TREE-RING ANALYSIS OF TIMBERS FROM NAUNTON COURT, NAUNTON ROAD, NAUNTON BEAUCHAMP, NEAR PERSHORE, WORCESTERSHIRE

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View to the rear of the north – south range of Naunton Court

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Summary

Analysis by dendrochronology of 11 out of 12 samples obtained from two areas of this building has produced two dated site chronologies and dated a further single sample individually.

The first site chronology comprises four samples, its 145 rings dated as spanning the years 1387–1531. It is likely that the timbers represented by these samples were felled in the period 1546–71.

The second site chronology comprises two samples, its 88 rings dated as spanning the years 1481–1568. It is unlikely that the timbers represented by these samples were felled before 1583.

The rings of the single dated sample span 1527–80 and it is likely that the timber represented was felled in the period 1590–1615.

It seems likely, therefore, that the latest phase of work found by this programme of tree-ring analysis uses timber felled in the very early–seventeenth century, a period of work when older timber, originally felled, say, c 1560, and re-claimed or savaged from other sites, was re-used.

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Introduction

Naunton Court stands a very short way off the B4082, at Naunton Beauchamp near Pershore in Worcestershire (SO 957 524, map Fig 1). The building (Fig 2) presents two main ranges, both of two storeys with attics. One range is aligned roughly north-south and lies parallel to the road; the roof of this range is half hipped at its northern end. To the southern end of this range is attached the second, aligned roughly east-west, and gable end to the road. To the exterior, both front and rear, may be seen a substantial quantity of timber framing formed mostly of irregular vertical close studding, but with some square panelling as well, particularly to the east-west range. To the front, much of the ground floor has been replaced with stone and/or brick, to which some 'timbering' has been applied as paint.

Within the building a quantity of further timber may also be found. To the ground and first floor rooms this mainly comprises a series of ceiling beams, though portions of square panelled timber framing are also visible, particularly to the south wall of the main ground-floor room of the north-south range, and the stairs situated at the west gable end of the east-west range (Fig 3a/b).

Further timbering may be seen in the 'attic', or top-floor, rooms of both ranges. That to the north-south range comprises four principal rafter with collar trusses (without tiebeams), forming three bays, while that the east-west range comprises three, more widely spaced, trusses, again of principal rafter with trusses. Only the southern-most truss of the north-south range, at the junction with the east-west range, is closed, again with square panelled timber framing (Fig 4).

There appears to be a mixture of timber found in both ranges at this site, with oak and elm being used in both portions. The amount of each and its function, however, do seem to vary between the two ranges. There is a greater quantity of oak in the north-south range than there is in the east-west range. In the former, oak is used throughout the roof and for most of the closed southern truss, with elm being used for timbers such as wall plates and one or two cross-rails. In the east-west range, all the roof timbers are of elm as are some of the stud posts; other studs, particularly to the stairway wall, are of oak.

There is substantial evidence for the reuse of older timber at this site. A number of ceiling beams, for example appear to be reused, as do at least four principal rafters of the north-south range roof. It is unsubstantiated by any documentary evidence, but there is a local tradition that much of the timber used at Naunton Court has been reclaimed from an older building, either on this site, or from other buildings in the general locality.

Sampling

Sampling and analysis by tree-ring dating of timbers within Naunton Court were commissioned by 110 Archaeology, Evesham. The purpose of this programme of analysis was to inform a programme of repairs by establishing dates for the timbers of the two main elements of this building, the north-south and the east-west ranges, and determining a possible construction date for the present structure.

Thus, from the timbers available a total of 12 samples was obtained, 10 by coring *in-situ* timbers and two by slicing two beams removed from the rear external wall. Each sample was given the code NTN-A (for Naunton, site 'A') and numbered 01–12. The positions of these samples are marked on a schematic sketch plan made at the time of sampling, this being reproduced here as Figure 5. Details of the samples are given in Table 1.

The Laboratory would like to take this opportunity to thank the owners of Naunton Court for their help and cooperation during sampling, and for their enthusiasm for this programme of tree-ring analysis. We would also like to thank Jill Atherton for assisting with the interpretation of the site prior to tree-ring sampling and for her helpful discussions relating to the possible development of the building. Finally we would like to thank the contractors working on site at the time of sampling who helped with obtaining the sliced samples.

Tree-ring dating

Tree-ring dating relies on a few simple, but quite fundamental, principles. Firstly, as is commonly known, trees (particularly oak trees, the most frequently used building timber in England) grow by adding one, and only one, growth-ring to their circumference each, and every, year. Each new annual growth-ring is added to the outside of the previous year's growth just below the bark. The width of this annual growth-ring is largely, though not exclusively, determined by the weather conditions during the growth period (roughly March – September). In general, good conditions produce wider rings and poor conditions produce narrower rings. Thus, over the lifetime of a tree, the annual growth-rings display a climatically influenced pattern. Furthermore, and importantly, all trees growing in the same area at the same time will be influenced by the same growing conditions and the annual growth-rings of all of them will respond in a similar, though not identical, way.

Secondly, because the weather over any number of consecutive years is unique, so too is the growth-ring pattern of the tree. The pattern of a short period of growth, 20, 30 or even 40 consecutive years, might conceivably be repeated two or even three times in the last one thousand years. A short pattern might also be repeated at different time periods in different parts of the country because of differences in regional micro-climates. It is less likely, however, that such problems would occur with the pattern of a longer period of growth, that is, anything in excess of 54 years or so. In essence, a short period of growth, anything less than 54 rings, is not reliable, and the longer the period of time under comparison the better.

The third principle of tree-ring dating is that, until the early- to mid-nineteenth century, builders of timber-framed houses usually obtained all the wood needed for a given structure by felling the necessary trees in a single operation from one patch of woodland, or from closely adjacent woods. Furthermore, and contrary to popular belief, the timber was used "green" and without seasoning, and there was very little long-term storage as in timber-yards of today. This fact has been well established from a number of studies where tree-ring dating has been undertaken in conjunction with documentary studies. Thus, establishing the felling date for a group of timbers gives a very precise indication of the date of their use in a building.

Tree-ring dating relies on obtaining the growth pattern of trees from sample timbers of unknown date by measuring the width of the annual growth-rings. This is done to a tolerance of 1/100 of a millimeter. The growth patterns of these samples of unknown date are then compared with a series of reference patterns or chronologies, the date of each ring of which *is* known. When the growth-ring sequence of a sample "cross-matches" repeatedly at the same date span against a series of different relevant reference chronologies the sample can be said to be dated. The degree of cross-matching, that is the measure of similarity between sample and reference, is denoted by a "*t*-value"; the higher the value the greater the similarity. The greater the similarity the greater is the probability that the patterns of samples and references have been produced by growing under the same conditions *at the same time*. The statistically accepted fully reliable minimum *t*-value is 3.5.

However, rather than attempt to date each sample individually it is usual to first compare all the samples from a single building, or phase of a building, with one another, and attempt to cross-match each one with all the others from the same phase or building. When samples from the same phase do cross-match with each other they are combined at their matching positions to form what is known as a "site chronology". As with any set of data, this has the effect of reducing the anomalies of any one individual (brought about in the case of tree-rings by some non-climatic influence) and enhances the overall climatic signal. As stated above, it is the climate that gives the growth pattern its distinctive pattern. The greater the number of samples in a site chronology the greater is the climatic signal of the group and the weaker is the non-climatic input of any one individual.

Furthermore, combining samples in this way to make a site chronology usually has the effect of increasing the time-span that is under comparison. As also mentioned above, the longer the period of growth under consideration, the greater the certainty of the cross-match. Any site chronology with less than about 55 rings is generally too short for reliable dating.

Having obtained a date for the site chronology as a whole, the date spans of the constituent individual samples can then be found, and from this the felling date of the trees represented may be calculated. Where a sample retains complete sapwood, that is, it has the last or outermost ring produced by the tree before it was cut, the last measured ring date is the felling date of the tree.

Where the sapwood is not complete it is necessary to estimate the likely felling date of the tree. Such an estimate can be made with a high degree of reliability because oak trees generally have between 15 to 40 sapwood rings. For example, if a sample with, say, 12 sapwood rings has a last sapwood ring date of 1400, it is 95% certain that the tree represented was felled sometime between 1403 (1400+3 sapwood rings (12+3=15)) and 1428 (1400+28 sapwood rings (12+28=40)).

Given that in a timber-framed building the trees required for each phase are almost certainly to have been cut in a single felling operation especially for that building, it is usual to calculate the average date of the heartwood/sapwood boundary of *all* the dated samples from each phase of a building and add 15 to 40 rings to get the overall likely felling date of the group.

Analysis

Each of the 12 samples obtained was prepared by sanding and polishing. It was seen at this point that one sample, NTN-A12, had less than 54 rings, the minimum required for reliable dating, and it was rejected from this programme of analysis. The annual growth rings of the remaining 11 samples were, however, measured and then compared with each other. This process allowed two groups of samples to be formed.

The four samples of the first group (NTN-A01, 02, 03, and 04), cross-matching with each other at positions as shown in the bar diagram, Figure 6, were combined to form site chronology NTNASQ01, this having an overall length of 145 rings. These rings were dated as spanning the years 1387 to 1531. The evidence for this dating is given in the *t*-values of Table 2.

The two samples of the second group (NTN-A10 and A11) cross-match with each other at positions as shown in the bar diagram, Figure 7. These samples were combined at these positions to form site chronology NTNASQ02, this having an overall length of 88 rings. These rings were dated as spanning the years 1481 to 1568. The evidence for this dating is given in the *t*-values of Table 3.

The two site chronologies, NTNASQ01 and NTNASQ02 were then compared with each other, and with the five remaining measured but ungrouped samples. There was, however, no further satisfactory cross-matching. The five ungrouped samples were then compared individually with a full range of reference chronologies for oak. This process indicated a cross-match and date for only one further sample, NTN-A06, this having a first ring date of 1527 and a last ring date of 1580. The evidence for this dating is given in the *t*-values of Table 4.

Interpretation

Analysis by dendrochronology of 11 out of the 12 samples obtained from this site has produced two dated site chronologies. The first, NTNASQ01, comprises four samples, its 145 rings dated as spanning the years 1387–1531. The second site chronology, NTNASQ02, comprises two samples, its 88 rings dated as spanning the years 1481–1568. A single sample has been dated individually, its 54 rings dated as spanning the years 1527–80.

It is very likely that the four timbers, all principal rafters of two trusses forming the roof of the main north-south range and represented by the four samples NTN-A01, 02, 03, and 04 in site chronology NTNASQ01, were all cut at the same time in a single programme of felling sometime between 1546–71. Such an interpretation is based on the fact that one of the samples, NTN-A01, has a heartwood/sapwood boundary date of 1531, ie, only the sapwood rings are missing, and that the usual sapwood element of oak trees accounts for a minimum of 15 rings, and a maximum of 40 rings. Furthermore, these four samples cross-match with each other at *t*-values which would indicate that they are from trees growing close to each other in the same patch of woodland. Such factors make it unlikely that they were felled at different times.

Neither of the two samples in site chronology NTNASQ02 (NTN-A10 and 11), from stud posts in the stairway wall of the east-west range, retains any sapwood or the heartwood/sapwood boundary. It is therefore not possible to estimate the felling date of the timbers represented with any accuracy except, given that the latest, heartwood, ring on either sample dates to 1568, to say that it is unlikely to be before 1583. This date is again calculated on the basis that the tree represented had a minimum of 15 sapwood rings. Again it is likely that the two timbers represented were felled at the same time as each other.

The final, individually, dated sample, NTN-A06, from a cross-rail in the framing of truss 1, has a last ring date of 1580, and having five sapwood rings, thus a heartwood/sapwood boundary date of 1575. Using the usual estimate of 15–40 sapwood rings that the tree might have had would give the timber an estimated felling date in the range 1590 to 1615.

Conclusion

Naunton Court, therefore, appears to contain timbers of at least two different felling dates. One group of timbers, that used in the roof of the main north-south range, is estimated to have been felled in the mid- to third quarter of the sixteenth century, with another timber, in truss 1 at the south end of this range, being felled in the late-sixteenth to early-seventeenth century. The felling date of a third group of timbers from the east-west range cannot be accurately determined, but is unlikely to be before the late-sixteenth century as well.

It is probable, therefore, that what are now the dated principal rafters of the main north-south range represent an earlier phase of felling in round terms of, say, *c*. 1560, these timbers being reused in the construction of the present building which appears to use timbers felled, again in round terms, say, *c* 1600–10.

It is not possible to be certain where the original source woodland for the timber used in the two parts of this building was located. However, as can be seen from Tables 2–4 which shows the reference chronologies against which site chronologies NTNASQ01 and SQ02 have been dated, the highest *t*-values, ie the greatest degree of similarity, appears to be with references from sites to the east of Naunton, particularly in Warwickshire, Staffordshire, and Derbyshire. Such a distribution may indicate that the timbers have come from some distance perhaps suggesting a shortage of oak in the immediate vicinity of Naunton, a possibility given further support by the reuse of older timbers and the extensive use of elm at this site, a material used much less frequently in timber-framing than oak.

Four measured samples, NTN-A05, 07, 08, and 09, remain ungrouped and undated, despite all of them having sufficient rings for reliable analysis; as will be seen in Table 1, the longest undated sample, NTN-A05, has 91 rings. It is noticeable, however, as may be seen in Fig 8, that three of these samples, NTN-A05, 07, and 08, have disturbed growth by way of compression rings or erratic growth. These disturbances are the most likely reason for the lack of dating.

The fourth undated sample, NTN-A09, however, has both sufficient rings and what appears to be an undisturbed growth pattern. It is not known why such a sample might not date, but it is possibly from a place and/or a time period for which little or no reference material is available.

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Table 1: Details of samples from Naunton Court, Naunton Beauchamp, Worcestershire

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
NTN-A01	East principal rafter, truss 2	120	h/s	1412	1531	1531
NTN-A02	West principal rafter, truss 2	75	no h/s	1398	------	1472
NTN-A03	East principal rafter, truss 3	54	no h/s	1427	------	1480
NTN-A04	West principal rafter, truss 3	55	no h/s	1387	------	1441
NTN-A05	Intermediate stud, truss 1	91	no h/s	------	------	------
NTN-A06	Cross-rail, truss 1	54	5	1527	1575	1580
NTN-A07	Sill beam to rear wall (uncertain location)	83	h/s	------	------	------
NTN-A08	Sill beam to rear wall (uncertain location)	84	h/s	------	------	------
NTN-A09	Rail to stairway wall, first-second floor	74	h/s	------	------	------
NTN-A10	Stud 'V' to stairway, first floor landing	60	no h/s	1481	------	1540
NTN-A11	Stud 'IV' to stairway, first floor landing	88	no h/s	1481	------	1568
NTN-A12	Stud 'III' to stairway, first floor landing	nm	---	------	------	------

*h/s = heartwood/sapwood boundary
nm = sample not measured

Table 2: Results of the cross-matching of site chronology NTNASQ01 and relevant reference chronologies when first ring date is 1387 and last ring date is 1531

Reference chronology	Span of chronology	*t*-value	
Kingsbury Hall, Kingsbury, Warwicks	AD 1391 – 1564	10.0	(Arnold and Howard 2006)
Sinai Park, Burton on Trent, Staffs	AD 1227 – 1750	8.4	(Tyers 1997)
Wakelyn Old Hall, Hilton, Derbys	AD 1415 – 1573	8.3	(Arnold *et al* 2007 unpubl)
Primrose Hill, King's Norton, Birmingham	AD 1354 – 1593	7.9	(Arnold *et al* 2007 forthcoming)
Guildhall / Pedagogues' House, Stratford upon Avon, Warwicks	AD 1377 – 1502	7.8	(Arnold *et al* 2006)
26 Westgate Street, Gloucester	AD 1399 – 1622	7.5	(Howard *et al* 1998)
East Midlands Master Chronology	AD 882 – 1981	7.2	(Laxton and Litton 1988)
Wales and West Midlands	AD 1341 – 1636	7.2	(Siebenlist-Kerner 1978)

Table 3: Results of the cross-matching of site chronology NTNASQ02 and relevant reference chronologies when first ring date is 1481 and last ring date is 1568

Reference chronology	Span of chronology	*t*-value	
Chicksands Priory, Beds	AD 1200 – 1541	6.3	(Howard *et al* 1998)
Kingsbury Hall, Kingsbury, Warwicks	AD 1391 – 1564	6.2	(Arnold and Howard 2006)
Newnham Murren, Oxon	AD 1412 – 1614	6.1	(Arnold and Howard 2006 unpubl)
Polesworth Abbey Gatehouse, Warwicks	AD 1446 – 1582	5.8	(Arnold and Howard 2007)
Stoneleigh Abbey, Stoneleigh, Warwicks	AD 1398 – 1658	5.6	(Howard *et al* 2000)
Lodge Park, Aldsworth, Glos	AD 1324 – 1587	5.6	(Howard *et al* 1995)
England	AD 401 – 1981	5.4	(Baillie and Pilcher 1982 unpubl)
Wales and West Midlands	AD 1341 – 1636	4.8	(Siebenlist-Kerner 1978)

Table 4: Results of the cross-matching of sample NTN-A06 and relevant reference chronologies when first ring date is 1527 and last ring date is 1580

Reference chronology	Span of chronology	*t*-value	
Wales and West Midlands	AD 1341 – 1636	6.6	(Siebenlist-Kerner 1978)
MC10---H	AD 1386 – 1585	6.3	(Fletcher 1978)
England	AD 401 – 1981	6.2	(Baillie and Pilcher 1982 unpubl)
South	AD 1458 – 1681	5.8	(Howard 2002 unpubl)
Lodge Park, Aldsworth, Glos	AD 1324 – 1587	5.8	(Howard *et al* 1995)
Sinai Park, Burton on Trent, Staffs	AD 1227 – 1750	5.6	(Tyers 1997)
26 Westgate Street, Gloucester	AD 1399 – 1622	5.2	(Howard *et al* 1998)
Polesworth Abbey Gatehouse, Warwicks	AD 1446 – 1582	4.8	(Arnold and Howard 2007)