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Dendrochronology, timber analysis, and historic building consultants

CANNINGTON COURT,
CANNINGTON,
NEAR BRIDGWATER,
SOMERSET,

TREE-RING ANALYSIS OF TIMBERS

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SUMMARY

A total of 10 core samples were obtained from the south range roof trusses at Cannington Court, Cannington. Analysis by dendrochronology of eight of these samples (two samples having insufficient rings for reliable dating) has resulted in the production of a single dated site chronology comprising six of these eight. This site chronology is 104 rings long, these rings dated as spanning the years 1332–1435. Interpretation of the sapwood on the dated samples would indicate that, although the *exact* year of felling date cannot be determined, the timbers were probably all cut as part of a single programme of felling at some point between 1448 at the earliest and 1473 at the latest. The two remaining measured samples from this roof are undated.

In addition to the roof samples, an attempt was made to take a core from a post in the face of the south wall (the side facing onto the courtyard) of the north range. The timber proved to be very decayed and a full core could not be obtained. It was seen that, in any case, the timber had too few rings for reliable analysis.

The substantial roof of the west range was also assessed as to its potential for tree ring analysis, but the timbers here were all seen to be of elm. As yet elm is not amenable to dating by dendrochronology, and no samples were taken.

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Introduction

Cannington Court lies in the pretty village of Cannington, just to the north of the A39 trunk road, a few miles west of Bridgwater in Somerset (ST 257 395, Fig 1a/b).

By the twelfth century it is known that the manor of Cannington was held by the Curci family, and that *c*.1138 Robert de Curci gave part of his estate to found a house of Benedictine nuns at Cannington. By the early sixteenth century the nuns' estate included lands round the priory, the manor, and the rectory and vicarage. By the time the priory was dissolved in 1536 some land had already been let to Sir Edward Rogers and in 1539 the Crown also granted him the site of the nunnery, the manor, rectory, and advowson and the former priory lands in the parish and elsewhere. The property remained with the Rogers family until 1672 when Cannington reverted to the Crown. The estate then passed to the Clifford family who hold the land (though not Cannington Court itself) to this day.

Cannington Court, formerly the Court House, originated in the remains of the priory and has a twelve-bayed, three-storied west front of sandstone rubble except for the top storey which is of brick with keyed oval openings. The buildings of the nunnery lay immediately to the north of the parish church to which they were linked before their post-Dissolution conversion. Whether the twelfth-century church abutted the south side of the cloister or was divided from it by an open passage is not now clear but that appears to have been the arrangement after the rebuilding of the church on a new alignment in the later-fifteenth century. The eastern claustral range has been demolished, although the outline of its gable can be seen on the church, but the western and northern ranges survive in a much-altered form. The north range, presumably the refectory, has an arch-braced roof which was formerly open. On the first floor of the west range there is a much restored and reset early sixteenth-century fireplace with a frieze of quatrefoiled panels enclosing shields and the initials of the Cliffords. The west range continues northwards and with the east and north ranges, which both appear to be of medieval origin, it now encloses a second courtyard. The north range is not aligned with the other buildings and it was not originally joined to the west range.

The conversion into a house for the Rogers family was centered on a first-floor hall in the northern half of the east range. There were service rooms to the north and other principal rooms on the first floor of the central and western ranges. The northern court was entered by a gateway with a two-storied porch in limestone ashlar. Soon after the house passed to them the lords Clifford made further alterations, extending the west range northwards and adding a second floor to the west range and porch. At its southern end the added floor is only a façade.

The description of the house as 'a ruin' in the 1790s may relate to the demolition of the southern end of the east range. A chapel in existence by 1776 was rebuilt by John Peniston in 1830. It is now a lecture room known as the Clifford Hall. The room is octagonal, with a domed and coffered ceiling rising to an octagonal lantern, and two large Corinthian columns flank the opening to the former chancel. The octagonal nave was probably constructed within the walls of the earlier chapel. In 1919 the tenth Lord Clifford granted the lease of Cannington Court to Somerset County Council. The house and buildings were adapted for Somerset College of Agriculture and Horticulture, known as Somerset Farm Institute. The successor to the institute was Cannington College, which became nationally known for its provision of Land-based education. Having been altered and developed over several centuries in now forms a series of ranges round a courtyard, Figure 2.

Sampling

Cannington Court has recently been purchased by EDF Energy with a view to developing the buildings into a national training centre for the company's staff. This development includes the restoration of the Court buildings to bring them back into beneficial use, the landscaping of the central courtyard to improve the setting of the listed building with replacement car parking provided nearby, a new single-storey building in place of the Amory Block, together with the restoration and refurbishment of several existing buildings, and a 'green travel' plan to minimise additional traffic, including a pick up and drop off service at local railway stations and airports for EDF Energy staff using the training facility.

As part of this restoration and development, a research programme of investigation, survey, and recording, has sought to establish the date and sequential development of the building in order to reassess its significance, with tree-ring analysis being employed in an attempt to date the timbers. It was hoped that dendrochronology would shed light not only on the date of the building but also on its development, a greater archaeological understanding of its significance informing the preparation of conservation proposals. This programme of tree-ring dating was thus commissioned on behalf of EDF Energy, initially by the contractors C S Williams, and then by by Kier Construction.

With the aim of fulfilling the application of tree-ring dating to this project, an inspection was made of the arch-braced roof trusses to the west and south ranges. It was seen at this time that although a considerable quantity of timber was to be found to the roof of the west range in the form of several arch-braced principal rafter trusses with collars and tiebeams (Fig 3a/b), and with double purlins, wind-braces, and struts, all the beams, without exception, were of elm (it was noted at this time that all timbers were carefully carpentered and the beams appear to display a full set of carpenter's assembly marks, Figure 3c). Currently, probably due to the variation and erratic nature of the annual growth rings of this tree, it is not possible to reliably date elm, and no samples were obtained from this roof.

Fortunately, the four arch-braced trusses of the south range, were, by contrast, all of oak and appeared to contain sufficient numbers of rings, Figure 3d.

In addition to the roof timbers of the west and south ranges, a small number of timbers were exposed in the south face of the north range (the wall facing onto the courtyard). An examination of these timbers showed them to be heavily decayed and rotted, Figure 3e. Despite this, an attempt was made to core one of the timbers, the resultant sample, unfortunately, breaking into a number of small pieces. It was observed from these pieces that the timber was derived from a fast-grown tree and had insufficient rings (ie, less than 50) for reliable analysis.

From the trusses of the south range roof a total of 10 core samples were obtained. Each sample was given the code CAN-A (for Cannington – site 'A'), and numbered 01–10. The layout and arrangement of the trusses of the south range roof are shown on a simple schematic plan, Figure 4, with the sampled timbers being located on simple schematic drawings shown here as Figures 5a–d. Details of the samples are given in Table 1, including the timber sampled and its location, the total number of rings each sample has, and how many of these, if any, are sapwood rings. The individual date span of each dated sample is also given. In this report, the ranges of the building are described by compass point as lying either north, south, east, or west around the courtyard, with the sampled roof trusses of the south range being numbered west–east, 1–4, with individual timbers identified on a north–south basis as appropriate.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank EDF Energy for generously funding this programme of tree-ring analysis, along with Andrew Asprey, Project Manager, of Leslie Clark Construction Consultants who helped facilitate sampling and analysis. The Nottingham Laboratory would also like to thank Dave Foreman of Kier Construction (Western & Wales), plus all on-site contractors and staff who helped and cooperated with sampling, and made the site work both safe and productive.

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 timber most commonly used in building construction until the introduction of pine from the late eighteenth century onwards) 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 (Fig 6).

Secondly, because the weather over a certain number of consecutive years (the statistically reliable minimum calculated as being 54 years) is unique, so too is the growth-ring pattern of the tree. The pattern of a shorter 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, and is considered less reliable. 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 45 years or so. In essence, a short period of growth, anything less than 45 rings, is not reliable, and the longer the period of time under comparison the better.

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 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 (and therefore a heartwood/sapwood boundary ring date of 1388), 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)).

<u>Analysis</u>

Each of the 10 samples obtained from the roof timbers of the south range of Cannington Court was prepared by sanding and polishing. It was seen at this time that two of these 10 samples, CAN-A02 and A07, had too few rings for reliable dating, ie, less than 50, and they were rejected from this programme of analysis. The annual growth ring widths of the eight remaining samples were, however, measured and the data were then compared with each other as described in the notes above. By this process a single group, comprising six of the eight measured samples could be formed, the samples cross-matching with each other as shown in the bar diagram, Figure 7.

The six cross-matching samples were combined at their indicated off-set to form CANASQ01, a site chronology with an overall length of 104 rings. This site chronology was then satisfactorily dated by repeated and consistent cross-matching with a large number of relevant reference chronologies for oak as spanning the years 1332 to 1435. The evidence for this dating is given in the *t*-values of Table 2.

Site chronology CANASQ01 was compared with the two remaining measured but ungrouped samples, but there was no further satisfactory cross-matching. The two remaining measured but ungrouped sample were then compared individually with the full body of reference material, but again there was no further cross-matching or dating.

Interpretation

None of the six samples in site chronology CANASQ01 retain complete sapwood (the last ring produced by the tree immediately before it was cut down, the sapwood probably having been trimmed off by the original carpenters), and it is thus not possible to say precisely when any of the trees were felled. Two of the samples (CAN-A08 and A09) do, however, retain the heartwood/sapwood boundary (denoted by h/s in Table 1 and the bar diagram), this meaning that only the sapwood rings are missing. Given that the number of sapwood rings on oak trees generally lie within known limits (the 95% probability interval being 15–40 sapwood rings), it is possible to calculate the likely felling date of the timbers with a high degree of reliability. The average date of the heartwood/sapwood boundary on the two samples that retain it is 1433. Adding to this date the likely minimum and maximum number of sapwood rings (15–40) would give the timbers an estimated felling date of some time between 1448 at the earliest and 1473 at the latest. The dates of the last rings on the other four samples in site chronology CANASQ01 would suggest that they too were felled at this time, and that all the timbers were cut as part of a single programme of felling specifically for their use in the construction of this roof.

Undated samples

Two measured samples, CAN-A01 and A10, remain ungrouped and undated. With 128 and 87 rings respectively, both samples are in theory quite satisfactory. Both samples do, however, show some disturbance to their ring patterns. While the possible disturbance to sample CAN-A01 is quite pronounced, with notable compression (narrowing of the annual growth ring widths) to the earlier growth of the tree, and then some rather indistinct rings to the middle and outer growth of the tree, that on sample CAN-A10 is quite slight, with only mild compression. It is possibly these features which make the cross-matching and dating of these timbers problematic.

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Table 1: Details of tree-ring samples from Cannington Court, Cannington, near Bridgwater, Somerset

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	South range roof					
CAN-A01	North principal rafter, truss 1	128	no h/s	------	------	------
CAN-A02	Collar, truss 1	nm	---	------	------	------
CAN-A03	North principal rafter, truss 2	76	no h/s	1341	------	1416
CAN-A04	South principal rafter, truss 2	92	no h/s	1332	------	1423
CAN-A05	North principal rafter, truss 3	68	no h/s	1342	------	1410
CAN-A06	South principal rafter, truss 3	74	no h/s	1353	------	1426
CAN-A07	Collar, truss 3	nm	---	------	------	------
CAN-A08	North principal rafter, truss 4	91	h/s	1340	1430	1430
CAN-A09	South principal rafter, truss 4	99	h/s	1337	1435	1435
CAN-A10	Collar, truss 4	87	no h/s	------	------	------
	North range (south wall)					
CAN-A11	Wall post	nm	---	------	------	------
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing						
nm = sample not measured						

Table 2: Results of the cross-matching of site chronology CANASQ01 and the reference chronologies when the first ring date is 1332 and the last ring date is 1435		
Reference chronology	*t*-value	
The Old Manor, West Lavington, Wilts	6.7	(Hurford and Tyers forthcoming)
Holy Trinity Church, Hagworthingham, Lincs	6.3	(Laxton *et al* 1984)
46 High Street, Exeter, Devon	6.1	(Arnold and Howard 2009)
England, London	5.9	(Tyers and Groves 1999 unpubl)
Lacock Abbey, Lacock, Wilts	5.8	(Esling *et al* 1990)
Ulverscroft Priory, Charnwood, Leics	5.6	(Arnold *et al* 2008)
St Mary Magdalene, Cowden, Kent	5.6	(Howard *et al* 1999)
Daubeneys, Colerne, Wilts	5.5	(Hurford *et al* forthcoming)

Site chronology CANASQ01 is a composite of the data of the relevant cross-matching samples as seen in the bar diagram Figures 7. This composite data produces an 'average' tree-ring pattern, where the overall climatic signal of the growth is enhanced, and the possible erratic variations of any one individual sample are reduced. This 'average' site chronology is then compared with several hundred reference patterns covering every part of Britain for all time periods, cross-matching with a number of these only at the time span indicated, the table giving only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity). It may be noticed from this Table that the resultant *t*-values are well in excess of the *t*=3.5 value usually taken as the minimum acceptable level for satisfactory dating. These values, along with the many other slightly lower, unlisted, cross-matches, indicate a very firm and reliable date for the Cannington Court timbers.

Figure 1a/b: Maps to show location of Cannington (top) and Cannington Court (bottom)

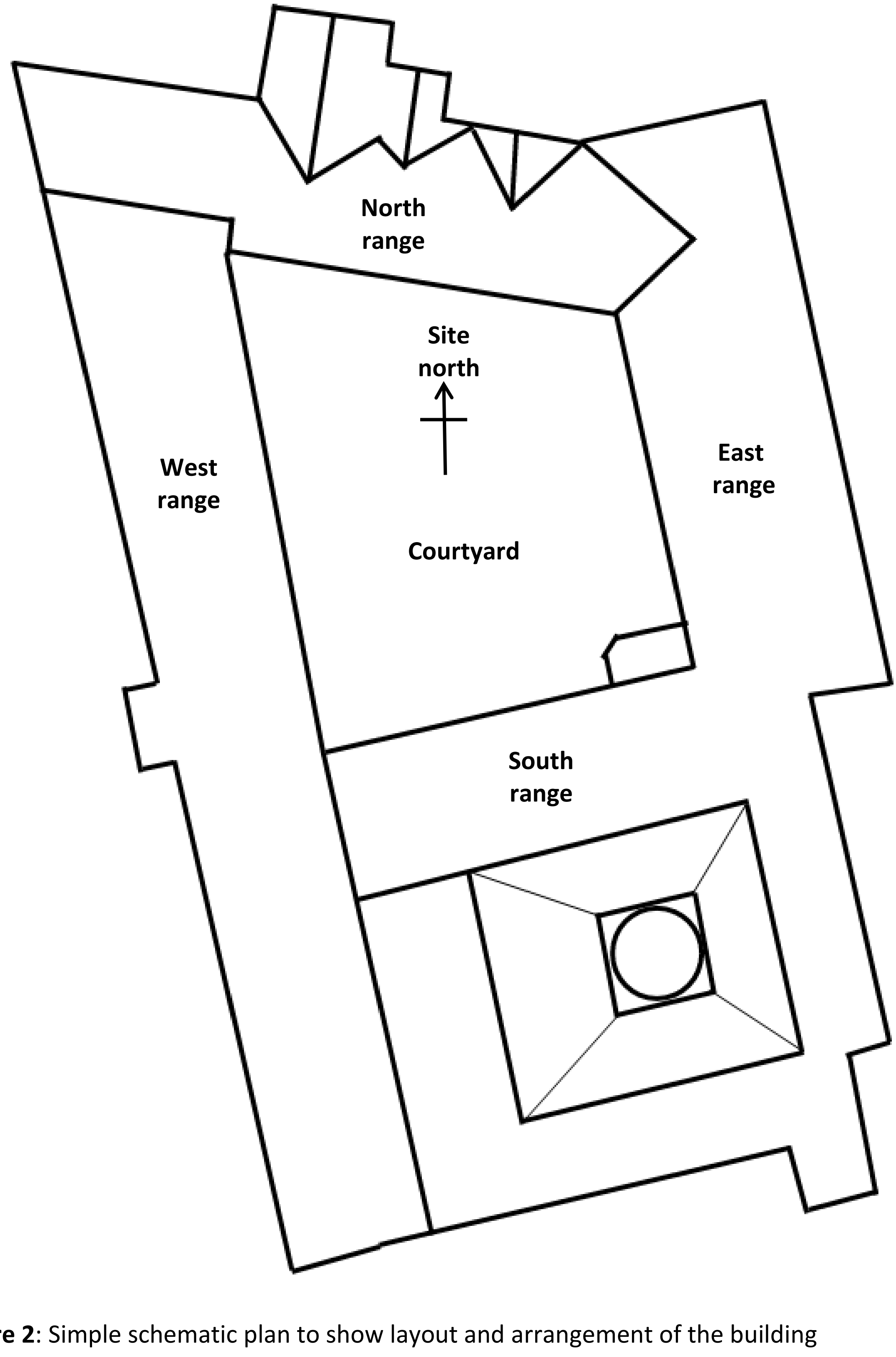


Figure 2: Simple schematic plan to show layout and arrangement of the building

Figure 3a–c: Views of the elm trusses to the west range (top and middle) and an example of a carpenter's assembly marks (bottom)

Figure 3d/e: Views of a truss of the sampled south range roof (top) and a post buried in the south wall of the north range (bottom)

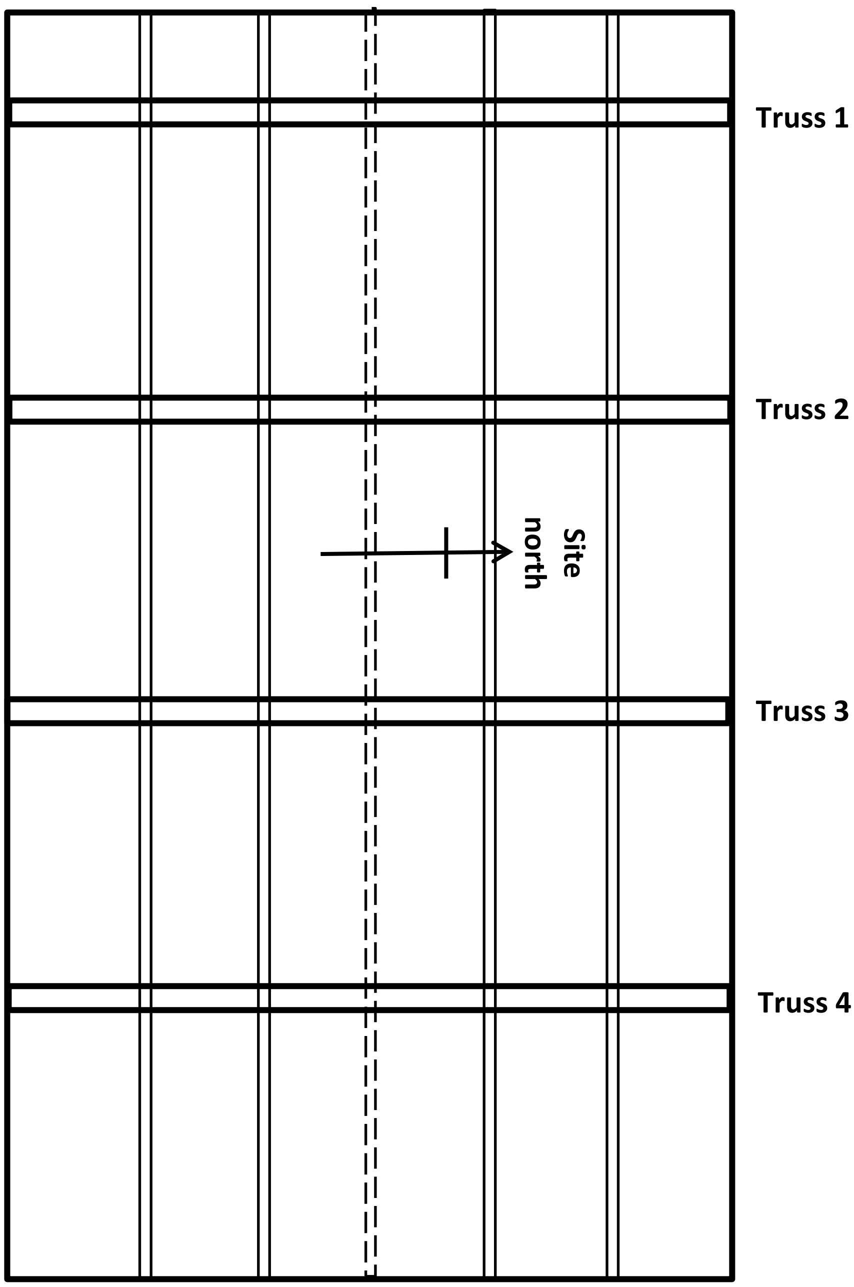


Figure 4: Simple schematic plan of the south range roof to show the layout and arrangement of the trusses

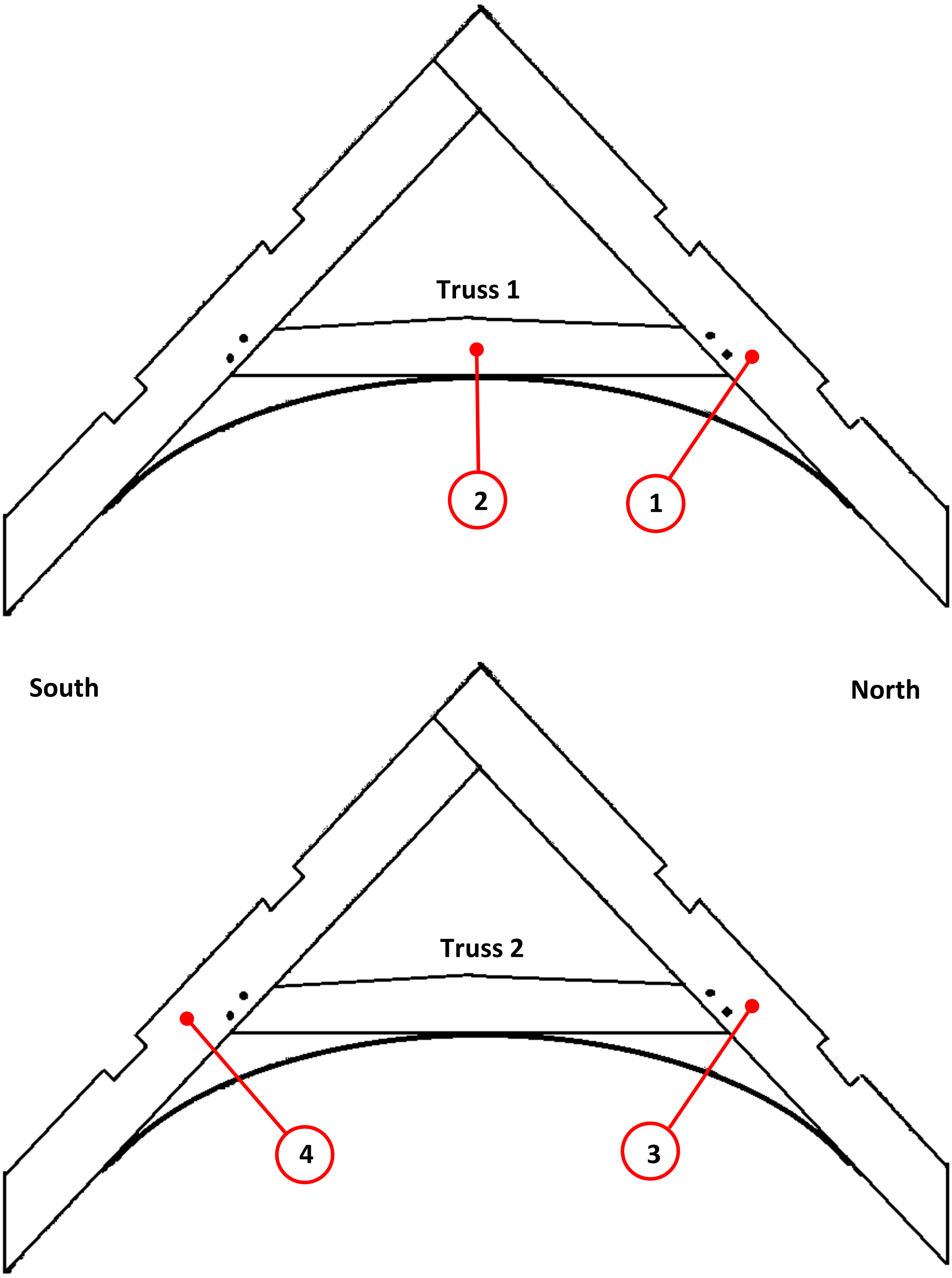


Figure 5a/b: Simple schematic drawings of the south range roof trusses to locate the sampled timbers

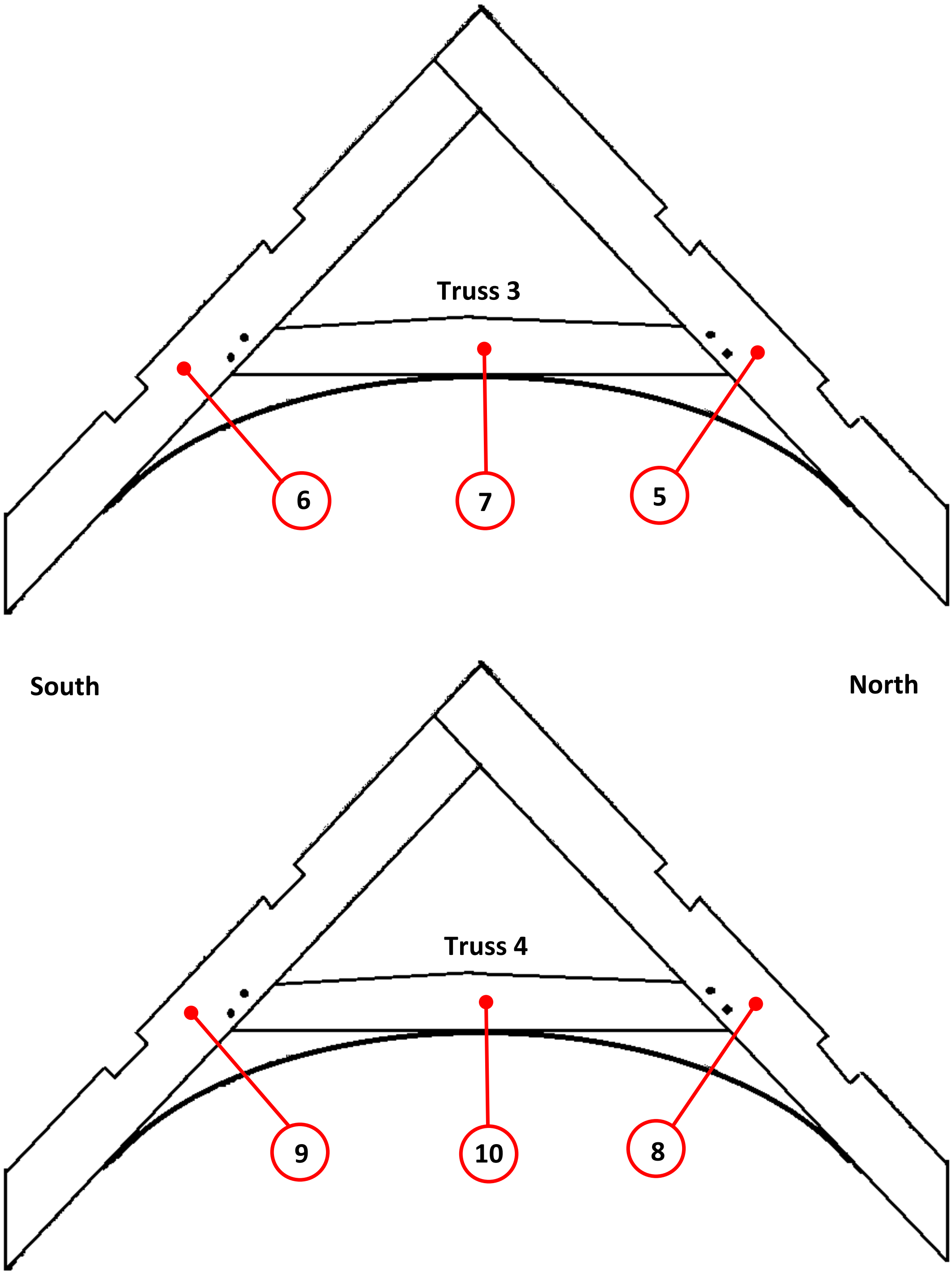


Figure 5c/d: Simple schematic drawings of the south range roof trusses to locate the sampled timbers

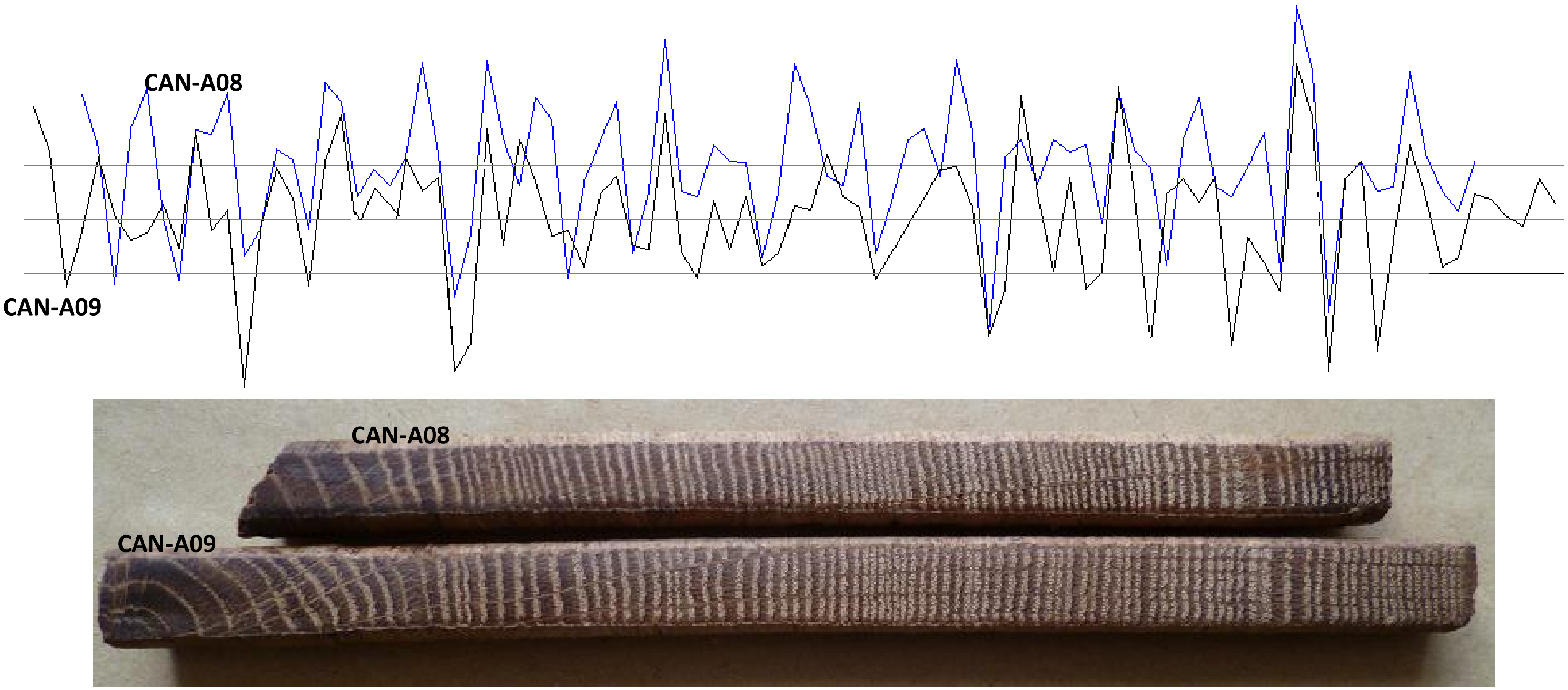
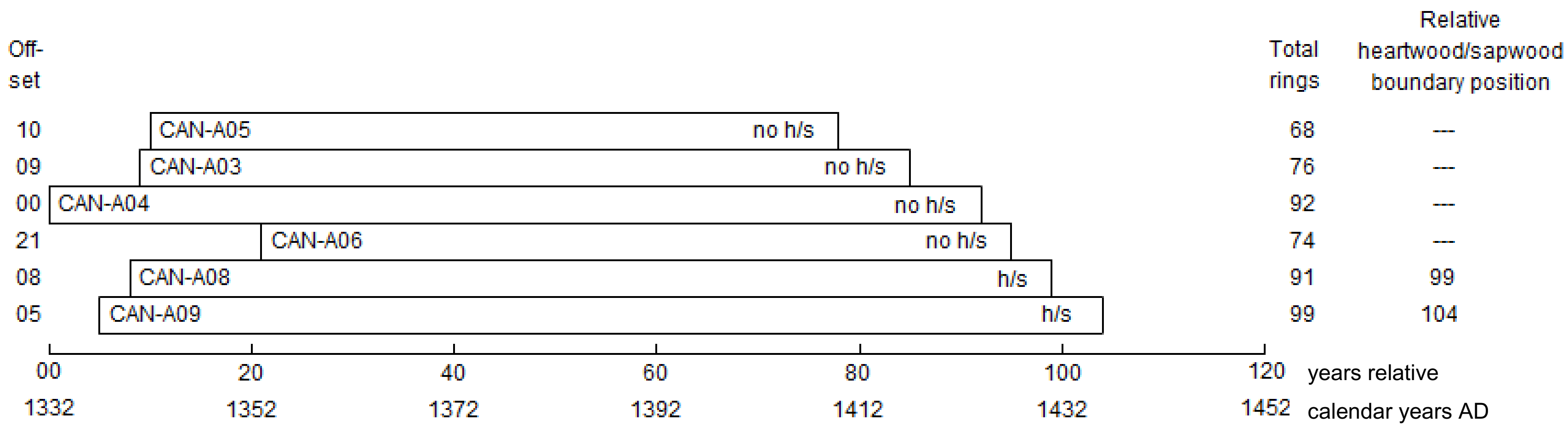


Figure 6: Graphic representation of the cross-matching of two samples, CAN-A08 and A09

When cross-matched at the correct positions, as here, the variations in the rings of these two samples correspond with a high degree of similarity. As the ring widths of one sample increase (represented by peaks in the graph), or decrease (represented by troughs), so too do the annual ring widths of the second sample. This similarity in growth pattern is a result of the two trees represented having grown in the same area *at the same time.* The growth ring pattern of two samples from trees grown at different times would never correspond so well.



blank bars = heartwood rings
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figure 7: Bar diagram of the samples in site chronology CANASQ01

The six samples of site chronology CANASQ01 are shown here in the form of a bar diagram at positions where the ring variations of the samples cross-match with each other. This similarity is produced by the trees represented sharing periods of growth in common (i.e., where the bars overlap). The samples are combined at these offsets to form a 'site chronology' which is compared with a large database of reference chronologies for all time periods for all parts of England. The site chronology cross-matches only with a date span of 1332, the date of the earliest ring on any individual sample (CAN-A04) to, the date of the latest ring on any individual sample (CAN-A09) (see Table 2).

None of the samples retain complete sapwood (the last ring produced by the tree before felling) and it is thus not possible to say with reliable precision when any of the trees were cut down. Two of the samples do, though, retain the heartwood/sapwood boundary (h/s), meaning that only the sapwood rings are missing. By taking the average date of this boundary (here 1433) and adding to this the minimum/maximum number of sapwood rings the trees are likely to have had (15/40), an estimated felling date range for the timbers of 1448–73 can be calculated.