell 1996, Photo 12).

The oak timbers throughout this structure include sapwood and bark-edge. The primary, re-used, and later oak insertions seemed to include suitable ring sequences. The supporting timbers for the later floor were not suitable for analysis as they appeared to be a mixture of elm and softwood beams, and those that could be examined had too few rings for successful analysis.

Initial Aims

The principal aims of the analysis were to date as precisely as possible the three hypothesised building phases of Prudhoe and Wrathmell 1996, primarily in order to determine whether the surviving structures were originally part of a coherent building plan or an *ad hoc* collection (Etté pers comm.). These primary building phases can be summarised as follows:

1) 'Brewhouse'
2) 'Refectory' western end trusses 1-4
3) 'Refectory' eastern end trusses 9-11

The initial programme of sampling and analysis revealed a more complex situation than was expected. An "extended brief" was agreed attempting to date the various re-used and later repair elements to help place the development of the structures into a local and national context

and help inform the repair and display brief. Although these aims may be considered secondary, they are crucial to the integrated interpretation of the 'Home Farm' area.

Methodology

Scheduled Monument Consent for undertaking dendrochronological sampling was obtained as part of the consent for the related building works. Using elevations and the discussion sections from Prudhoe and Wrathmell 1996 as a guide, the timbers in the accessible areas of the structures were carefully examined in an attempt to identify those timbers with the most suitable ring sequences for analysis. Those with more than 50 annual rings and some survival of the original sapwood and bark-edge were sought.

A selection of the most promising timbers from both buildings were sampled using a 15mm diameter corer attached to an electric drill. The cores were taken from the timbers in the most suitable direction for maximising the numbers of rings for subsequent analysis. The core holes were left open. The ring sequences in the cores were revealed by sanding.

The complete sequences of growth rings in the samples that were selected for dating purposes were measured to an accuracy of 0.01mm using a micro-computer based travelling stage (Tyers 1997a). 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 any found to cross-match were combined to form a site master curve. These, and any remaining unmatched ring sequences were 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.

The tree-ring dates produced by this process initially date only the rings present in the timber. The interpretation of these dates 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 missing sapwood rings. 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. The sapwood estimates applied throughout this report are 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). If bark-edge survives, then a felling date can be directly utilised from the date of the last surviving ring. In this instance if the growth rate is sufficiently high, the completeness of the last surviving ring can be determined by the anatomical differences between the spring growth wood and the later summer growth wood (Baillie 1982, 47). It is possible to differentiate reliably timber felling periods into two categories: timbers felled in the early spring; and those felled either later in the year or before the start of the growing season of the subsequent year. 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 important element of the tree-ring analysis of buildings and archaeological assemblages is the identification of 'same tree' groups within the sampled material. Inspection of timbers, both in buildings and archaeological sites, often suggests that the patterns of knots or branching in timbers are so similar that they appear to be derived from a single tree. Tree-ring analysis is often used to support these suggestions. The identification of 'same tree' groups is based on 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 necessarily exclude the possibility. It is the balance of a range of information that provides the evidence.

Sampling

The initial sampling programme obtained samples from 36 oak timbers (*Quercus* spp.). These can be divided into 11 from the 'Brewhouse', 11 from the eastern end of the 'Refectory', and 14 from the western end of the 'Refectory'. These include samples from both buildings that were parts of secondary modifications. The initial analysis of these samples revealed two rather unexpected aspects of the 'Brewhouse' structure and revealed a problem with the Prudhoe and Wrathmell 1996 interpretation of the 'Refectory'. In both cases it was thought that additional sampling would help resolve these unanticipated interpretative issues. Additional permission and funds were sought to proceed with this extension to the original dendrochronological brief. A further six timbers, four from the 'Brewhouse' and two from the 'Refectory' were selected for sampling, and five previously sampled timbers, three from the 'Brewhouse' and two from the 'Refectory' were re-sampled. Four of these were in an attempt to overcome either loss of sapwood and/or bark-edge on the initial samples whilst one of these was to further investigate a difficult ring sequence. In total samples were obtained from 42 timbers were sampled: 15 from the 'Brewhouse', 11 from the eastern end of the 'Refectory', and 16 from the western end of the 'Refectory' (Table 1 a, b). The samples are coded by truss or bay number (Figs 3 and 5) and element code (Figs 2 and 4) as used by Prudhoe and Wrathmell 1996. Where it is necessary to distinguish the samples in the general discussion and tables these are prefixed by R and B for the 'Refectory' and 'Brewhouse' respectively.

Revised Aims

The aims of the analysis, as revised following the initial results, can be summarised as follows:

'Brewhouse'

a) To determine the date of the primary trusses (five sampled timbers)

b) To determine the date of the intermediate trusses (four sampled timbers)

c) To determine the extent of later disturbance in the floor (six sampled timbers). Figure 6 provides details of the joist sample numbering scheme employed.

'Refectory' East

d) To determine the date of the eastern end of the building (nine sampled timbers)

e) To determine the date of the inserted girding beam (one sampled timber)

f) To determine the date of the re-used girding beam (one sampled timber)

'Refectory' West

g) To determine the date of the western end of the building (13 sampled timbers)

h) To determine the date of the replacement truss 6 (three sampled timbers)

Results and Interpretation

The 'Brewhouse'

14 of the 15 samples were obtained from the 'Brewhouse' were suitable for measurement. Sample B11PR1 disintegrated during coring and could not be reliably measured (Table 1a). 11 of these samples cross-matched (Table 2) to form a 274-year chronology BREWHOUSE. This sequence was cross-matched with a range of reference chronologies and is dated to AD 1263 to 1536 inclusive (Table 3a). The bar diagram (Figure 7 a and b) shows that this material is divided into two groups. The earlier of these groups is composed of three tiebeams and a girding beam from the principal trusses, and three of the joists from the floor. Two of the joists include bark-edge: one dated as felled in winter or early spring of AD 1480/1, whilst the other was felled in the spring of AD 1481. All the other material includes either some sapwood, or the heartwood/sapwood boundary and these combine to give a felling date range of AD 1478-1500. The heartwood/sapwood boundaries are consistent for a single phase group (see Baillie 1982, 57) There seems no reason to doubt that the material without surviving bark-edge are contemporary and were felled at the same time as the two precisely dated joists. These results therefore indicate that the principal trusses and the floor were originally constructed in AD 1481, or shortly thereafter. By contrast a second group of three tiebeams and a king post from one of the intermediate trusses date to over fifty years later. These four timbers all include extensive sapwood and, including unmeasured rings, end at AD 1528, 1534, 1535, and 1536. The heartwood/sapwood boundaries are consistent with these samples being derived from a single phase group. Timber B10TB includes probable bark-edge indicating it was felled in late AD 1536 or early AD 1537 and it is assumed here that this sample provides the construction date for the intermediate trusses. There are no clear cut same-tree identifications within all of the 'Brewhouse' timbers, although there are several extremely similar groups that include one from both phases of the structure. The similarity of samples B12TB and T12TB (Table 2) perhaps suggest that some of the trees used for both phases of the building were derived from the same or neighbouring woodlands and appears to suggest there is continuity of woodland exploitation in the immediately pre-Dissolution period at Nostell.

A girding beam, T11GB, was shown to be much later in date (Fig 7c). This detail was noted by Prudhoe and Wrathmell 1996, and the result is discussed below with the other later timbers from the 'Refectory'. Two samples, B11JB and B12JF, could not be dated.

The 'Refectory'

23 of the 27 samples that were obtained from the 'Refectory' (Table 1b), were suitable for measurement. Samples T2PP2, T2TB, and T6TB were unsuitable because of lack of rings, whilst sample B11WP1 disintegrated during coring and could not be reliably measured. 19 of these samples cross-matched (Table 4), to form a 253-year chronology REFECTORY. This sequence was cross-dated with a range of reference chronologies and is dated AD 1269 to 1523 inclusive (Table 3b). The bar diagram (Figure 7 d-g) shows that this material is divided into four groups.

The principal groups are firstly two aisle ties, two wall plates, and three principal posts from trusses 9 - 11 inclusive (Fig 7d). The second main group is composed of three tiebeams, a girding beam, a king post, four wall plates, and a principal post from trusses 1 - 4 inclusive (Fig 7g). Nine of these timbers, one each from trusses 1, 3, 4, 10 and 11, one each from bays 2, and 10, and two from bay 4, are complete to bark-edge and in every case the last ring present is AD 1509. For most of these samples the last ring is an apparently complete annual ring suggesting they were felled late in AD 1509 or before the start of growth in spring AD 1510. All but one of the other dated timbers includes some sapwood and these combine to give a felling date range of AD 1508-1527. Again the consistency of the heartwood/sapwood transitions points to a single phase group (Baillie 1982, 57). Hence there seems no reason to doubt that the material without surviving bark-edges from these two principal groups were felled at the same time as the nine precisely dated timbers. These results therefore indicate that the entire structure from trusses 1 - 4 and 9 - 11, all linked by a common series of wall plates, was built with timber felled in late AD 1509 or early AD 1510. Assuming the material was used whilst still green (Rackham 1990, 69) implies the buildings were originally constructed at this time or shortly thereafter. A small point from the dendrochronological analysis is that T1GB is not a replacement timber as was suggested by Prudhoe and Wrathmell 1996.

In contrast the two girding beams, T10GB and T11GB, are both later than this date. The decorated beam T11GB was felled AD 1515/6 (Fig 7f) whilst the inserted timber T10GB was probably felled *c* AD 1536-8 (Fig 7e). Thus both are dated later than the primary build. Note that although two separate complete bark-edge cores were obtained from T10GB, the last few

rings are extremely narrow (Fig 8). It was not possible to obtain a reliable count from this timber. The most reliable estimate of the felling date, or death, of this tree is within the AD 1536-8 period.

There are no clear cut same-tree identifications within all of the 'Refectory' timbers, although there are several extremely similar groups that include timbers from both halves of the building. Samples B4WP2e and T10PP2 are one such pair, whilst B9WP1, B10WP2, and B4WP2w form another group linked by high *t*-values and similar growth characteristics (Table 4). The two later insertions are not markedly dissimilar to the original phase timbers. As with the 'Brewhouse' this similarity of timber used throughout the differing phases may perhaps indicate that much of the building timber used in the 'Refectory' was derived from the same or neighbouring woodlands. The two principal rafters from the replacement truss 6 were found to cross-match with the 'Brewhouse' T10GB and to be of significantly later date (Fig 7h). These are discussed together below. Two samples, T4PP2 and T11PP1, remain undated.

The 'Brewhouse' and 'Refectory' medieval timbers

A total of 30 timbers were dated from the site that belong to five felling phases in the latter part of the fifteenth century and the first part of the sixteenth century. The earliest of these is dated to AD 1481 and the latest to AD 1536-8. A comparison of the degree of correlation (as indicated by *t*-values) of the sequences measured from timbers between the separate buildings and phases (Table 5), when compared with the degree of similarity between sequences from a single building or phase (Tables 2 and 4) shows that there is a remarkably high level of consistency both within and between the buildings. In addition the individual building mean sequences have a very high correlation (*t*-value = 13.4). These data would seem to imply that the timbers used to build all these structures were derived from a common woodland, or group of woodlands. This may suggest that the Priory was exploiting the same woodlands throughout the latter part of the fifteenth century and the first part of the sixteenth century. This may suggest that these are timbers from the Priory's own woodlands rather than gifts of trees for building, which contrasts with several well known examples such as the thirteenth-century gifts from Henry III for the building of Gloucester Blackfriars (Rackham 1990, 55). Combining the BREWHOUSE and REFECTORY mean sequences yields improved matching to other reference data sets (Table 3c), a phenomenon widely observed in tree-ring studies. Such improvements in cross-matching with increased numbers of samples, and the attendant increased likelihood of obtaining a reliable date are a well understood reason for increasing the

size and diversity of sampling programmes in standing buildings. The combined chronology NOSTELL1 is listed in Table 6.

The 'Brewhouse' and 'Refectory' post-medieval timbers.

A girding beam from the 'Brewhouse' (B T10GB), and the two principal rafters from the 'Refectory' truss 6 (R T6PR1 and R T6PR2) were found to cross-match (Table 7). These were combined to create a 209-year sequence NOSTELL2. This sequence was cross-matched with a range of reference chronologies and is dated AD 1535 to 1743 inclusive (Table 8). The bar diagram (Figure 7 c and h) shows that this material is from two separate felling phases. The 'Brewhouse' girding beam was felled in AD 1727/8, whilst the 'Refectory' principal rafters, derived from a single tree, were felled in AD 1748/9.

The girding beam in the floor of the 'Brewhouse' proven to be felled *c* AD 1727/8, suggested the possibility that other timbers of this date were present in the floor. During the second sampling phase an attempt was made to identify if other eighteenth-century timbers were present in the 'Brewhouse' floor. A careful comparison of the toolmarks and other physical details on the girding beam and on the nearby joist timbers dating to AD 1481 proved inconclusive since only two joists appeared similar and when analysed both these proved to be from the AD 1481 phase. This result may indicate that only the girding beam is a replacement timber.

The sample from the 'Refectory' truss 6 tiebeam produced too few rings to allow reliable analysis. However, there seems no reason to doubt this is a single phase truss as the toolmarks and numbering style are consistent throughout the truss.

The mean sequence NOSTELL2 is listed in Table 9. Note that the chronology NOSTELL2 overlaps the NOSTELL1 sequence by 2 years. It would be possible to create a single 481-year sequence dated AD 1263-1743 inclusive, this has not been done since the differences in growth rate and variance of the outer end of NOSTELL1 and the inner end of NOSTELL2 would distort the trends in the data were they combined.

Discussion

The 'Brewhouse'

The identification of two phases of roof construction was not the expected result of dendrochronological analysis in this building. Careful examination of the tool marks and timber

conversions and scantling sizes, after the initial results, suggests that there are few consistent differences between the timbers of the primary trusses and the intermediate trusses. Since they are different dates, and only 55 years apart, there perhaps needs to be a careful re-examination of the structural evidence in this building. Obvious questions that need addressing are: why was roof strengthening necessary and how was it done? A structural engineer may be needed to answer these. Although the absence of wind-braces leading to cranking may be the answer, alternative hypotheses include the use of stone slates which increased the loading on the roof, or that these additional trusses relate to the stone infilling phase.

The issue of re-used timbers also needs to be addressed with some care here. It is commonplace to assume use of freshly felled 'green' timber (Rackham 1990, 67; Charles and Charles 1995) for building projects. However, on monastic sites around the time of the Dissolution this is not necessarily the case since it seems inevitable that large building timbers became available for salvage during the required demolition of the church, and perhaps the cloistral buildings. Fortunately all the timbers for which we have obtained felling dates are felled before the Dissolution and are not part of an asset-stripping exploitation of the Priory's woodlands. The intermediate trusses are the right size for the structure and there are no obvious redundant mortises or other features, which may have indicated they were re-used, therefore it seems likely that the intermediate trusses are a genuine late pre-Dissolution modification to the 'Brewhouse'.

Unfortunately, the situation is not so clear-cut in the floors. Firstly, there is the eighteenth-century girding beam, that can only have been inserted with significant disturbance of the rest of the floor. Secondly, the changes seen in the east end of the 'Brewhouse' may be contemporary with the insertion of the girding beam, and all this activity may be part of a general reorganisation of the estate buildings at this time. It seems possible that the rest of the timbers from the now lost west end of the building may have been available for re-use in a repair to the extant 'Brewhouse' floor at this date and therefore some of the early joists may not be in their original positions. A potential solution to this conundrum may lie in the oak floorboards in bays 10-12 of the 'Brewhouse'.

The 'Refectory'

Following the interpretation of Prudhoe and Wrathmell 1996 the dendrochronological analysis was not expected to identify a single phase of construction for the primary structure of this building. With hindsight a careful examination of the tool marks and the structure of the wall

plates, suggests that the building was likely to be of a single build. Truss numbering schemes do not have to run through a building in a logical manner. What the numbering scheme does do is focus attention on the area of bay 1, and trusses 1 and 2. This is clearly different from the rest of the building. There are entrances both sides, taper burns on the timbers, and clear evidence of original flooring. This perhaps suggest a more domestic use of the upper floor in this bay, perhaps as a reeve's lodging to prevent pilfering. The eastern section was clearly part of the original scheme since the wall plates run through the truss 1 principal posts to await the truss 11 wall plates and they have the same scarf joint as the rest of the wall-plate junctions in both halves of the building. Perhaps the building was constructed westwards from the intended entrance first and then eastwards. If the eastern construction used frames in batches of three this could explain the curious numbering.

A different series of questions relate to the floors of this building. Originally was only bay 1 floored? Was there no flooring in the original scheme for bays 2 - 7? Such suggestions do not make much sense as far as the functionality of the building is concerned. The surviving posts for trusses 9 - 11 show that there were integral girding jowls in bays 9 - 11, but neither of the two extant timbers in the floor here can be original to the construction of a floor in this end. Perhaps the original floor has been lost except in bay 1, possibly something to do with the fire in bay 5/6. Secondly there are difficulties in determining when the truss 10 and truss 11 girding beams were actually placed there. If it is not re-used then the T10GB date suggests a pre-Dissolution date, but it seems equally possible that both are re-used in the post-Dissolution period from two different pre-Dissolution contexts.

A slightly unusual conclusion from the dendrochronology derives from the observation that the fire damage that led to the replacement of truss 6 appears restricted to bay 5 by a brick wall. In particular the wall plate in bay 5 is charred only up to the brick wall, and not beyond it. This may suggest that the brick wall, and hence the replacement of truss 5, pre-dates AD 1748/9 which the dendrochronological analysis suggests is the date of the replacement of truss 6 after fire damage.

Note that access was unsuitable for sampling purposes west of truss 6. Prudhoe and Wrathmell 1996 suggest that trusses 7 and 8 include some original timbers but unfortunately they are all boxed in and currently impossible to assess or access for tree-ring purposes without causing significant disruption to the building. Of course, if access is possible or planned during the re-

organisation work then additional sampling should allow these two trusses to be reliably tied to the rest of the building.

The 'Home Farm' complex

Clearly the 28 year difference in the initial construction of the 'Brewhouse' and 'Refectory' buildings in their original form shows that their development was not the direct product of a coherent expansion plan. Rather it suggests that they were the *ad hoc* response to increasing requirements for agricultural or tithe storage on the Priory. Such a conclusion seems to be reflected in other dendrochronological analyses of former monastic granges and farms. The surplus capital produced by the booming economy of most monastic sites was being invested in building programmes right up until the dawn of the Dissolution in AD 1536. Similar results from recent work at Sheffield include building phases dating to AD1500/1 for St Aylotts, a hunting lodge associated with Saffron Walden Abbey, Essex (Tyers 1996a), AD1511 for Cann Hall, a manor house associated with St Osyths Priory, Essex (Tyers 1998), and AD 1494-1534 for a phase at Sinai Park, a manor house associated with Burton Abbey (Tyers 1997b). No doubt other laboratories have similar results .

What may have occurred simultaneously at Nostell Priory is the strengthening of the roof in the 'Brewhouse' and the insertion of a girding beam in the 'Refectory'. Both are dated to *c* AD 1536-8, which suggests they are remarkably late examples of pre-Dissolution building programmes, even if both are prompted by necessary repairs. This late pre-Dissolution date indicates these repairs overlap with the first stages of the suppression of the smaller monastic houses dating from AD 1536.

Similarly both the dated late phases of work in the buildings, although 21 years apart, seem to be contemporary with the massive changes underway in the main house and park in the mid eighteenth century. The replacement truss in the 'Refectory' is presumably a response to an unexpected accident, whilst the new girding beam in the 'Brewhouse' may be either a simple repair or part of a re-organisation of the buildings, perhaps contemporaneous with the shortening of both.

The tree-ring results suggest that all the medieval timbers sampled and dated from six different construction phases derived from the exploitation of a fairly restricted area of woodland. It would be interesting to follow through the documentary details of the Priory's estate holdings at the time of its surrender to investigate how diverse a woodland area it had at its disposal.

Conclusion

The 'Brewhouse' at Nostell Priory includes a series of trusses dated AD 1481, whilst a major series of intermediate trusses are dated *c* AD 1536/7. The reasons for this rapid reconstruction are not clear. Some re-organisation of the floor occurred in the mid eighteenth century, *c* AD 1727/8. The nearby 'Refectory' is not two buildings despite an unusual numbering sequence that has led to this suggestion. Instead the presence of wall plates common to both halves, a continuous series of numbered trusses, and identical felling dates for timbers throughout the primary components indicate a single building campaign probably in AD 1509/10. Two surviving timbers suggest that a change was made to the flooring arrangements in the eastern end possibly *c* AD 1536-8, whilst reconstruction following a damaging fire in the western end of the building is dated *c* AD 1748/9.

Dendrochronological analysis has led to significant refinement of the interpretation of these buildings and has also raised questions which only further detailed survey and documentary research, plus additional dendrochronology as necessary, can hope to answer. The opportunity to undertake a second sampling trip allowed very precise dates to be obtained for a series of pre-Dissolution inserted trusses, and an eighteenth century inserted girding beam, both from the 'Brewhouse', as well as two pre-Dissolution girding beams of differing dates, and a later eighteenth century replacement truss in the 'Refectory'. These additional refinements significant aid the interpretation of the buildings.

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Figure 1 showing the location of the two buildings and their hypothesised original extent, after Prudhoe and Wrathmell 1996, fig 4. Scale 1:1250.

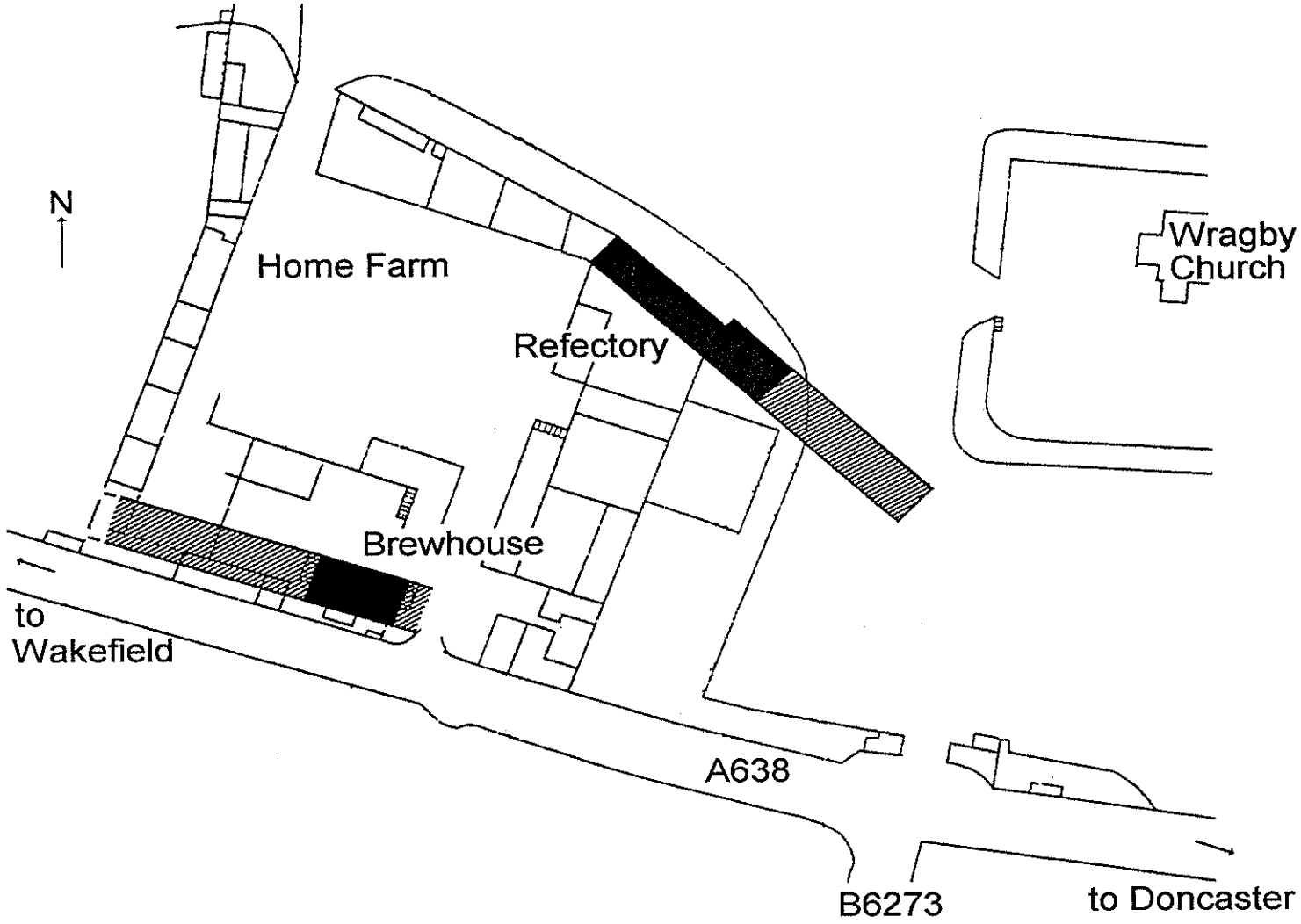

Figure 2 'Brewhouse' typical truss, after Prudhoe and Wrathmell 1996, fig 3. Showing sampled element codes used throughout this report. KEY: GB girding beam, KP king post, PR1 north principal rafter, TB tiebeam. Not to scale.

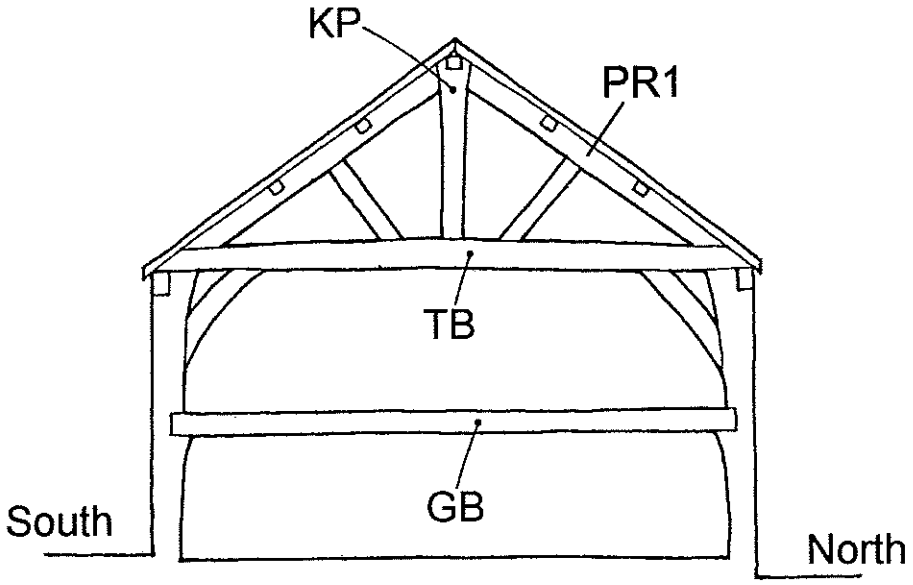

Figure 3 North elevation of the 'Brewhouse' showing truss, bay and intermediate truss numbering scheme, after Prudhoe and Wrathmell 1996, fig 1b. Not to scale.

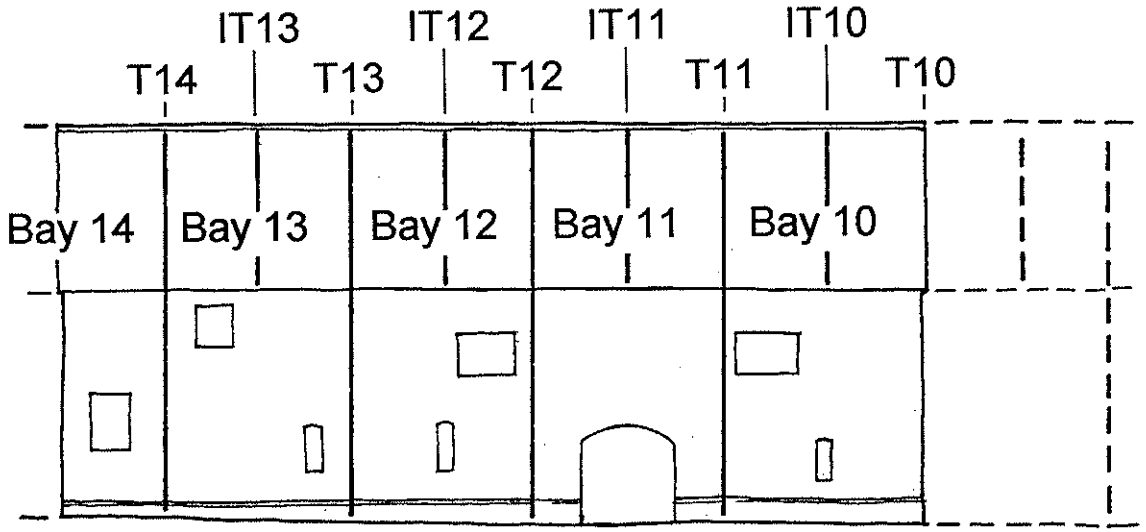

Figure 4 'Refectory' typical truss from the original build. This is from the eastern end with a north aisle, after Prudhoe and Wrathmell 1996, fig 2. Showing sampled element codes used throughout this report. KEY: AT aisle tie, GB girding beam, KP king post, PP principal post, PR principal rafter, TB tiebeam, WP wall plate. Where elements are present both sides of the building: 1 southern, 2 northern. Not to scale.

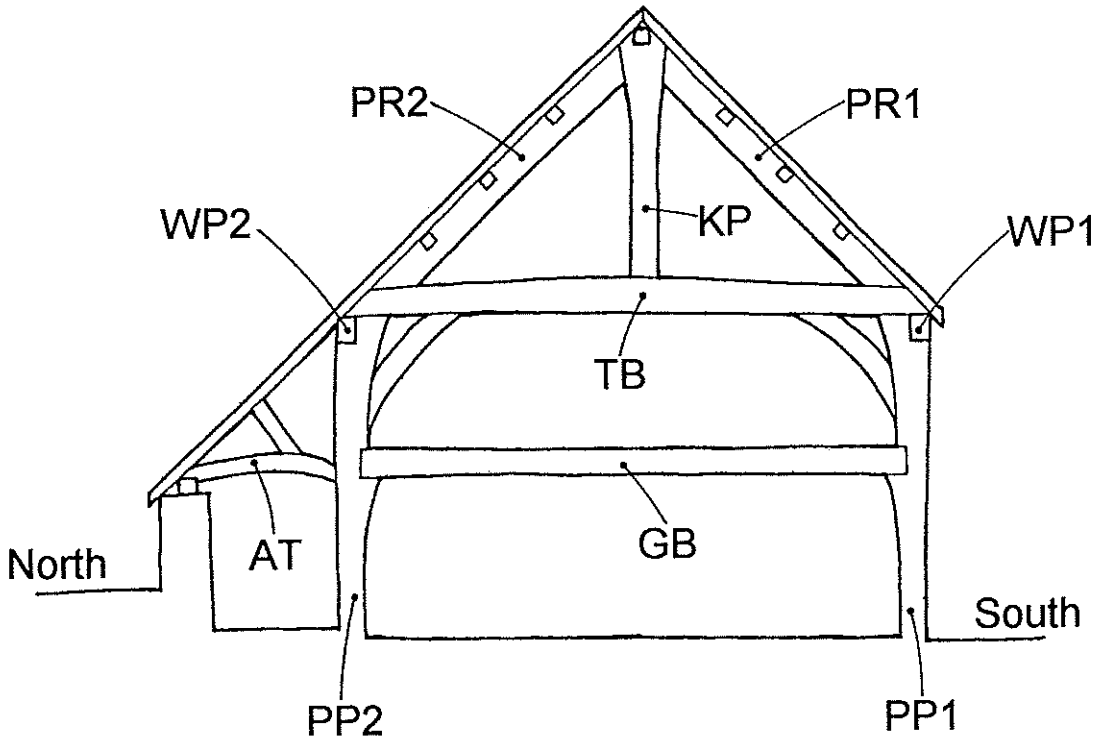

Figure 5 South elevation of the 'Refectory' showing truss and bay numbering scheme, after Prudhoe and Wrathmell 1996, fig 1a. Not to scale

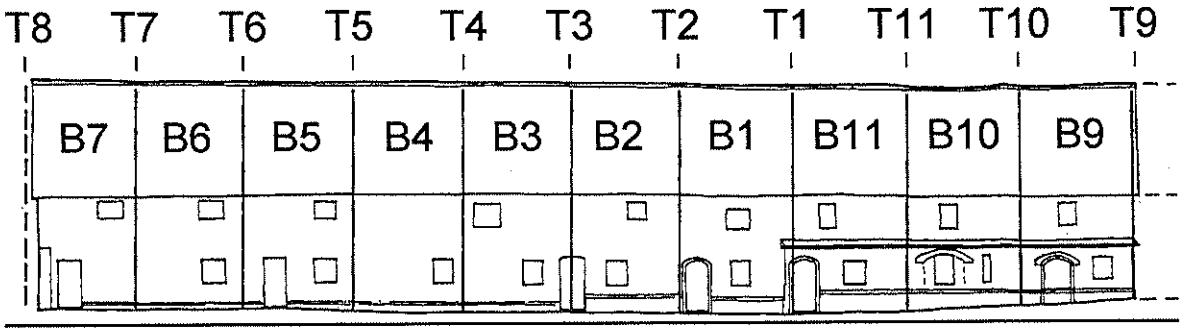

Figure 6 Plan of the 'Brewhouse' floor in bays 10 - 12 showing the joist labelling scheme adopted during sampling. The approximate location and direction of coring for the five joist samples and the two girding beam samples is also indicated. The joists were labelled in three continuous sequences B10JA to B10JN, B11JA to B11JN, and B12JA to B12JO, each series running southwards from the entrance side of the ground floor. Missing joists that were evident from empty housings or other evidence were included in the labelling scheme. Dashed lines represent missing joists. The relative positions of joists between different bays are not accurately represented. Not to scale.

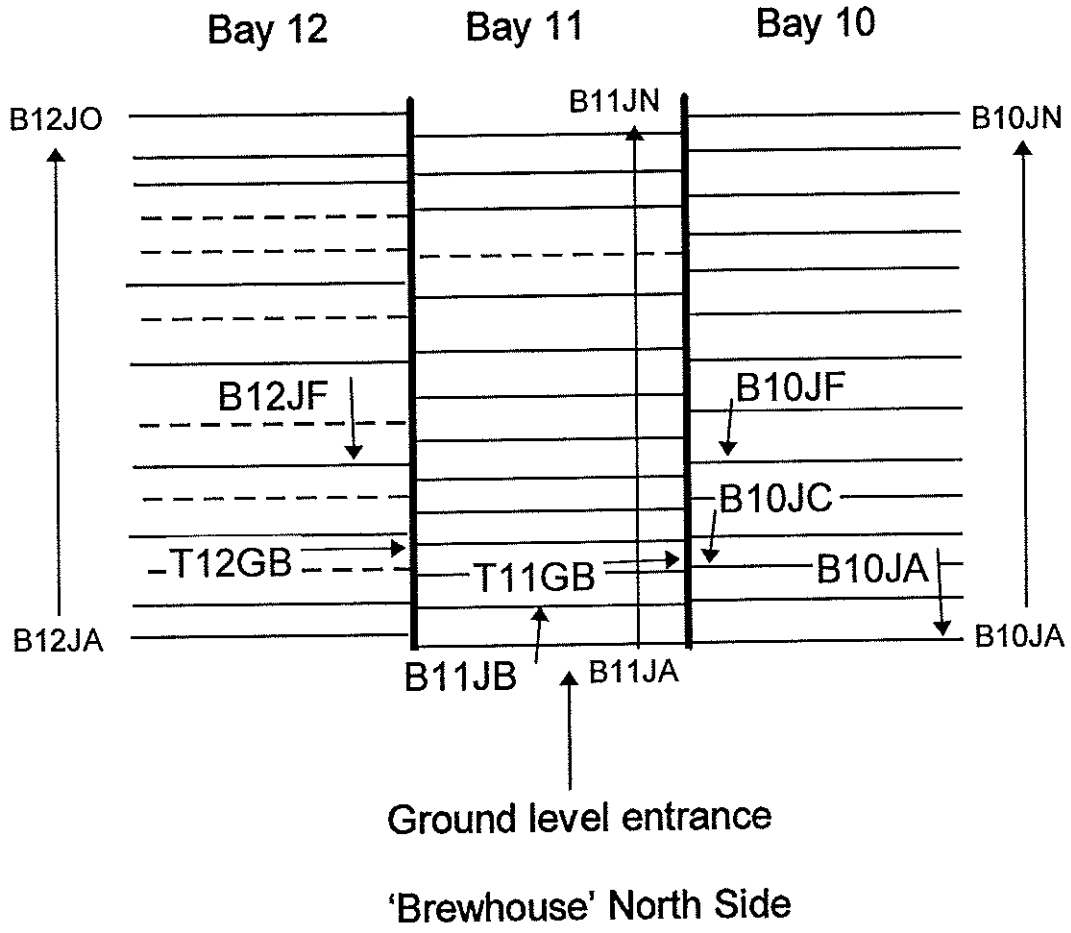

Figure 7 Bar diagram, showing interpretation groups based on the dendrochronological results from Nostell Priory 'Brewhouse' and 'Refectory', truss and bay numbering and timber codes follows Prudhoe and Wrathmell 1996, see also figure 2 and 4; T truss, B bay (this includes intermediate trusses in 'Brewhouse'), TB tiebeam, GB girding beam, WP wall plate, AT aisle ties, PP principal posts, KP king posts, J joists, PR principal rafters. White bars heartwood, hatched bars sapwood, the felling date interpretations listed in Table 1 are included, these dates and ranges are calculated using a 10-55 sapwood estimate (Hillam *et al* 1987) where no bark-edge was present, ? indicates the heartwood/sapwood boundary or the bark-edge was probably present rather than positively identified.

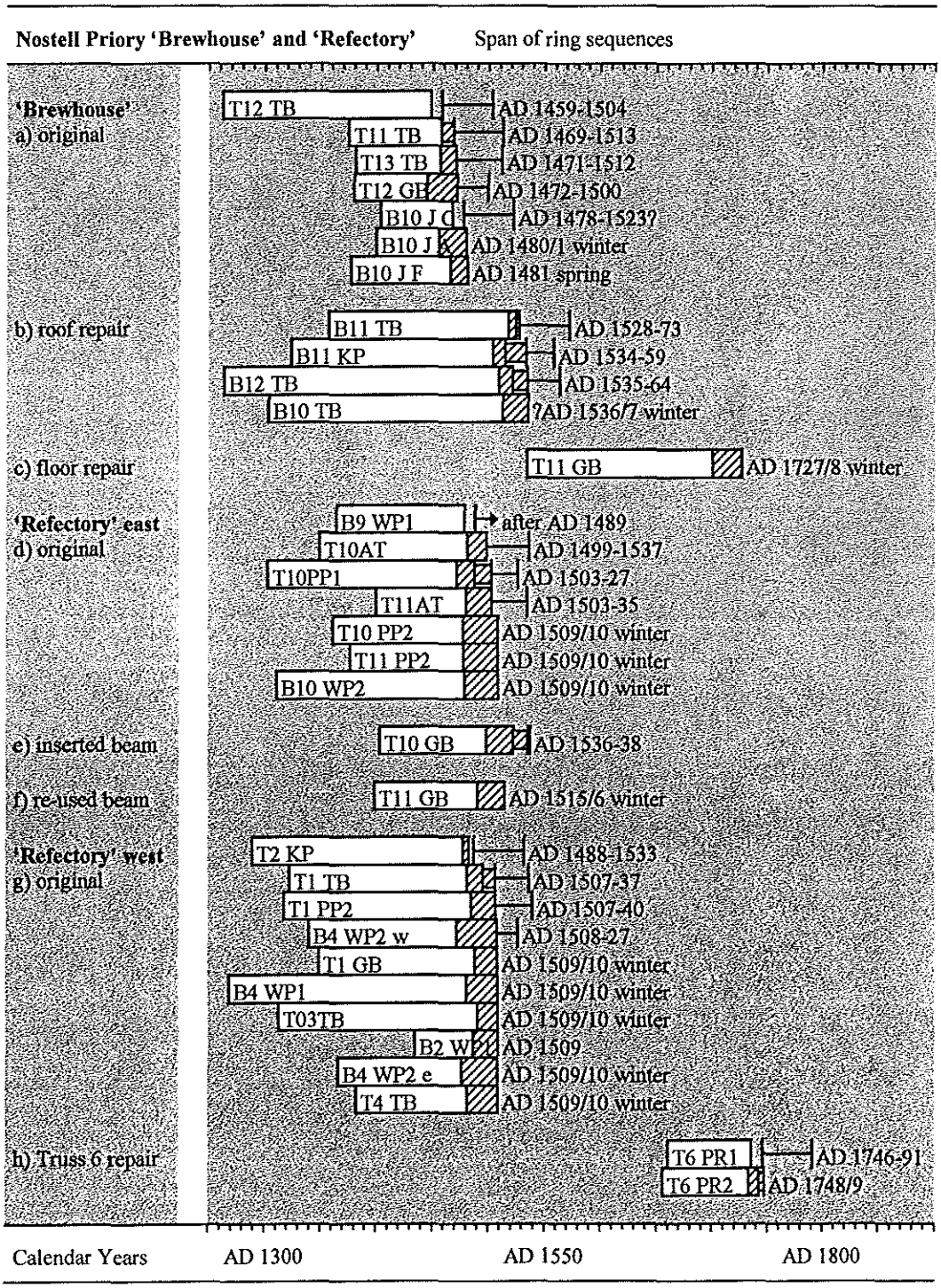

Figure 8

Photomicrograph of the last 15 mm of a core from the 'Refectory' T10GB timber. This shows that the tree became very slow grown after AD 1530. Two cores were taken from this timber some distance apart and both show the same effect. Both sides of both cores were independently assessed by four dendrochronologists. The conclusion reached is that the ring boundaries cannot be reliably resolved with an accuracy better than ± 1 ring. It is suggested that the tree was felled, or possibly died, between AD 1536 and AD 1538. Magnification approximately x 12.5.

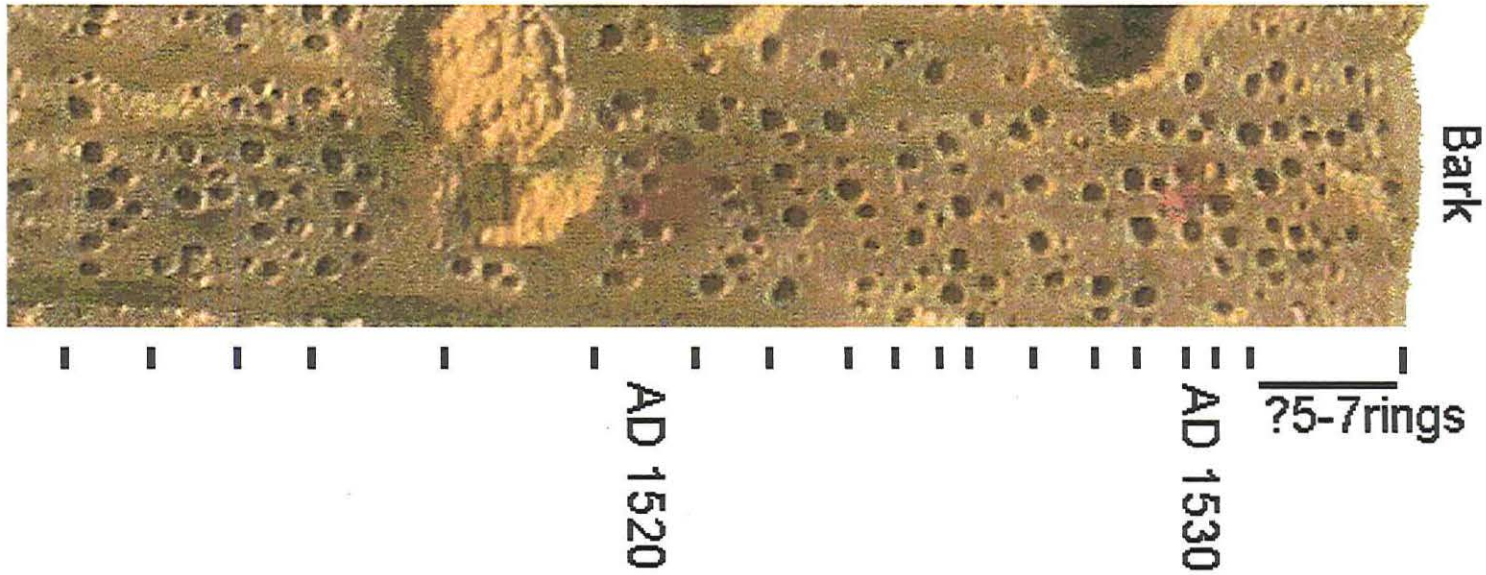

Table 1 Details of samples from Nostell Priory

Sample	Description of timber	Type	Size (mm)	No. of rings	Sapwood rings	Bark	ARW [1]	Date of sequence	Felling date range[5]
a) 'Brewhouse' samples									
B10JA	Ground floor bay 10 joist A	oak	170 x 165	81	24	yes	1.27	AD 1400-1480	AD 1480/1
B10JC	Ground floor bay 10 joist C	oak	180 x 170	65	?h/s		2.41	AD 1404-1468	?AD 1478-1523
B10JF	Ground floor bay 10 joist F	oak	170 x 160	105	15	yes	1.72	AD 1377-1481	AD 1481 spring
B10TB	Roof bay 10 intermediate truss tiebeam	oak	450 x 270	233	23	?yes	1.19	AD 1304-1536	?AD 1536/7
T11GB	Ground floor truss 11 girding beam	oak	405 x 210	193	26	yes	1.48	AD 1535-1727	AD 1727/8
T11TB	Roof truss 11 tiebeam	oak	330 x 220	84	h/s+11 [2]		2.54	AD 1375-1458	AD 1469-1513
B11JB	Ground floor bay 11 joist B	oak	185 x 155	75	15		2.91	undated	
B11KP	Roof bay 11 intermediate truss king post	oak	250 x 250	192	11+19 [2]		0.77	AD 1324-1515	AD 1534-59
B11PR1	Roof bay 11 intermediate truss principal rafter north	oak	350 x 150	-				fragmented core	
B11TB	Roof bay 11 intermediate truss tiebeam	oak	460 x 290	168	7		0.88	AD 1358-1525	AD 1528-73
T12GB	Ground floor truss 12 girding beam	oak	330 x 290	93	27		2.27	AD 1380-1472	AD 1472-1500
T12TB	Roof truss 12 tiebeam	oak	420 x 300	187	h/s		1.46	AD 1263-1449	AD 1459-1504
B12JF	Ground floor bay 12 joist F	oak	290 x 185	77	18		2.44	undated	
B12TB	Roof bay 12 intermediate truss tiebeam	oak	420 x 270	259	13+13 [2]		1.46	AD 1264-1522	AD 1535-64
T13TB	Roof truss 13 tiebeam	oak	420 x 290	91	14		1.69	AD 1381-1471	AD 1471-1512
b) 'Refectory' samples									
T1GB	Truss 1 girding beam	oak	250 x 200	160	20	yes	1.48	AD 1350-1509	AD 1509/10
T1PP2	Truss 1 north principal post	oak	570 x 220	190	22		1.00	AD 1318-1507	AD 1507-40
T1TB	Truss 1 tiebeam	oak	420 x 200	174	14+11 [2]		1.48	AD 1323-1496	AD 1507-37
T2KP	Truss 2 king post	oak	260 x 170	195	6		1.06	AD 1290-1484	AD 1488-1533
T2PP2	Truss 2 north principal post	oak	275 x 240					too few rings	
T2TB	Truss 2 tiebeam	oak	370 x 200					too few rings	
B2WP1	Bay 2 south wall plate	oak	295 x 245	75	22	yes	1.79	AD 1435-1509	AD 1509
T3TB	Truss 3 tiebeam	oak	360 x 220	197	18	yes	1.34	AD 1313-1509	AD 1509/10
T4PP2	Truss 4 north principal post	oak	335 x 225	63	18		1.25	undated	
T4TB	Truss 4 tiebeam	oak	340 x 220	127	27	yes	2.08	AD 1383-1509	AD 1509/10
B4WP1	Bay 4 south wall plate	oak	300 x 230	241	28	yes	0.95	AD 1269-1509	AD 1509/10
B4WP2e	Bay 4 north wall plate, east of scarf joint	oak	290 x 220	143	32	yes	1.32	AD 1367-1509	AD 1509/10
B4WP2w	Bay 4 north wall plate, west of scarf joint	oak	290 x 220	169	36		1.37	AD 1340-1508	AD 1508-27
T6PR1	Truss 6 south principal rafter	oak	305 x 110	76	h/s		1.68	AD 1661-1736	AD 1746-91
T6PR2	Truss 6 north principal rafter	oak	300 x 120	87	9+5 [2]	yes [3]	1.24	AD 1657-1743	AD 1748/9
T6TB	Truss 6 tiebeam	oak	340 x 265					too few rings	
B9WP1	Bay 9 south wall plate	oak	280 x 220	115			1.13	AD 1365-1479	after AD 1489
T10AT	Truss 10 north aisle tie	oak	220 x 160	150	17		1.64	AD 1350-1499	AD 1499-1537
T10GB	Truss 10 girding beam	oak	320 x 255	120	24+13-5 [2]	yes [3]	1.89	AD 1404-1523	AD 1536-8
T10PP1	Truss 10 south principal post	oak	? [4] x 250	186	16+15 [2]		1.43	AD 1303-1488	AD 1503-27
T10PP2	Truss 10 north principal post	oak	445 x 240	148	31	yes	1.29	AD 1362-1509	AD 1509/10
B10WP2	Bay 10 north wall plate	oak	280 x 220	199	30	yes	1.22	AD 1311-1509	AD 1509/10
T11AT	Truss 11 north aisle tie	oak	250 x 170	104	23		1.96	AD 1400-1503	AD 1503-35
T11GB	Truss 11 girding beam	oak	310 x 240	117	24	yes	2.09	AD 1399-1515	AD 1515/6
T11PP1	Truss 11 south principal post	oak	? [4] x 250	49	26		0.87	undated	
T11PP2	Truss 11 north principal post	oak	540 x 230	133	31	yes	1.07	AD 1377-1509	AD 1509/10
B11WP1	Bay 11 south wall plate	oak	280 x 220					fragmented core	

KEY [1] ARW = average growth rate (mm/year)

[2] the second value gives the number of additional unmeasured rings that survive on these samples which have been used in the felling date calculation

[3] The bark-edge is intact after the additional unmeasured but counted rings given in the 'Sapwood rings' column

[4] this dimension cannot be measured because the timber is embedded in the stone wall

[5] these dates and ranges are calculated using a 10-55 sapwood estimate (Hillam *et al* 1987) where no bark-edge was present, ? indicates the heartwood/sapwood boundary or the bark-edge was probably present rather than positively identified

Table 2 *t*-values between individual dated 'Brewhouse' timbers, - indicates *t*-value less than 3.00.

Area		'Brewhouse' original						'Brewhouse' later trusses			
	Sample	B10JC	B10JF	T11TB	T12GB	T12TB	T13TB	B10TB	B11KP	B11TB	B12TB
	B10JA	3.61	5.63	3.90	4.34	-	3.29	3.87	3.23	-	4.52
	B10JC		5.98	5.40	4.90	4.08	-	-	3.70	3.98	3.10
'Brewhouse'	B10JF			6.56	5.77	-	4.16	-	6.25	4.60	4.76
original	T11TB				4.55	-	3.87	4.22	3.87	3.45	3.48
	T12GB					3.32	3.48	4.10	3.64	3.72	4.60
	T12TB						-	7.73	7.28	5.07	10.10
	T13TB							-	3.65	-	-
'Brewhouse'	B10TB								10.00	7.26	8.68
later trusses	B11KP									5.77	9.01
	B11TB										5.62

Table 3 example *t*-values between the medieval site master sequences from Nostell Priory and independent reference sequences: a). the BREWHOUSE chronology constructed from 11 timbers and dated AD 1263-1536; b). the REFECTORY chronology constructed from 19 timbers and dated AD 1269-1523; and c) the combined chronology NOSTELL1 constructed from 30 timbers and dated AD 1263-1536.

Reference sequence	a	b	c
East Midlands Master (Laxton and Litton 1988)	10.47	10.68	13.84
Worcester Commandery, Worcestershire (Pilcher pers comm)	6.98	6.73	7.32
Hereford Cathedral Barn 2, Herefordshire (Tyers 1996b)	7.71	8.08	8.44
Hereford Farmers Club, Herefordshire (Tyers 1996b)	6.68	6.30	7.02
Sinai Park, Staffordshire (Tyers 1997b)	7.27	7.29	8.32
John Bunny's House, Wakefield, Yorkshire (Morgan pers comm)	8.83	7.99	10.99
Calverley, Yorkshire (Hillam 1982)	5.63	6.80	7.69
Elland Old Hall, Yorkshire (Hillam 1984)	5.58	7.35	7.92

Table 4 *t*-values between individual dated 'Refectory' timbers, - indicates *t*-value less than 3.00.

Area		'Refectory' Western End trusses/bays 1-4									'Refectory' Eastern End trusses/bays 9-11							Re-used	Insert
	Samples	T1PP2	T1TB	T12KP	B2WP1	T3TB	T4TB	B4WP1	B4WP2 e	B4WP2 w	B9WP1	T10AT	T10PP1	T10PP2	B10WP2	T11AT	T11PP2	T11GB	T10GB
	T1GB	8.95	5.28	9.02	4.94	7.47	5.59	5.66	9.45	8.93	8.50	6.22	8.34	9.99	7.70	7.19	7.02	4.80	7.21
	T1PP2		4.47	6.44	4.82	8.09	-	5.55	6.89	7.21	7.02	4.54	7.37	7.50	7.22	-	5.07	3.34	4.96
	T1TB			6.70	5.23	7.39	4.63	7.33	5.52	8.28	4.68	5.14	6.29	6.49	7.69	5.04	6.44	-	3.85
'Refectory'	T2KP				5.62	6.49	5.50	6.77	7.51	8.81	7.07	4.90	7.79	8.80	7.52	5.47	6.50	3.89	6.49
Western End	B2WP1					3.89	3.13	-	5.74	3.44	4.26	3.55	3.80	5.66	4.71	4.93	3.59	3.15	4.24
	T3TB						3.91	6.45	9.14	7.82	6.43	4.56	8.74	7.60	11.48	5.01	6.39	3.46	5.05
	T4TB							5.15	6.26	6.07	4.53	5.60	4.94	5.95	4.13	5.95	4.88	4.71	4.59
	B4WP1								7.54	7.83	6.11	4.24	8.27	7.79	8.92	4.54	6.19	4.46	4.70
	B4WP2e									7.74	7.15	6.57	8.24	10.10	7.77	7.58	5.66	3.50	7.60
	B4WP2w										10.11	6.86	9.21	8.75	9.58	7.22	6.59	3.76	6.45
	B9WP1											6.44	6.91	8.71	9.88	4.40	6.95	-	4.88
	T10AT												5.84	7.27	4.80	12.16	5.65	4.80	7.27
	T10PP1													9.89	9.34	7.23	8.82	3.20	3.19
'Refectory'	T10PP2														6.70	6.60	7.71	4.45	7.74
Eastern End	B10WP2															5.63	7.43	3.40	5.56
	T11AT																7.30	4.05	6.52
	T11PP2																	-	5.35
Re-used	T11GB																		4.89

Table 5 *t*-values between individual dated timbers from the 'Brewhouse' and the 'Refectory', - indicates *t*-value less than 3.00.

Area		'Refectory' Western End trusses/bays 1-4										'Refectory' Eastern End trusses/bays 9-11							Re-used	Insert
	Samples	T1GB	T1PP2	T1TB	T2KP	B2WP1	T3TB	T4TB	B4WP1	B4WP2 e	B4WP2 w	B9WP1	T10AT	T10PP1	T10PP2	B10WP2	T11AT	T11PP2	T11GB	T10GB
	B10JA	4.24	-	-	3.95	-	4.17	-	-	3.83	3.52	3.55	-	3.00	-	4.38	-	-	-	-
	B10JC	4.65	-	-	4.82	-	4.33	3.96	3.25	5.51	4.29	3.97	6.35	4.10	5.68	4.15	5.76	3.58	3.55	5.30
'Brewhouse'	B10JF	5.67	3.47	3.92	3.85	3.17	6.77	4.61	3.73	7.73	5.23	4.03	5.11	6.53	4.48	6.71	7.86	5.63	-	4.72
original	T11TB	8.40	5.67	3.04	5.16	-	6.45	3.00	3.52	6.06	7.00	5.14	5.80	4.20	5.15	4.85	4.96	4.14	4.64	3.90
	T12GB	4.99	3.97	3.10	4.77	-	5.83	-	5.17	5.19	4.53	5.00	3.05	5.04	5.52	5.27	4.18	5.13	3.34	4.76
	T12TB	3.31	4.08	6.29	6.28	-	6.41	-	8.81	-	5.43	3.78	3.78	4.85	5.08	6.93	5.61	-	-	-
	T13TB	3.48	-	-	3.01	-	4.24	-	-	-	-	-	-	4.77	-	-	-	4.61	-	-
	B10TB	6.07	5.99	5.38	6.40	5.48	7.15	-	8.21	5.33	5.56	6.53	-	5.20	7.41	8.16	3.21	-	3.75	4.06
'Brewhouse'	B11KP	6.88	4.83	6.67	8.39	5.05	7.44	5.36	7.76	9.82	6.17	5.85	5.83	7.02	6.23	8.39	7.80	5.35	-	4.57
later trusses	B11TB	6.73	6.05	3.80	6.89	3.59	6.11	4.92	6.13	5.37	6.32	7.22	3.60	4.87	6.25	5.95	6.28	4.91	4.35	6.87
	B12TB	6.91	6.91	8.70	7.32	4.89	9.75	3.93	8.98	7.54	7.24	4.20	4.39	6.55	6.80	8.36	4.95	6.19	3.18	5.58

Table 6 Ring-width data from site master NOSTELL1, dated AD 1263-1536 inclusive

Date	Ring widths (0.01mm)										No of samples									
AD 1263			161	197	161	243	158	290	329	300			1	2	2	2	2	2	3	3
	255	219	200	169	157	118	161	153	152	187	3	3	3	3	3	3	3	3	3	3
	243	226	199	215	224	250	130	143	181	273	3	3	3	3	3	3	3	3	3	4
	216	234	210	191	191	199	175	145	119	139	4	4	4	4	4	4	4	4	4	4
AD 1301	152	162	152	121	141	129	122	127	129	129	4	4	5	6	6	6	6	6	6	6
	158	131	132	129	148	162	132	127	119	117	7	7	8	8	8	8	8	9	9	9
	129	93	129	116	135	73	100	113	107	104	9	9	10	11	11	11	11	11	11	11
	89	100	99	90	128	111	88	122	149	144	11	11	11	11	11	11	11	11	11	12
	143	138	144	88	139	114	107	165	165	109	12	12	12	12	12	12	12	12	12	14
AD 1351	92	96	114	108	61	85	92	80	73	80	14	14	14	14	14	14	14	15	15	15
	75	133	161	98	88	102	98	106	142	128	15	16	16	16	17	17	18	18	18	18
	106	77	89	104	104	141	132	140	163	138	18	18	18	18	19	19	21	21	21	22
	112	119	126	116	137	146	184	153	126	123	23	23	24	24	24	24	24	24	24	24
	126	98	125	123	117	156	108	126	124	153	24	24	24	24	24	24	24	24	25	27
AD 1401	162	153	198	206	165	185	159	162	136	161	27	27	27	29	29	29	29	29	29	29
	158	210	185	183	156	131	101	155	122	177	29	29	29	29	29	29	29	29	29	29
	160	135	195	149	110	88	101	147	163	124	29	29	29	29	29	29	29	29	29	29
	138	193	118	129	150	142	178	178	131	159	29	29	29	29	30	30	30	30	30	30
	175	130	174	155	141	110	118	130	147	116	30	30	30	30	30	30	30	30	30	29
AD 1451	147	166	141	127	129	156	130	135	116	143	29	29	29	29	29	29	29	29	28	28
	125	127	112	107	137	144	167	154	159	168	28	28	28	28	28	28	28	28	27	27
	140	106	134	125	183	134	126	108	136	134	27	26	25	25	25	25	25	25	25	24
	168	137	141	132	135	158	197	147	139	103	23	22	22	22	21	21	21	21	20	20
	93	113	137	140	137	186	127	97	104	105	20	20	20	20	20	20	19	19	19	18
AD 1501	95	122	114	116	110	118	110	101	123	130	18	18	18	17	17	17	17	16	15	6
	142	134	137	124	113	106	89	136	139	117	6	6	6	6	6	4	4	4	4	4
	133	144	116	140	116	230	173	188	163	156	4	4	3	2	2	1	1	1	1	1
	188	174	129	105	136	126					1	1	1	1	1	1				

Table 7 *t*-values between the eighteenth-century timbers from both buildings. Note that R T6PR1 and R T6PR2 are derived from the same tree.

	R T6PR1	R T6PR2
B T11GB	5.84	4.02
R T6PR1		**9.67**

Table 8 example *t*-values between the post-medieval site master sequence NOSTELL2, dated AD 1535-1743 constructed from three timbers, and independent reference sequences.

Reference sequence	NOSTELL2
Winchester, Hampshire (Barefoot 1975)	5.33
East Midlands Master (Laxton and Litton 1988)	8.24
Astley Castle, Warwickshire (Howard *et al* 1997)	4.96
Ridgeway, Derbyshire (Sheffield Dendrochronology Laboratory unpubl)	5.18
Sefton Fold, Lancashire (Groves and Hillam 1993)	5.38
Claydon House, Buckinghamshire (Tyers 1995)	5.62
Welsh Borders (Siebenlist-Kerner 1978)	5.39
Finthorpe Barn, Huddersfield, Yorkshire (Boswijk 1997)	6.60

Table 9 Ring-width data from site master NOSTELL2, dated AD 1535-1743 inclusive

Date	Ring widths (0.01mm)										No of samples									
AD 1535					181	188	192	292	219	446					1	1	1	1	1	1
	519	556	583	658	500	385	291	316	263	202	1	1	1	1	1	1	1	1	1	1
AD 1551	230	167	184	190	270	202	132	128	147	224	1	1	1	1	1	1	1	1	1	1
	161	249	230	196	156	152	139	191	213	211	1	1	1	1	1	1	1	1	1	1
	199	184	222	202	231	191	176	142	212	218	1	1	1	1	1	1	1	1	1	1
	195	143	119	162	187	216	161	133	144	101	1	1	1	1	1	1	1	1	1	1
	69	60	80	132	108	90	78	44	39	62	1	1	1	1	1	1	1	1	1	1
AD 1601	60	68	69	73	62	72	99	78	62	66	1	1	1	1	1	1	1	1	1	1
	104	80	88	58	59	72	108	113	84	94	1	1	1	1	1	1	1	1	1	1
	91	86	116	79	74	105	116	106	83	98	1	1	1	1	1	1	1	1	1	1
	131	155	145	99	161	128	126	202	164	185	1	1	1	1	1	1	1	1	1	1
	153	236	212	176	141	203	231	153	112	140	1	1	1	1	1	1	1	1	1	1
AD 1651	103	95	89	99	119	115	122	158	111	169	1	1	1	1	1	1	2	2	2	2
	159	166	191	225	171	117	138	180	158	166	2	2	2	2	2	2	2	2	2	2
	211	172	231	165	144	107	163	170	110	172	2	2	2	2	2	2	2	2	2	2
	111	166	113	69	64	64	107	121	146	102	2	2	2	2	2	2	2	2	2	2
	118	78	84	97	106	122	111	139	109	111	2	2	2	2	2	2	2	2	2	2
AD 1701	113	120	135	109	92	115	136	144	124	90	2	2	2	2	2	2	2	2	2	2
	112	132	159	115	105	108	110	98	108	100	2	2	2	2	2	2	2	2	2	2
	124	163	110	121	147	101	141	186	170	165	2	2	2	2	2	2	2	1	1	1
	145	156	133	130	173	149	101	189	241	134	1	1	1	1	1	1	1	1	1	1
	108	90	127								1	1	1							