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TREE-RING ANALYSIS OF TIMBERS FROM THE BARN AND MAIN HOUSE, ALDEBY HALL, ALDEBY, NEAR BECCLES, NORFOLK

A J ARNOLD
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SUMMARY

Analysis by dendrochronology of 23 of the 28 samples obtained from the timbers of a barn at Aldeby Hall (five of the 28 samples being unsuitable for dating), has resulted in the production of a single site chronology. This site chronology, comprising samples from 11 roof timbers, three ground floor ceiling beams, one first floor ceiling beam, one ground floor partition wall timber, and a ground floor window jamb (total 17 samples), has an overall length of 187 rings. These rings are dated as spanning the years 1422–1608. Interpretation of the sapwood on the dated samples would suggest the likelihood that all the trees used for these timbers were probably all cut as part of a single episode of felling at some point between 1614 at the earliest and 1626 at the latest.

A further single sample from a ground floor ceiling beam of the barn was dated individually. This sample has a last rings date of 1722. Allowing for missing sapwood rings on this sample it is likely that the tree represented was felled at some point between 1726 at the earliest and 1751 at the latest.

Five of the 23 measured samples from the barn remain ungrouped and undated.

In addition to the 28 samples from the barn, samples were obtained from two ceiling joists in the central (probably primary) range of the main house. These two samples were combined to form a second site chronology, this having an overall length of 54 rings. These 54 rings were dated as spanning the years 1442–1495. Interpretation of the sapwood on these samples would indicate that the trees used for these beams were also probably all cut as part of a single episode of felling at some point between 1510 at the earliest and 1535 at the latest.

NTRDL, 20 Hillcrest Grove, Sherwood, Nottingham, NG5 1FT
Telephone 0115 960 3833 (laboratory);
07980 305583 / 07913 427987 (Mobiles)
roberthoward@tree-ringdating.co.uk
alisonarnold@tree-ringdating.co.uk

Introduction

Aldeby Hall, standing some way to the south of the village of the same name (TM 444 928, Figs 1a/b), is a very fine Grade II listed country house with the outward appearance of being of eighteenth century date. Of colourwashed brick beneath a hipped roof of black glazed pantiles, it is of two storeys on an H-shaped plan with a façade of five bays: It has chimney stacks on the rear wall of the front range and large axial stacks on the ridge line. There are also large stacks on the east and west sides of the wings (Fig 2a).

The central range, between the two cross-wings, appears to be fully timber-framed, and is probably the primary element of the present structure (Fig 2b). The present roof of this range, however, is a later, probably eighteenth century, replacement.

Close to the main house stands a brick-built barn of eight bays (Fig 3) formed by the two gable end walls and seven principal rafter with collar trusses to the roof. There are raking struts between the tiebeams and the principal rafters, these rafters in turn supporting double purlins to each pitch of the roof (Fig 4a). The tiebeams of the trusses form the main ceiling beams of the first floor, while there are a further seven lower cross-beams forming the ceiling of the ground floor. To both ground and first floor ceiling there are smaller longitudinal joists between each of the cross-beams. At both ground and first floor there are timber-framed partition walls (Fig 4b), though there is no timberwork to the main, exterior walls at either ground or first floor level.

The brickwork, particularly to the east flank of the barn, has an open joint in it on the line of truss, and lower cross-beam, 4 (Fig 5). This has led to speculation that the two ends of the barn are of different dates to each other, either end or that it has been affected by some disturbance or alteration at this point.

Sampling

Sampling and analysis by tree-ring dating of the timbers within the barn and the central range of the main house at Aldeby Hall were commissioned by John Dean, consulting building archaeologist, on behalf of the owners, Mr and Mrs Atfield. This was conducted as part of a larger and more widespread survey and record of the site, including archaeological excavations, undertaken out of personal interest in the history of the site, and particularly for the repair and conservation of the barn building. It was hoped that this programme of tree-ring analysis would establish the date for the house and barn and determine how much of the fabric might be original and how much, if any my represent later repair and alteration. In particular it was hoped that tree-ring analysis might show whether or not the two ends of the barn were of the same or different dates.

With this aim in mind core samples were obtained from several different timbers of the barn during two episodes of felling, with a further two samples being obtained from the only apparently suitable timbers to the ground floor ceiling of the main range. In this last respect, although there were a larger number of other timbers of the main house in theory available for sampling, all appeared either to be derived from very fast-grown trees, and thus have insufficient numbers of rings for reliable dating, or, although appearing to be highly suitable

for dating, to be of a later phase of construction (ie, the roof), and to not form part of the immediate programme of investigation.

Each sample was given the code ADB-A (for Aldeby site 'A'), with the first batch of samples from the barn being numbered 01–11, and those from the main house being samples A12 and A13. The second batch of samples from the barn was numbered 14–30. The sampled timbers are located on plans based on those kindly provided by John Dean, or on photographs taken at the time of coring, these being given here as Figures 6a–8. 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 Table, and on the drawings, the trusses, bays, and individual timbers, have been located on a site north–south/east–west basis as appropriate.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank the owners of Aldeby Hall, Mr and Mrs Atfield, for their enthusiasm, help, and cooperation with this programme of analysis, and particularly for their generous funding of the project. We would also like to thank John Dean for arranging this programme, for help, advice, and comfortable hospitality, during sampling, and for so promptly providing the plans and drawings used in this report.

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 found preserved in archaeological excavations) 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 9)

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.

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 (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)).

Analysis

Each of the 30 samples obtained from the various timbers of the barn and the main house at Aldeby Hall were prepared by sanding and polishing. It was seen at this time that five of these five, samples ADB-A01, A04, A05, A06 and A30 (all from the barn), had too few rings

for reliable dating, ie, less than 35, and they were rejected from this programme of analysis. The annual ring widths of the 25 remaining samples were, however, measured and the data were then compared with each other as described in the notes above.

This comparative process indicated that 17 of the 23 measured samples from the barn cross-matched with each other, and could be formed into one single group, the length, relative position, and overlap of the respective samples of each group being shown in the bar diagrams Figure 10a. These 17 samples were combined at their indicated off-set positions to form ADBASQ01, a site chronology with an overall length of 187 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1422 to 1608. The evidence for this dating is given in the *t*-values of Table 2.

In addition, the two samples from the house (ADB-A12 and A13) also cross-matched with each other and could be formed into a second group, the length, relative position, and overlap of the respective samples of each group being shown in the bar diagrams Figure 10b. These two samples were combined at their indicated off-set positions to form ADBASQ02, a site chronology with an overall length of 54 rings. This site chronology was then also satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1442 to 1495. The evidence for this dating is given in the *t*-values of Table 3.

The six remaining, measured but ungrouped, samples were then compared individually with the full corpus of reference data, this indicating a cross-match only for sample ADB-A07 when the date of the first ring is 1673 and the date of the last ring is 1722. The evidence for this dating is given in the *t*-values of Table 4.

This analysis may be summarised as below:

Site sequence/ sample	Samples	Number of rings	Date span (where dated)
ADBASQ01	17	187	1422–1608
ADBASQ02	2	54	1442–1495
ADB-A07	1	50	1673–1722
Undated	5	---	------
Unmeasured	5	---	------

Interpretation

None of the dated samples in either site chronology retains complete sapwood (the last growth ring produced by the tree represented before it was cut down), and it is thus not possible to say with reliability exactly when any of the trees represented were felled. The majority of samples do, however, retain some sapwood or at least the heartwood/sapwood boundary (h/s in Table 1 and the bar diagrams), this last meaning that although all the sapwood rings (the most recent growth of the tree) have been lost from the core, it is *only* the sapwood rings that have been lost. Given that the number of sapwood rings on oak trees

generally lie within a certain figure (15–40 ring – see notes on tree-ring dating above), it is possible, taking into account the amount of sapwood remaining, and the date of the last extant ring on each sample, to calculate a felling date range within which it is very likely that the trees were cut.

Site chronology ADBASQ01 – the barn

The felling date range for a group of timbers is usually calculated by finding the average date of the heartwood/sapwood boundary of the samples which retain it (see Table 1 and bar diagram, Figure 10a). In this case the average heartwood/sapwood boundary ring date of the 13 samples in site chronology ADBASQ01 which have the heartwood/sapwood boundary is 1594. Adding to this the likely minimum/maximum number of sapwood rings, 15/40, would give these trees an estimated felling date of between 1609 at the earliest to 1634 at the latest.

However, if these trees had all been felled as early as 1609, then those represented by samples ADB-A02, A11, A15, A18, and A20, with heartwood/sapwood boundary ring dates of 1598/99, would have had only 10 or 11 sapwood rings. Furthermore, were all the timbers felled as late as 1634, the trees represented by sample ADB-A08, A17, and A27, with heartwood/sapwood boundary ring dates of 1586/87/88, would have had 46–48 sapwood rings. It will be seen that both these figures lie outside the 15/40 limit for the usual numbers of sapwood rings on oak trees, and while in theory this is possible, it is a little unlikely.

The earliest felling date of the timbers can thus perhaps be refined by allowing that the trees represented by samples ADB-A02, A11, A15, A18, and A20 had a minimum of 15 sapwood rings, and, with a heartwood/sapwood boundary ring date of 1599, could not, therefore, have been felled before 1614. The latest felling date of the timbers can also be refined by allowing that the tree represented by sample ADB-A08, A17, and A27, had a maximum of 40 sapwood rings, and, with a heartwood/sapwood boundary ring date of 1586, could not, therefore, have been felled after, say, 1626. It would appear, therefore, that he true felling date of the timbers lies between 1614 at the earliest and 1626 at the latest.

Sample ADB-A07 – the barn

One of the timbers from the barn, represented by sample ADB-A07, however, would appear to be later. This sample has a heartwood/sapwood boundary ring date of 1711. Allowing for a minimum/maximum of 15/40 sapwood rings would suggest that this timber was felled between 1726 at the earliest and 1751 at the latest

Site chronology ADBASQ02 – the main house

Both of the samples, ADB-A12 and A13, in site chronology ADBASQ02, retain the heartwood/sapwood boundary, this being dated to 1495, but no sapwood. Allowing again for a minimum/maximum of 15/40 sapwood rings would suggest that these timbers was felled between 1510 at the earliest and 1535 at the latest

Conclusion

It would appear, therefore, that in respect of the barn many of the roof timbers, plus at least some of the ground floor ceiling timbers, one first floor ceiling timber, a partition wall timber and possibly the window jamb, were felled during the first quarter of the seventeenth century, at some point between 1614–26. It would further appear likely that the barn underwent some change or alteration, perhaps something as simple as a repair or a replacement, in the second quarter of the eighteenth century, the timber used for this work being felled at some point between 1726–51.

Given that timbers of early-seventeenth century date are found to both ends of the barn, but a mid-eighteenth century timber is found close to the line of the open joint in the brickwork, this might suggest two possibilities. The first possibility is that the whole barn is of a single, early-seventeenth century, date and has simply undergone some slight, mid-eighteenth century, alteration or repair close to the line of the open joint. The second possibility is perhaps that there were two separate, but closely adjacent, early-seventeenth century buildings which have been joined together to form a single structure in the mid-eighteenth century.

Undated samples

Five measured samples, ADB-A10, A14, A21, A26, and A28 (all from the barn), remain ungrouped and undated. While, with only 39, 43, and 50 rings, less than the usual minimum for reliable dating of, this lack of dating is perhaps not unexpected for three of the samples, the other two samples have quite sufficient rings. None of the samples shows any problems such as distortion or compression, which might make cross-matching and dating difficult, and samples of similar length from this site have clearly dated. It is in theory possible that these timbers are of a completely different date and/or from a different woodland source, making them, in effect, a ‘singletons’, and while it is occasionally possible to date single samples (ie ADB-A07), it is often much more difficult. It is, in any case, a common feature in tree-ring analysis to have some samples which are inexplicably undated. Periodic attempts will be made to date these samples when further local reference data against which they can be compared, is accumulated.

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Table 1: Details of tree-ring samples from the barn and main house, Aldeby Hall, Aldeby, near Beccles, Norfolk

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
	Barn					
ADB-A01	Centre stud post, frame 7 (from north)	nm	---	------	------	------
ADB-A02	Ground floor ceiling beam 6	48	9	1561	1599	1608
ADB-A03	Ground floor ceiling beam 5	73	8	1530	1594	1602
ADB-A04	West stud post, frame 4	nm	---	------	------	------
ADB-A05	East cross-rail, frame 4	nm	---	------	------	------
ADB-A06	West cross-rail, frame 4	nm	---	------	------	------
ADB-A07	Ground floor ceiling beam 3	50	11	1673	1711	1722
ADB-A08	Ground floor ceiling beam 2	63	h/s	1524	1586	1586
ADB-A09	East ground floor cross-rail, frame 7	67	no h/s	1484	------	1550
ADB-A10	West cross-rail, frame 7	39	5	------	------	------
ADB-A11	First floor ceiling beam, frame 7	98	h/s	1501	1598	1598
	House					
ADB-A12	House, ground floor ceiling, south joist 5	54	h/s	1442	1495	1495
ADB-A13	House, ground floor ceiling, north joist 6	50	h/s	1446	1495	1495

*h/s = the last ring on the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing

nm = sample not measured

Table 1: Details of tree-ring samples from the barn and main house, Aldeby Hall, Aldeby, near Beccles, Norfolk

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
	Barn					
ADB-A14	East principal rafter, truss 1	83	h/s	------	------	------
ADB-A15	West principal rafter, truss 1	87	h/s	1512	1598	1598
ADB-A16	Collar, truss 1	63	h/s	1531	1593	1593
ADB-A17	East principal rafter, truss 2	126	h/s	1462	1587	1587
ADB-A18	West principal rafter, truss 2	118	h/s	1482	1599	1599
ADB-A19	Collar, truss 2	85	h/s	1505	1589	1589
ADB-A20	West principal rafter, truss 3	112	h/s	1488	1599	1599
ADB-A21	Collar, truss 3	58	h/s	------	------	------
ADB-A22	West principal rafter, truss 4	100	h/s	1497	1596	1596
ADB-A23	Collar, truss 5	48	no h/s	1489	------	1536
ADB-A24	East principal rafter, truss 6	175	5	1422	1591	1596
ADB-A25	Collar, truss 6	56	no h/s	1514	------	1569
ADB-A26	Collar, truss 7	50	h/s	------	------	------
ADB-A27	Collar truss 4	67	h/s	1522	1588	1588
ADB-A28	East strut, truss 5	43	h/s	------	------	------
ADB-A29	Left window jamb	52	no h/s	1485	------	1536
ADB-A30	Right window jamb	nm	---	------	------	------
					20717=1595	16(10)15-35

*h/s = the last ring on the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing

nm = sample not measured

Table 2: Results of the cross-matching of site chronology ADBASQ01 and the reference chronologies when the first ring date is 1422 and the last ring date is 1608

Reference chronology	*t*-value	
Apethorpe Hall, Apethorpe, Northants	10.3	(Arnold and Howard forthcoming a)
Powchers Hall, Ely Cathedral, Cambs	9.4	(Arnold *et al* 2004a)
Cratfield bellframe, Suffolk	9.2	(Bridge 2008)
Queen's Hall, Ely Cathedral, Cambs	8.9	(Arnold *et al* 2004a)
Flore's House, Oakham, Rutland	8.5	(Hurford *et al* 2008)
Oakham Castle, Oakham, Rutland	7.2	(Arnold and Howard forthcoming b)
Nevill Holt, Leicestershire	6.8	(Arnold *et al* 2008)
St Leonard's Church, Apethorpe, Northants	6.1	(Arnold and Howard 2008)

Table 3: Results of the cross-matching of site chronology ADBASQ02 and the reference chronologies when the first ring date is 1442 and the last ring date is 1495

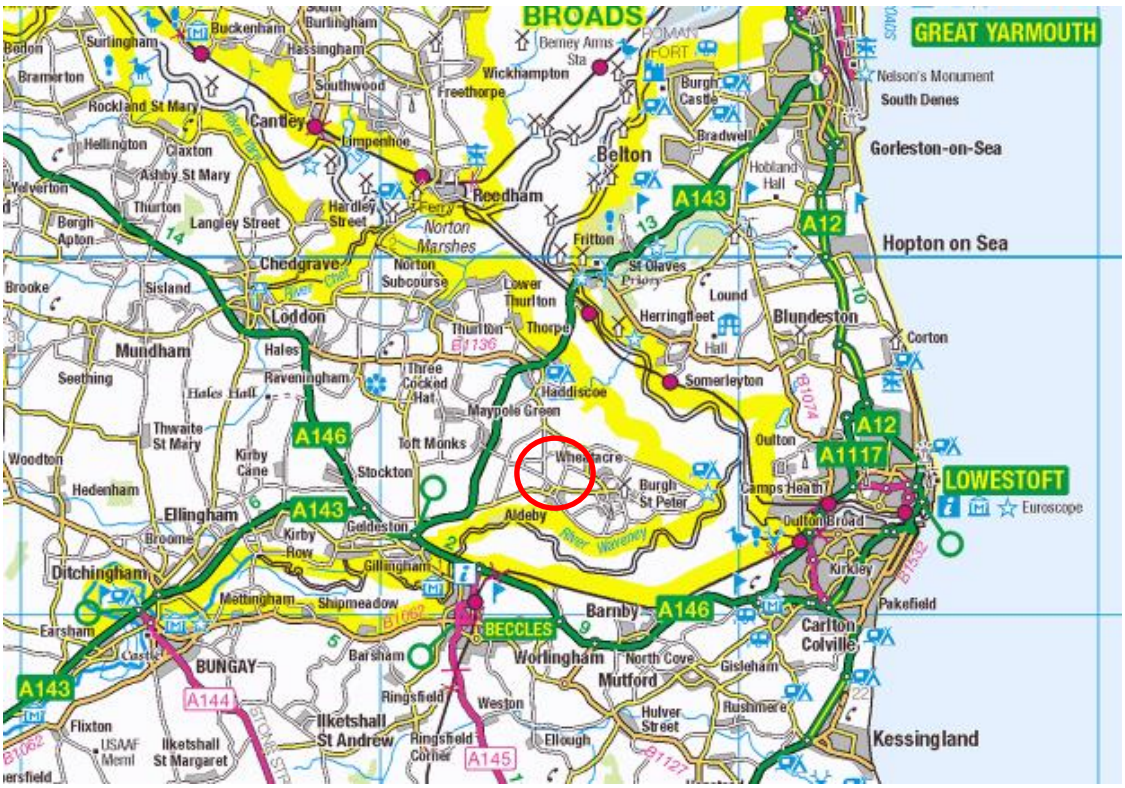
Reference chronology	*t*-value	
St Mary's Church, Attelborough, Norfolk	7.1	(Bridge 2004)
Danny House, West Sussex	7.0	(Miles *et al* 2010)
Hampshire County Chronology	6.3	(Miles 2003)
Trentham's Barn, Purley, Berks	6.2	(Howard *et al* 1996)
Pye Corner, Moulsford, Oxon	6.2	(Alcock *et al* 1991)
Westenhanger working mean, Kent	5.4	(Arnold and Howard 2009 unpubl)
Salisbury Cathedral, Wilts	5.3	(Miles *et al* 2005)
Chicksands Priory, Beds	5.2	(Howard *et al* 1998)

Table 4: Results of the cross-matching of sample ADB-A07 and the reference chronologies when the first ring date is 1673 and the last ring date is 1722

Reference chronology	***t*-value**	
Cobham Hall, Cobham, Kent	5.4	(Arnold *et al* 2003)
Croome Court, Worcestershire	5.4	(Arnold *et al* 2004c)
Coates' Barn, Cosby, Leics	5.3	(Alcock *et al* 1991)
England, London	5.2	(Tyers and Groves 1999 unpubl)
Kibworth Harcourt Mill, Leics	5.1	(Arnold *et al* 2004b)
Sarehole Mill, Hall Green, Birmingham	5.0	(Howard *et al* 1986 unpubl)
Hampshire County Chronology	4.7	(Miles 2003)

Site chronologies ADBASQ01 and SQ02 (above and Figs 10a/b) are composites of the data of the relevant cross-matching samples, this producing 'average' tree-ring patterns, where the overall climatic signal of the ring growth is enhanced, and the possible erratic variations of any one individual sample is reduced. These 'average' site chronologies are then compared with several hundred reference patterns covering every part of Britain for all time periods. As can be seen here, site chronology ADBASQ01 matches only when its 187 rings span the years 1422–1608, and site chronology ADBASQ02 matches only when its 54 rings span the years 1442–1495, the degree of similarity between site and reference chronology being indicated by the '*t*-values'.

Sample ADB-A07 has been compared individually with the full corpus of reference data, its rings matching only over the years 1432–1722.



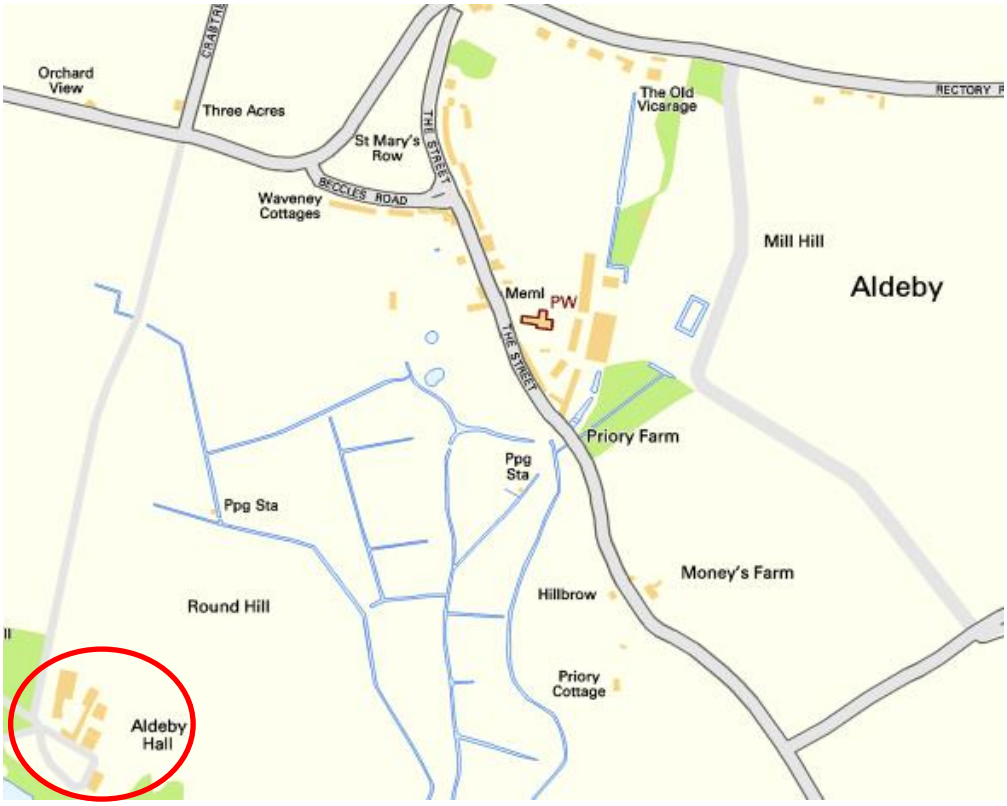


Figure 1a/b: Maps to show location of Aldeby (top) and Aldeby Hall (bottom)

Figure 2a/b: External view of the Hall showing the primary range between the two projecting wings (top), and internal view of ground floor ceiling joists (bottom)

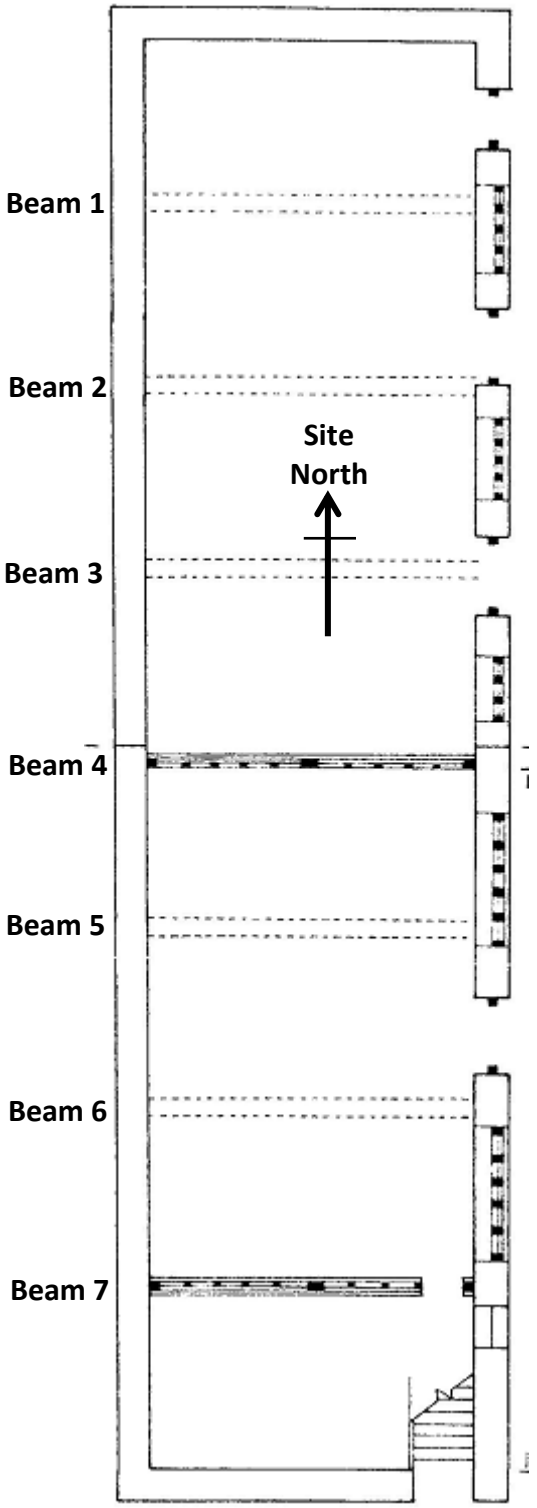


Figure 3: Ground floor plan of the barn to show layout and arrangement of the beams and partition walls (after John Dean

Figure 4a/b: View of the roof trusses to the barn (top) and the ground floor ceiling beams and partition wall (bottom)

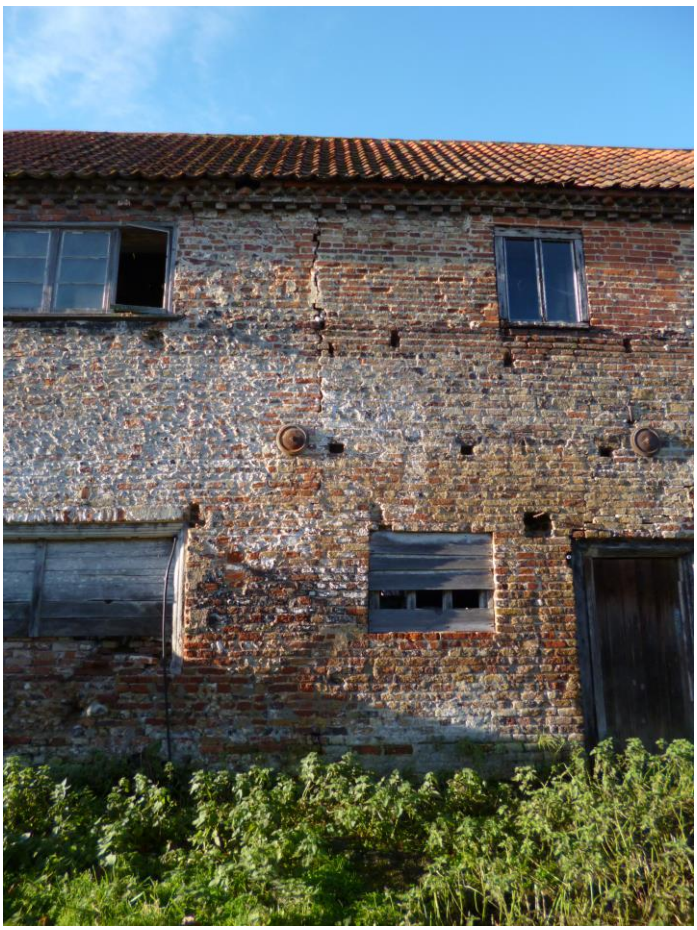


Figure 5: View of the open jointed brickwork to the east face of the barn believed to indicate a possible junction of two buildings.

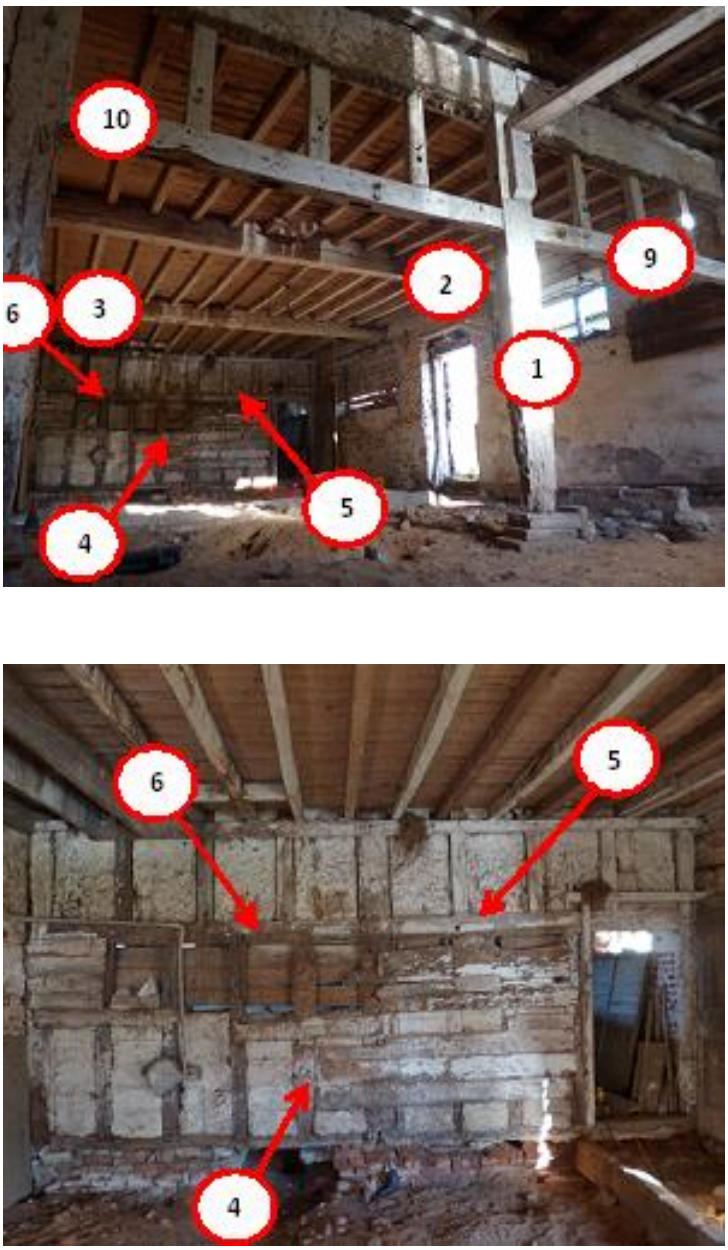


Figure 6a/b: Views of the interior of the barn to locate the sampled timbers (see Table 1)

Figure 6c/d: Views of the interior of the barn to locate the sampled timbers (see Table 1)

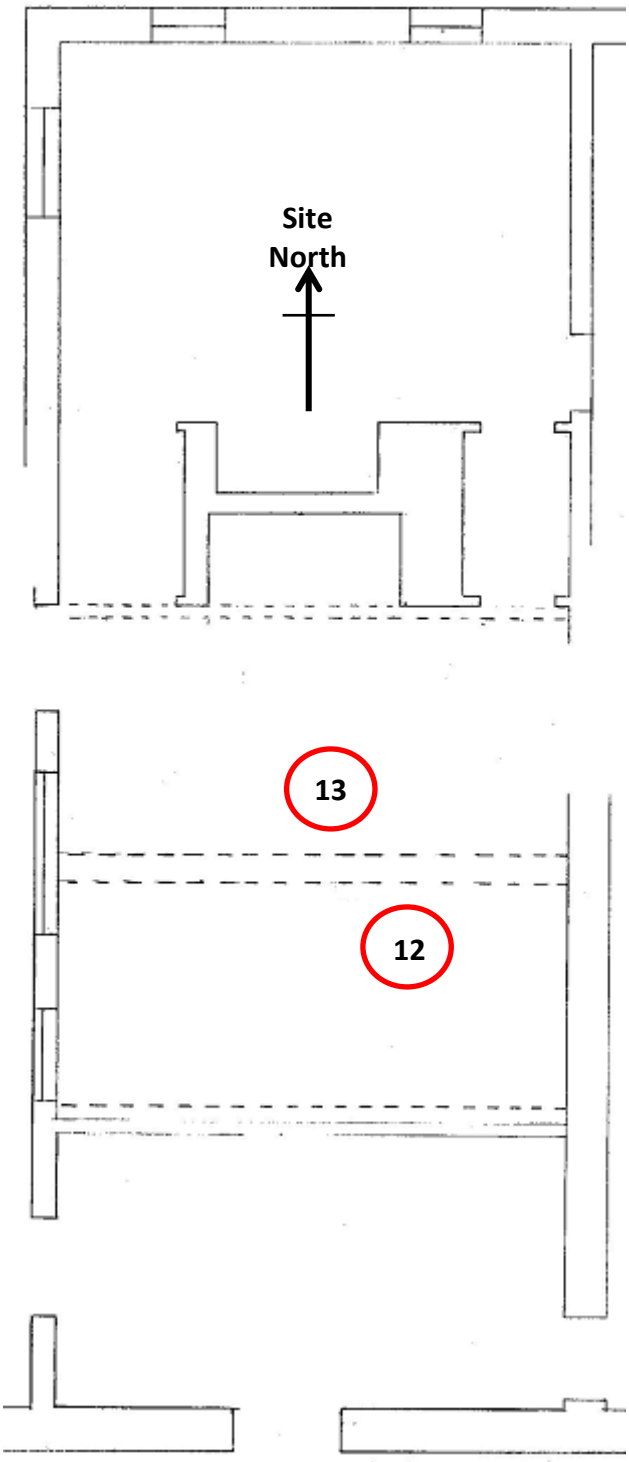


Figure 7: Plan of the central range of the house to show approximate position of the samples timbers (see Table 1) (after John Dean)

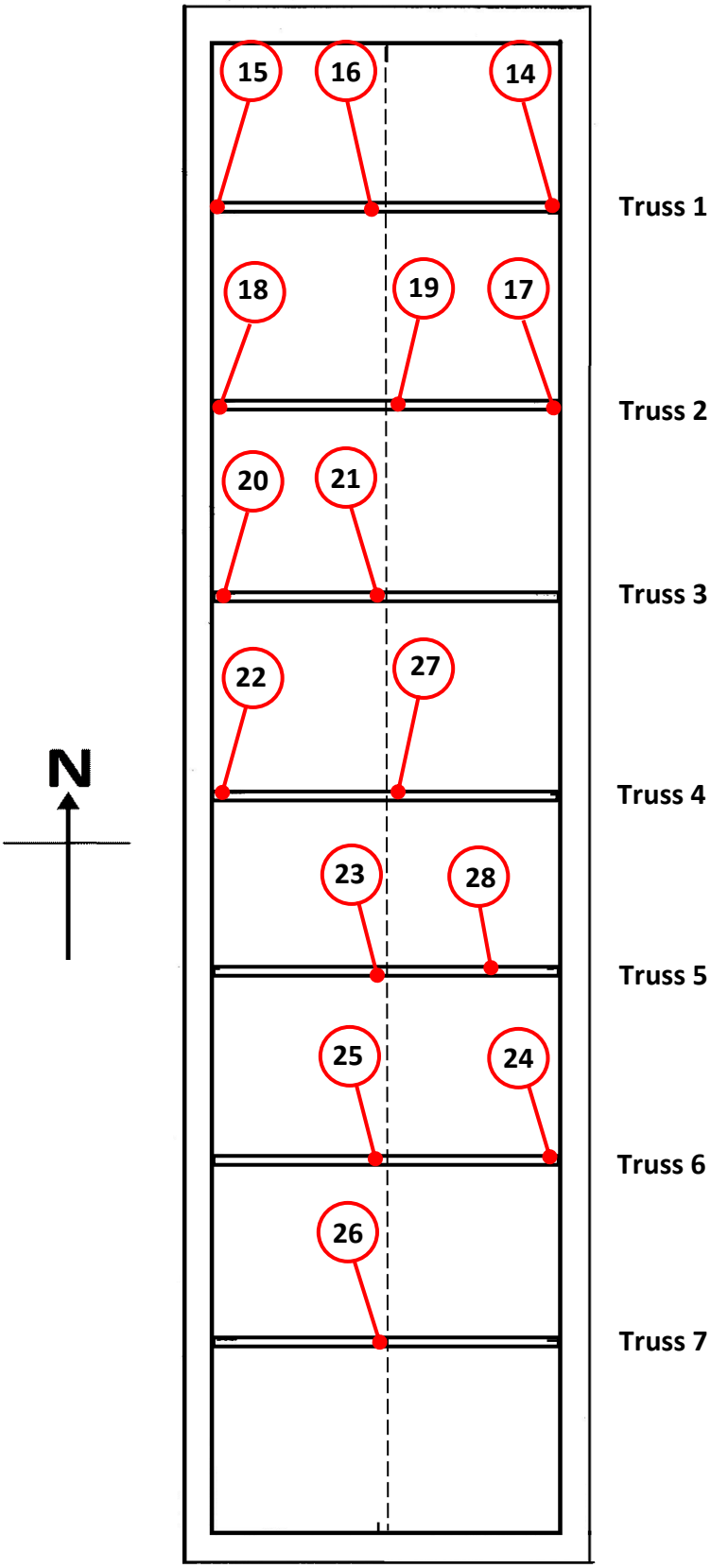
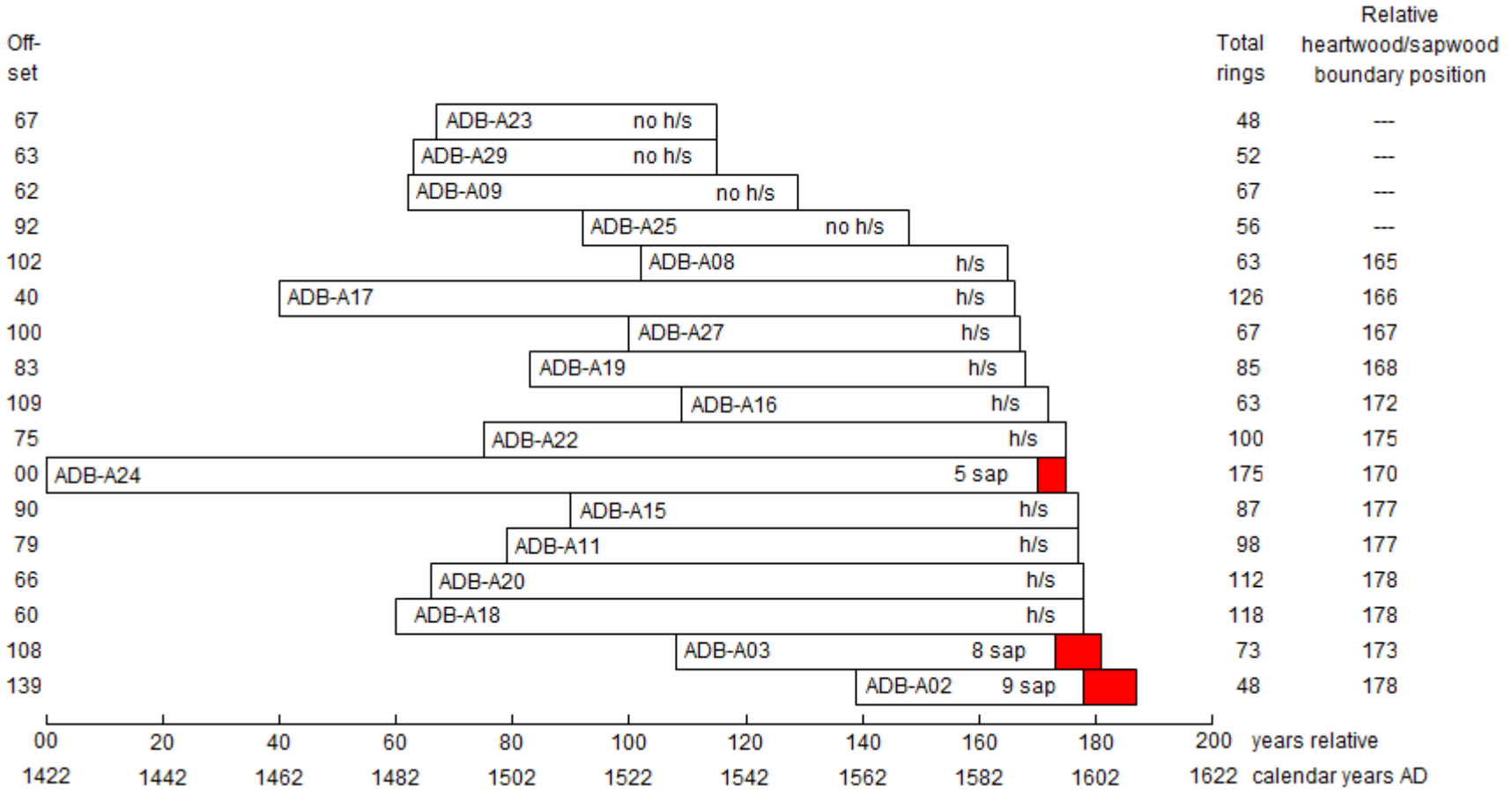


Figure 8: Plan of the upper level of the barn to show the positions of the trusses and identify the location of the sampled timbers (see Table 1) (after John Dean)

Figure 9: Graphic representation of the cross-matching of samples ADB-A19 and A22

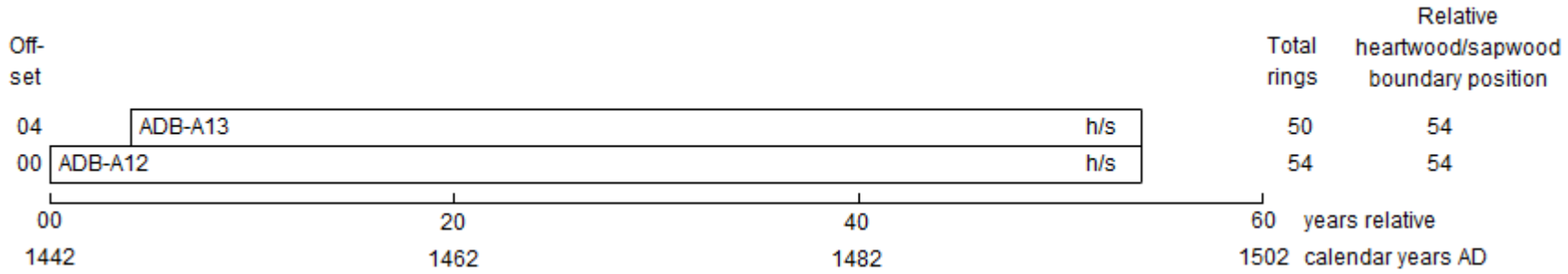
When cross-matched at the correct positions, as here, the variations in the rings of two samples correspond with a high degree of similarity. As the ring widths of one sample increase (represented by peaks in the graph), or decrease (represented by troughs), so too do the annual ring widths of the second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



White bars = heartwood rings, shaded bars = sapwood rings

h/s = the last ring on the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing

Figure 10a: Bar diagram of the samples in site chronology ADBASQ01



White bars [ ] = heartwood rings
h/s = the last ring on the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing

Figure 10b: Bar diagram of the samples in site chronology ADBASQ02

The samples in site chronologies ADBASQ01 and ADBASQ02 are shown in the form of 'bars' at the positions where the variations in the rings cross-match with each other, this similarity being produced by the trees from which the sampled beams were derived all growing at the *same time* in the *same place.* The samples are combined to form 'site chronologies', and it is these 'averaged' ring widths which are dated by comparison and 'cross-matching' with the 'reference' chronologies.