Dendrochronology, timber analysis, and historic building consultants

NEW HOUSE FARM,
MOCCAS,
HEREFORDSHIRE

TREE-RING ANALYSIS OF TIMBERS

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Summary

A total of twenty one core samples was obtained from the timbers of the still standing cross-wing of a now lost ceiled hall range of New House Farm, Moccas, and the timbers of an adjacent barn range. Analysis by dendrochronology of these samples shows that the cross-wing is built of timbers felled in 1584 specifically for its construction, with a single timber of this date also being reused in what is probably a later inserted or remodelled chimney stack.

The barn range also contains some reused 1584 timbers (presumably used originally in the hall range), along with one timber felled in 1611. Other timbers of the barn have an estimated felling date of between 1631 at the earliest and 1656 at the latest. These latter timbers probably indicate the construction date of the barn range and provide a *terminus ante quem* for the destruction of the now lost hall range.

From the cores obtained here a single site chronology comprising 13 samples was created, this having an overall length of 235 rings, these rings dated as spanning the years 1350–1584. A second site chronology of two samples was also created, its 89 rings spanning 1552–1618.

Two further site chronologies of two samples each were also created, one with an overall length of 70 rings, the other of 59 rings, but neither of these could be dated.

A further sample was dated individually, its 60 rings spanning the years 1560–1611.

One last sample remains both ungrouped and undated.

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Introduction

New House Farm, standing a short distance south of the B4352 between Bredwardine and Blackmere, near Hay on Wye in Herefordshire (SO 356 402, Fig 1a/b), is the remaining north-south aligned, two-bay, two-story with attics, timber-framed, cross-wing of a now-lost hall range, also of two storeys, which ran to its west (Figs 2 and 3a). On the basis of stylistic evidence and constructional form it is believed that the hall and cross-wing were originally built in the late-sixteenth or early-seventeenth century, and that the hall range was largely destroyed, reputedly by fire, at some unknown date thereafter.

Approximately 12 metres west of the surviving cross-wing, and on a parallel north-south alignment, is a long, four-bay, barn, also timber-framed (Fig 3b). It is believed that this barn is of late-seventeenth century date. The barn is linked to the cross-wing by a stone and brick, single storey, range.

The buildings have been the subject of detailed survey and recording which describe the features of the buildings and provide an interpretation of its history and development (James 2012). The report indicates that the cross-wing, with its three principal rafter with collar roof trusses and the first- and ground-floor ceiling frames (Fig 4a/b), along with two similar trusses remaining from the hall range and now forming a very short, east-west bay, would appear, structurally and stylistically, to be all of a single phase of construction, although having undergone some slight alteration. Amongst these alterations is the apparently anomalous position of a chimney stack and its ground and first-floor fireplaces, the evidence suggesting that these are possibly later insertions.

The 2012 survey report also indicates that the five trusses of the barn, on the other hand, are of a variety of forms and appears to possibly contain timbers of different dates, with some, particularly amongst the main wall posts, being reused, while other timbers are later insertions (Fig 5a/b). Although the trusses are in essence of principal rafter with tiebeam form, they have variations in the struts, studs, and positions of the collars. Some of the timbers also show evidence of slight decay as if they had once been exposed to weathering. There is thus some uncertainty over the date and possible development of this building.

Sampling

Sampling and analysis by tree-ring dating of the timbers of the cross-wing and barn of New House Farm were commissioned by the owner, Dr Rachel Jenkins. This was programme of work was undertaken out of personal interest in the building, for its history and development, and for its continuing conservation. It was hoped that tree-ring analysis would establish the date of the potentially original timbers of the cross-wing and the remains of the hall range with greater precision and reliability. It was also hoped that analysis might help determine the relationship of the chimney stack to the cross-wing, determine the construction date of the barn, and give some indication as to how much reused material there might be in the barn, and of what date this might be.

Thus, from the suitable timbers available a total of 21 core samples was obtained. Each sample was given the code MOC-A (for Moccas, site ‘A’), and numbered 01–21. The layout and arrangement of the trusses of the cross-wing and barn are shown in Figure 2, with the sampled timbers being identified and located on drawings made and provided by Duncan James and on annotated photographs, these shown here as Figures 6a–e. In this report the trusses are identified following the scheme of the 2012 buildings survey, with the trusses of the cross-wing being numbered T1–T5, while those of the barn are numbered BT1–BT5.

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.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank Dr Jenkins for commissioning and generously funding this programme of analysis, and the help and cooperation given during sampling. The Laboratory would also like to thank Duncan James for promoting this programme of work and for his considerable help with the interpretation of the phases of the building. We would also like to thank Duncan for the use of his notes in the introduction above and his plans and drawings used elsewhere in this report.

<u>Tree-ring dating</u>

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.

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)).

Analysis

Each of the 21 samples obtained from the various timbers of the cross-wing and barn range at New House Farm was prepared by sanding and polishing and the widths of its annual growth rings were measured. The data of these measurements were then compared with each other as described in the notes above. By this comparative process four different groups of cross-matching samples could be formed.

Site chronology MOCASQ01

The first group comprises 13 samples, the samples cross-matching with each other at the relative positions shown in the bar diagram Figure 7. The majority of these samples, MOC-A01–A09, are from the various timbers of the cross-wing, including the massive fireplace lintel, but three of them, samples MOC-A19, A20, and A21, are respectively from a door jamb or main wall posts of the barn range (all three samples showing some evidence for having been reused in their present positions).

The 13 samples of this first group were combined at their indicated off-set positions to form MOCASQ01, a site chronology with an overall length of 235 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1350 to 1584. The evidence for this dating is given in the *t*-values of Table 2.

Two of the samples in this group, MOC-A03 and MOC-A04, respectively from the north upper purlin between trusses T4–T5 and the south raking strut of truss T4, retain complete sapwood. This means that each sample has the last growth ring produced by the tree it represents before it was cut down (this being indicated by upper case 'C' in Table 1 and the bar diagram Figure 7). In both cases the last, complete, sapwood ring, and thus the felling date of the trees, is the same at 1584.

Of the remaining samples, seven retain some sapwood or at least the heartwood/sapwood boundary, this meaning that although they have lost some, or all, of their sapwood rings, it is *only* the sapwood rings that they have lost (the number of sapwood rings on oak trees generally lying within known limits – see notes above). Given that the relative position and date of the heartwood/sapwood boundary on these seven samples is at a very similar position to that on the samples from the trees whose felling date (1584) is known, it is virtually certain that these seven samples represent trees which were also felled in 1584.

Finally, while it is not possible to be absolutely certain that the four final samples of this group also represent trees felled in 1584, it is very likely that they do. This uncertainty is due to the fact that these four samples do not have the heartwood/sapwood boundary and have thus lost not only all their sapwood rings, but an unknown number of heartwood rings as well; in theory, it is possible that they were felled at any time after the date of their last extant ring. However, given the high degree of cross-matching between all 13 samples of this group it is very likely that the source trees were originally growing close to each other in the same copse or stand of woodland and it is unlikely that such trees, having been felled at different times, would come to be used in the same building as each other. The implication therefore, is that all the trees of this group were felled at the same time as each other in 1584.

Site chronology MOCASQ02

The second group to form comprises two samples, MOC-A15 and A16, respectively from the tiebeam and collar of truss BT4 of the barn range, the two samples cross-matching with each other at the relative positions shown in the bar diagram Figure 8. The two samples were combined at their indicated off-set positions to form MOCASQ02, a site chronology with an overall length of 89 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1530 to 1618, the evidence for this dating being given in the *t*-values of Table 3.

Neither of the two samples in site chronology MOCASQ02 retains complete sapwood on its core (the last growth ring produced by the tree represented before it was cut down), and it is thus not possible to say for certain exactly when either of the trees represented were felled. The two samples do, though, retain the heartwood/sapwood boundary (h/s in Table 1 and the bar diagram), this 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 to calculate a felling date range within which it is very likely that the trees were cut. This is done by taking the heartwood/sapwood boundary dates of the two samples, here 1614 and 1618, and calculating the average date, here 1616. To this is added the likely minimum and maximum number of sapwood rings (15–40), giving the timbers an estimated likely felling date of some time between 1631 at the earliest and 1656 at the latest.

Site chronologies MOCASQ03 and MOCASQ04

The third and fourth groups to form also comprises two samples each, MOC-A11 and A17, respectively from the vertical mid posts from cill to tiebeam of trusses BT3 and BT4, and samples MOC-A14 and A18, from the west lower purlin, truss BT3–BT4 and the west lower purlin, truss BT4–BT5, respectively, the samples of each group cross-matching with each other at the relative positions shown in the bar diagrams, Figures 9 and 10. The samples of each group were also combined at their off-set positions, forming site chronologies MOCASQ03 and SQ04, of length 71 and 59 rings respectively.

Each site chronology was then compared to the full corpus of reference data for oak, but there was no satisfactory cross-matching at any position and the two samples of each group must, therefore, remain undated for the moment. It is likely that, as further relevant local reference data is accumulated, further attempts will be made to date these samples.

It may be of interest to note that the level of cross-matching between samples MOC-A11 and A17, from the vertical mid posts of trusses BT3 and BT4, is sufficiently high (ie, the similarity of the growth patterns of each sample is so similar) as to suggest that both timbers have in fact been derived from the same tree. Such an interpretation is supported by the fact that both beams appear to be half-trees and have a similar shape and knot pattern. It is probably that the timbers represented by samples MOC-A14 and A18 are likely to be derived from two separate individual trees.

Samples MOC-A10 & MOC-A11

The two remaining ungrouped samples, MOC-A10 and MOC-A11, respectively from the east upper purlin of trusses BT2–BT3, and the tiebeam of truss BT3, were then compared individually with the full corpus of reference material. This indicated a cross-match and date for sample MOC-A11 only, its 60 rings dated as spanning 1552 – 1611. The evidence for this dating is given in the t-values of Table 4. This core sample also retains complete sapwood, the last ring produced by the tree before felling, this last ring, and thus the felling of the tree being dated to 1611.

Sample MOC-A10 must remain both ungrouped and undated.

Interpretation

It would appear, therefore, perhaps as intimated by the structural and carpentry evidence of the two buildings of this site, that the cross-wing (represented by sample MOC-A01, A02, A06, A07, and A08) and the lost hall (the remnants of this represented by samples MOC-A3, A04, and A05), is of a single phase of construction, this dating to 1584. Of particular interest to the interpretation of the range is the date of the chimney in bay 3 which, as intimated by its positioning and the structural evidence, it is believed to be a later insertion. Tree-ring dating, however, indicates that its oversize lintel was cut as part of the 1584 felling. It is likely, therefore, that this timber has been reused here and that the chimney is not a late-sixteenth century feature but is part of a later reordering of the site, perhaps dating to the mid-seventeenth century (see below).

The barn range, on the other hand, contains timbers of different dates. Some of the timbers here belong to the 1584 felling, and are almost certainly reused from the lost hall. At least one barn timber was felled in 1611, while other barn timbers were felled at some point between 1631 and 1656. Given that these middle-seventeenth century timbers probably represent the construction of the present barn, and taking account of the position of the barn relative to the remaining cross-wing, this date might give a *terminus ante quem* for the destruction of the hall range, and thus, possibly, of the insertion of the chimney and fire places into the cross-wing.

Woodland source

In this instance it is not possible to be absolutely precise as to the exact location of the original woodland source for the timbers used at New House Farm. However, as may be particularly illustrated in Table 2, although site chronology MOCASQ01 has been compared with reference chronologies from all over Britain, a series of particularly high *t*-values (or the greatest degrees of similarity), are found against those chronologies made up of material from other sites in ‘western’ England, with particularly good matches against other sites in Herefordshire (Shelsley Walsh) and Worcestershire (Feckenham). This would suggest, perhaps not unexpectedly, that the timbers used here are from a similar general area.

Undated samples

Although some samples (MOC-A13/A17, and MOC-A14/A18) cross-match with each other and group, indicating that the timbers they represent are of the same phase of felling as each other, they, plus one further individual sample, MOC-A10, have failed to cross-match with the reference chronologies and date. Both groups, and the single sample, certainly contain sufficient data for reliable analysis, and in theory are suitable for dating. A number of the samples, however, show bands of compressed or distorted annual growth rings, probably caused by some non-climatic event such as pollarding of lopping. It is possibly this disturbance which precludes their satisfactory dating, such phenomenon being a common feature of tree-ring analysis.

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Table 1: Details of tree-ring samples from New House Farm, Moccas, Herefordshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Cross-wing range					
MOC-A01	East middle purlin, truss T1 – T2	149	no h/s	1374	------	1522
MOC-A02	West middle purlin, truss T1 – T2	129	h/s	1429	1557	1557
MOC-A03	North middle purlin, truss T4 – T5	162	39C	1423	1545	1584
MOC-A04	South raking strut, truss T4	137	43C	1448	1541	1584
MOC-A05	Tiebeam, truss T4	144	no h/s	1350	------	1493
MOC-A06	North beam, first floor ceiling	120	17	1451	1553	1570
MOC-A07	East wall post, truss T2	180	22	1396	1553	1575
MOC-A08	North-west beam, ground floor ceiling	122	no h/s	1387	------	1508
MOC-A09	Fireplace bressumer	131	2	1440	1568	1570
	Barn range					
MOC-A10	East upper purlin, truss 2 – 3			------	------	------
MOC-A11	Tiebeam, truss BT3	60	22C	1552	1589	1611
MOC-A12	Collar, truss BT3	79	10	1471	1539	1549
MOC-A13	Mid post, cill to tiebeam, truss BT3	60	16	------	------	------
MOC-A14	West lower purlin, truss BT3 –BT4	52	15c	------	------	------
MOC-A15	Tiebeam, truss BT4	64	h/s	1555	1618	1618
MOC-A16	Collar, truss BT4	85	h/s	1530	1614	1614
MOC-A17	Mid post, cill to tiebeam, truss BT4	60	25C	------	------	------
MOC-A18	West lower purlin, truss BT4 – BT5	59	23C	------	------	------

Table 1: continued

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Barn range					
MOC-A19	West door jamb, truss BT2	77	h/s	1481	1557	1557
MOC-A20	West wall post, truss BT3	140	h/s	1402	1541	1541
MOC-A21	West wall post, truss BT4	115	no h/s	1361	------	1475

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

C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the tree represented

c = complete sapwood is found on the timber, but all or part has been lost from the sample in coring

Table 2: Results of the cross-matching of site chronology MOCASQ01 and the reference chronologies when the first ring date is 1350 and the last ring date is 1584		
Reference chronology	*t*-value	
Lower Bean Hall, Feckenham, Worcs	9.3	(Arnold and Howard 2005 unpubl)
Court House, Shelsley Walsh, Herefs	9.0	(Arnold *et a*l 2008)
Gatehouse, Kingswood Abbey, Glos	8.9	(Arnold *et al* 2003b)
Combermere Abbey, Combermere, Cheshire	8.8	(Howard *et al* 2003)
26 Westgate Street, Gloucester	8.7	(Howard *et al* 1998)
England Master Chronology	8.6	(Baillie 1977)
The Commandery, Worcester	8.5	(Arnold and Howard 2006)
Mercer's Hall, Mercer's Lane, Gloucester	8.0	(Howard *et al* 1996a)

Table 3: Results of the cross-matching of site chronology MOCASQ02 and the reference chronologies when the first ring date is 1530 and the last ring date is 1618		
Reference chronology	*t*-value	
Lower Bean Hall, Feckenham, Worcs	6.3	(Arnold and Howard 2005 unpubl)
St Mary's Church, Cratfield, Suffolk	6.0	(Bridge 2008)
White Tower, Tower of London	5.9	(Miles 2007)
De Grey Mausoleum, Flitton, Beds	5.9	(Arnold *et al* 2003c)
Church of St Andrew, Welham, Leics	5.6	(Arnold *et al* 2005)
Astley Castle, Warwickshire	5.8	(Howard *et al* 1997)
Wales and West Midlands Master Chronology	5.3	(Siebenlist-Kerner 1978)
Apethorpe Hall, Apethorpe, Northants	5.2	(Arnold and Howard forthcoming)

Table 4: Results of the cross-matching of sample MOC-A11 and the reference chronologies when the first ring date is 1552 and the last ring date is 1611		
Reference chronology	*t*-value	
Manor House, Sutton in Ashfield, Notts	5.8	(Howard *et al* 1996b)
Little Castle, Bolsover, Derbys	5.5	(Arnold *et al* 2003a)
Manor House, Nether Poppleton, N Yorks	5.2	(Arnold and Howard 2004 unpubl)
Westhorpe Farm, Killamarsh, Derbys	5.0	(Howard *et al* 1994)
Church of St Andrew, Welham, Leics	4.9	(Arnold *et al* 2005)
Old Hall, West Auckland, Co Durham	4.8	(Hurford *et al* 2010)
Manor House, Alford, Lincs	4.7	(Arnold *et al* 2003d)
Sutton Scarsdale Manor, Derbys	4.7	(Howard *et al* 1995 unpubl)

Site chronologies MOCASQ01 and SQ02 are composites of the data of the relevant cross-matching samples as seen in the bar diagrams Figures 7 and 8 below. This composite data produces 'average' tree-ring patterns, where the possible erratic variations of any one individual sample are reduced and the overall climatic signal of the growth is enhanced. These 'average' site chronologies are 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 date spans indicated, Tables 2 and 3 giving only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity). It may be noticed from these Tables 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 timbers.

Sample MOC-A11 (Table 4) has been compared individually with the reference chronologies.

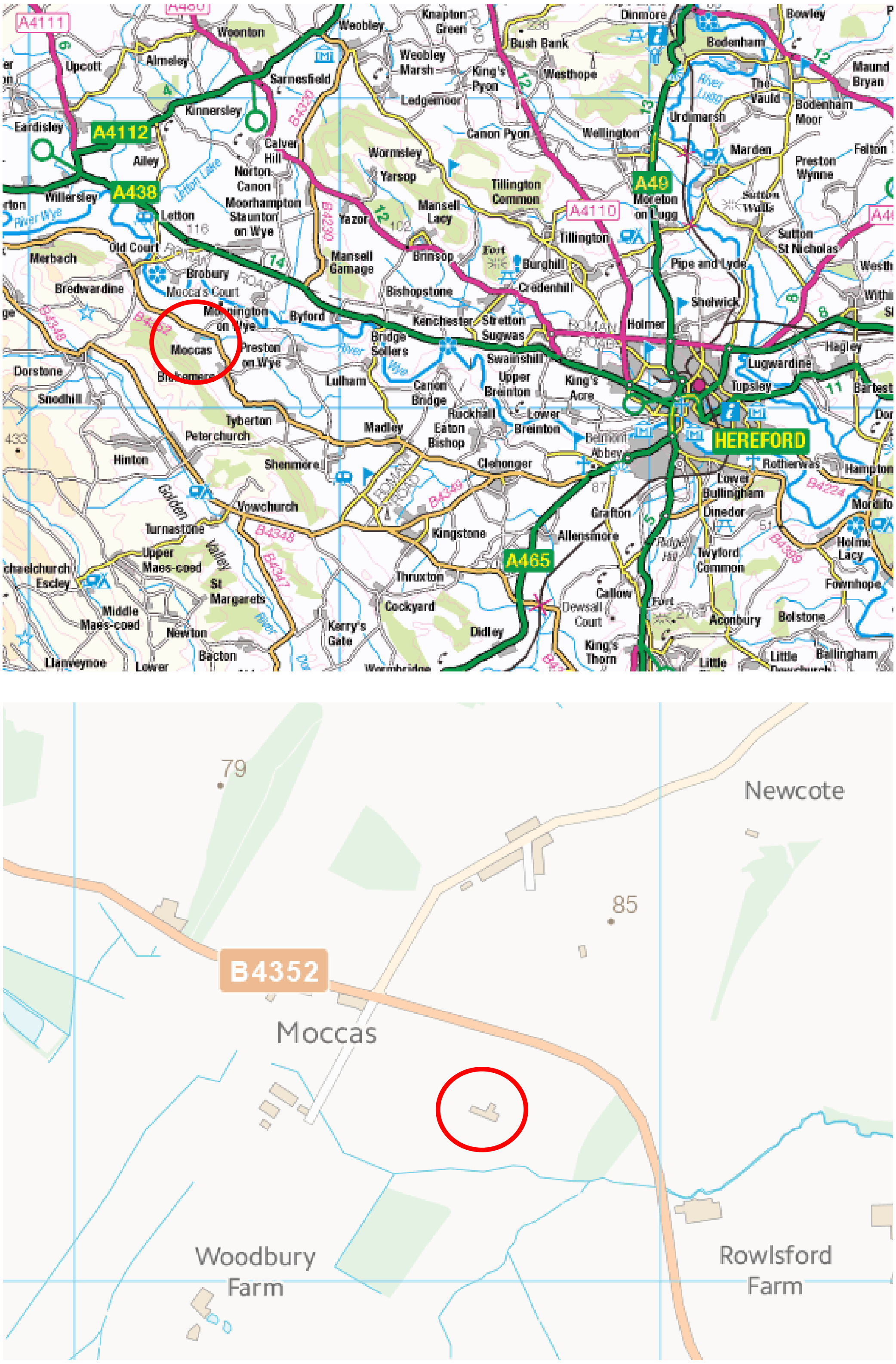


Figure 1a/b: Maps to show location of Moccas (top) and New House Farm (bottom)

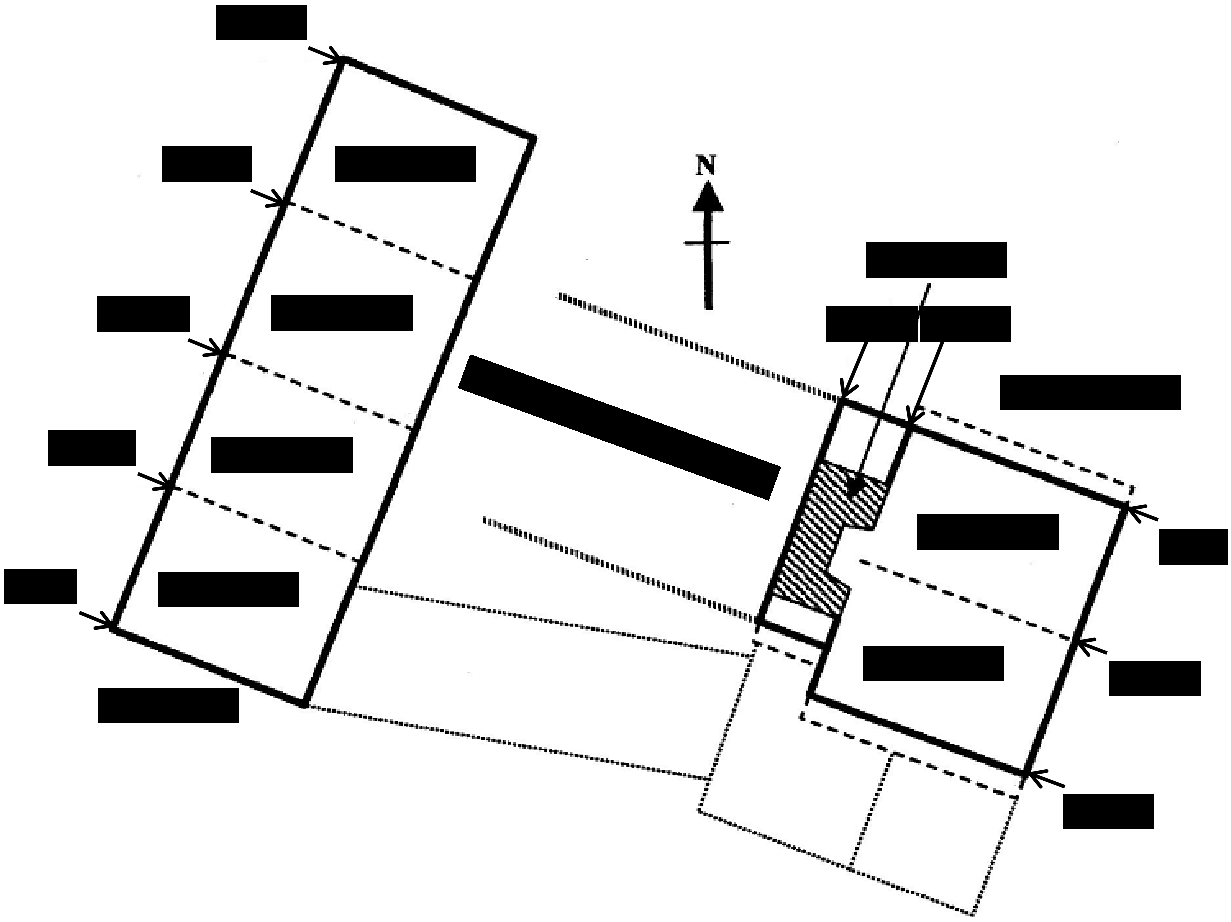


Figure 2: Plan of New House Farm (after Duncan James)

Figure 3a/b: Exterior views of the still standing cross-wing of the now lost hall (top) and the parallel barn range to its west (bottom)

Figure 4a/b: Interior views of the cross-wing range; west purlins trusses 1 – 2 (top) and ground floor ceiling beams (bottom)

Figure 5a/b: Interior views of the barn range, looking west to east (trusses 2 and 3) (top) and east to west (trusses 4 and 5) (bottom)

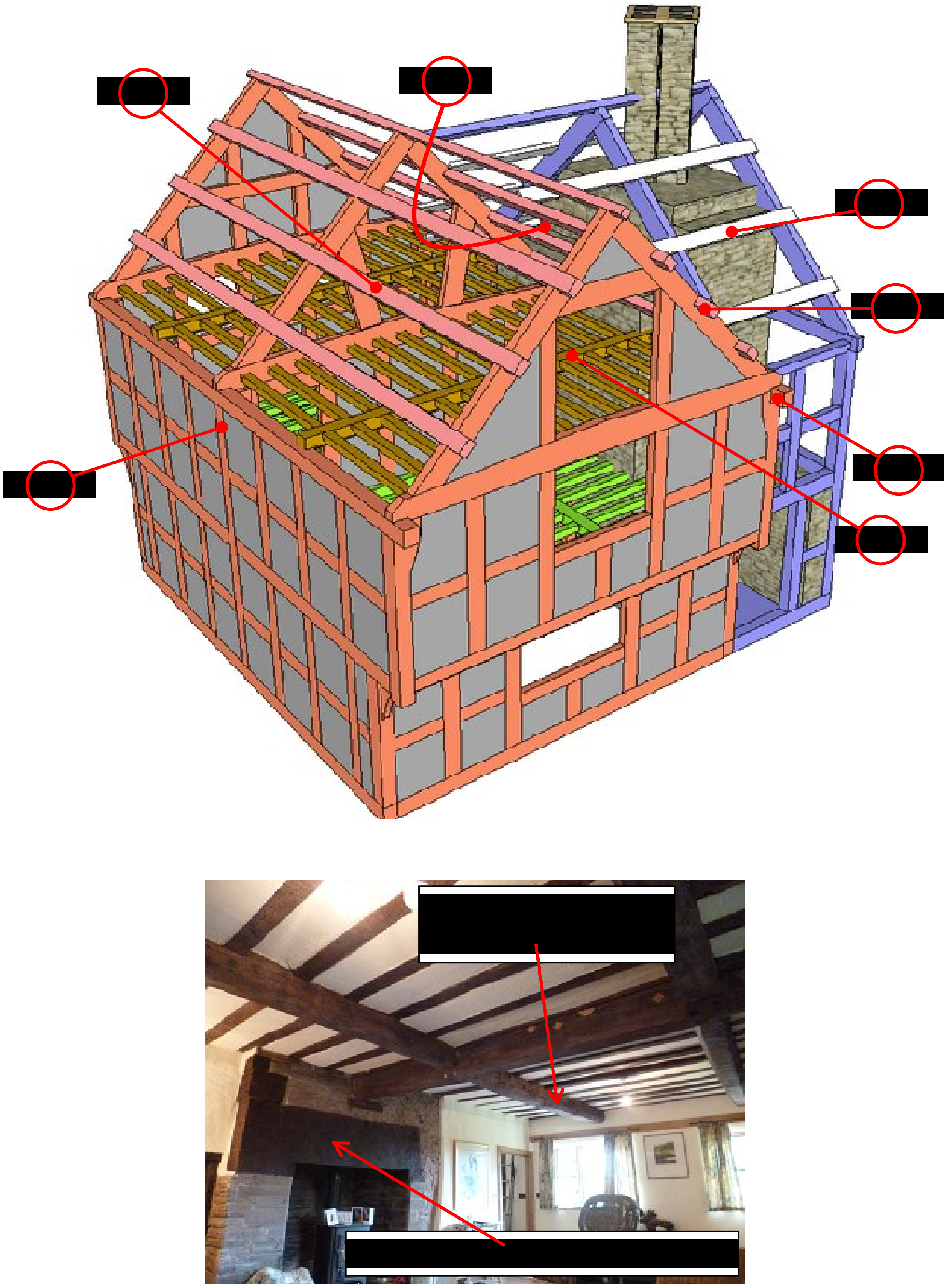


Figure 6a/b: Drawing (after Duncan James) and annotated photograph of the cross-wing to locate sampled timbers (see Table 1)

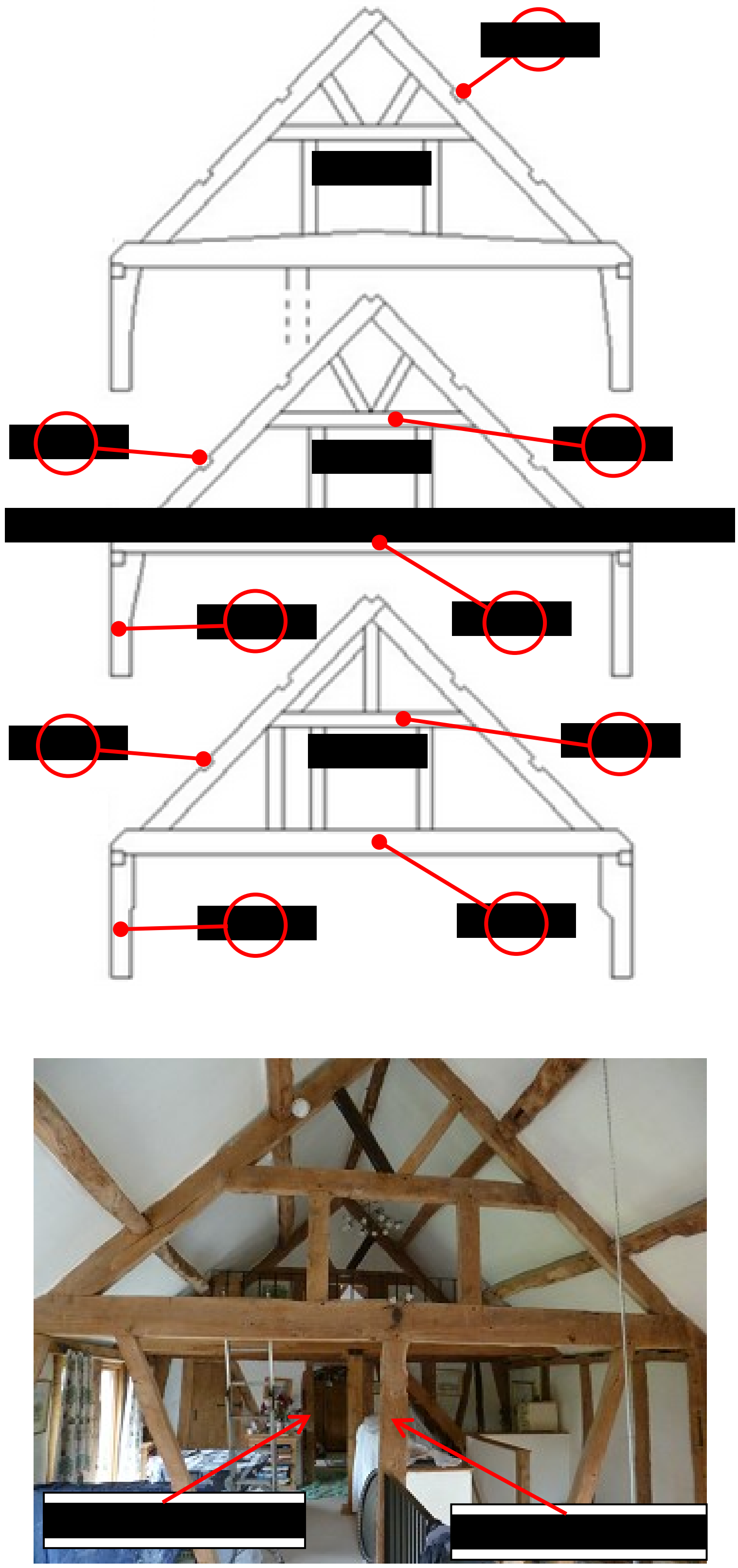


Figure 6c/d: Drawing (after Duncan James) and annotated photograph of the barn trusses to locate sampled timbers (see Table 1)

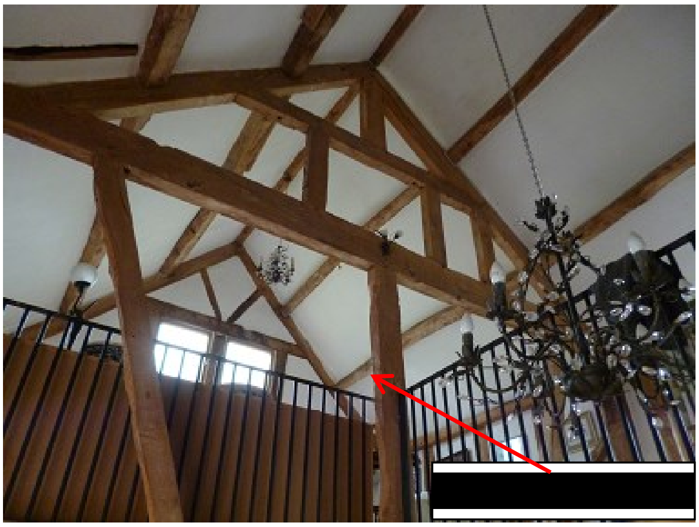
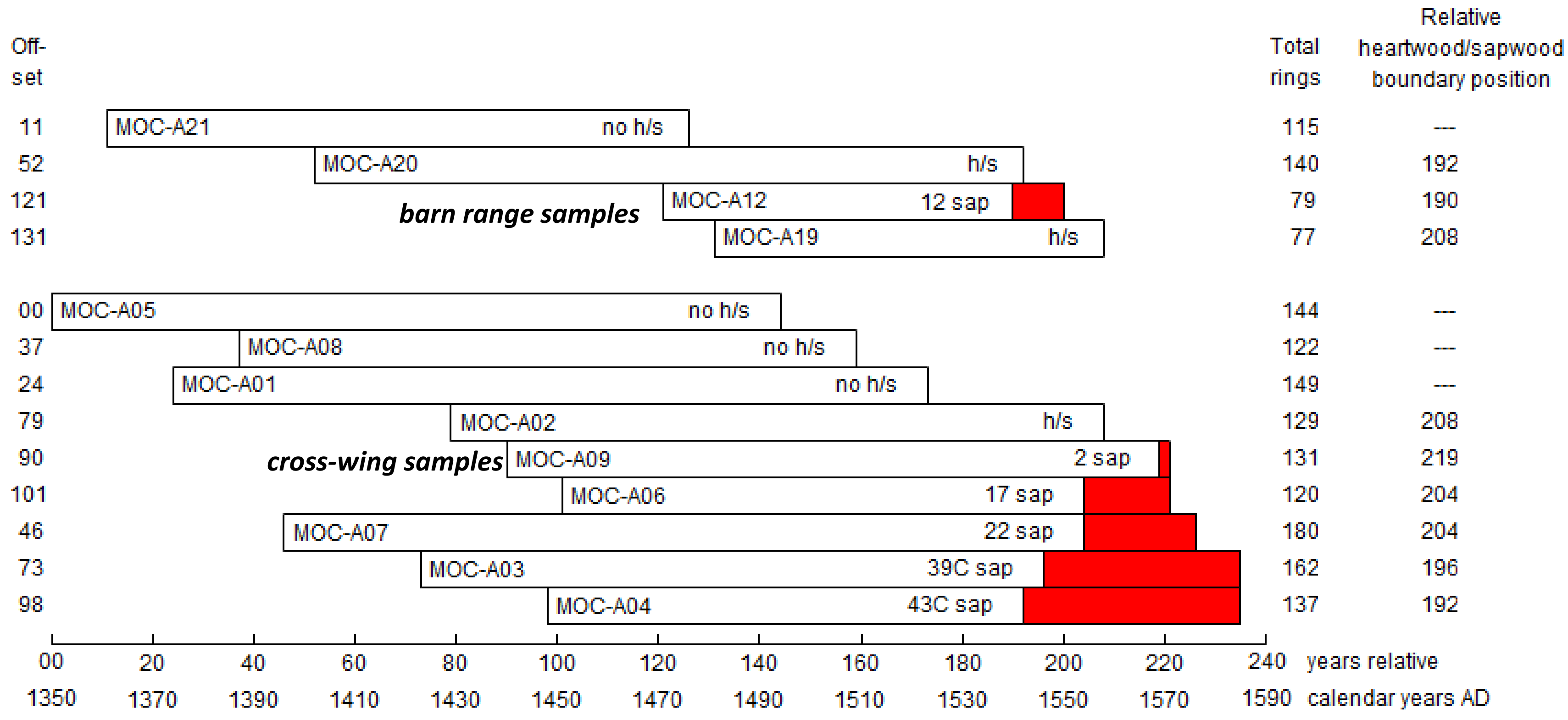


Figure 6e: Annotated photograph of the barn trusses to locate sampled timbers (see Table 1)



blank bars = heartwood rings; shaded bars = sapwood rings
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the tree represented
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figure 7: Bar diagram of the samples in site chronology MOCASQ01 (sorted by sample location) at positions indicated by their grouping. The samples are shown in the form of bars at positions where the ring variations of the samples cross-match with each other, this similarity being produced by the trees represented growing at the *same time* as each other in the *same place.* The samples are combined to form a 'site chronology', which is dated by comparison with the 'reference' chronologies (Table 2).

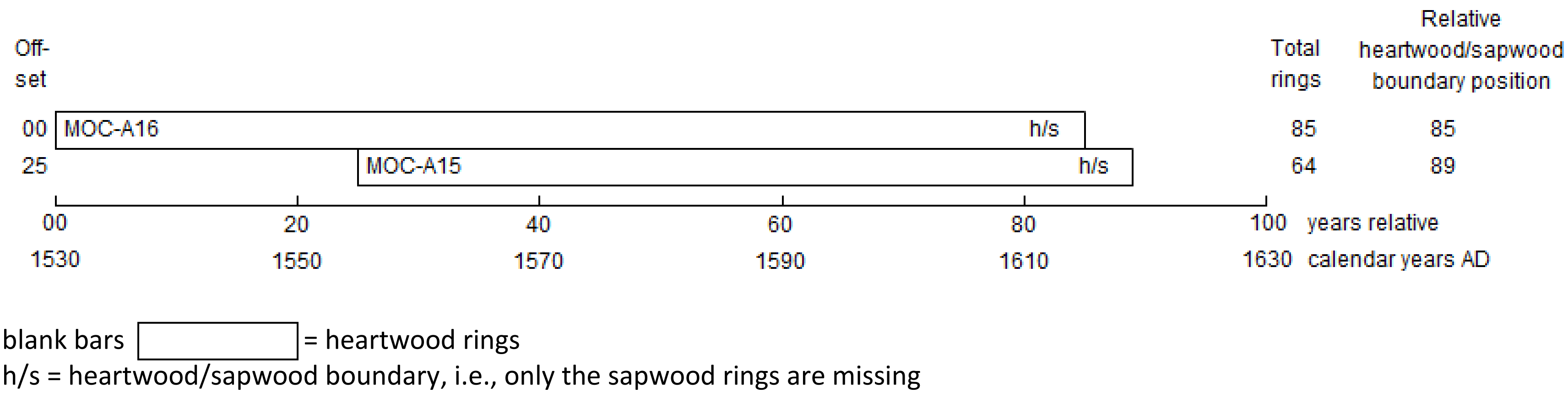
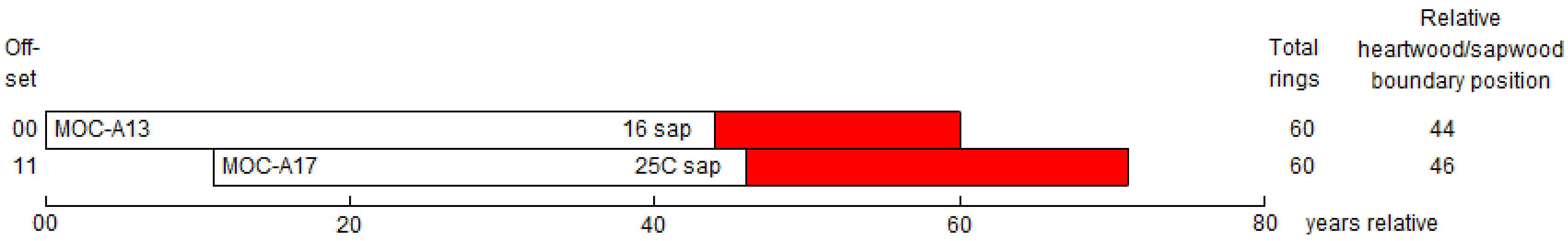
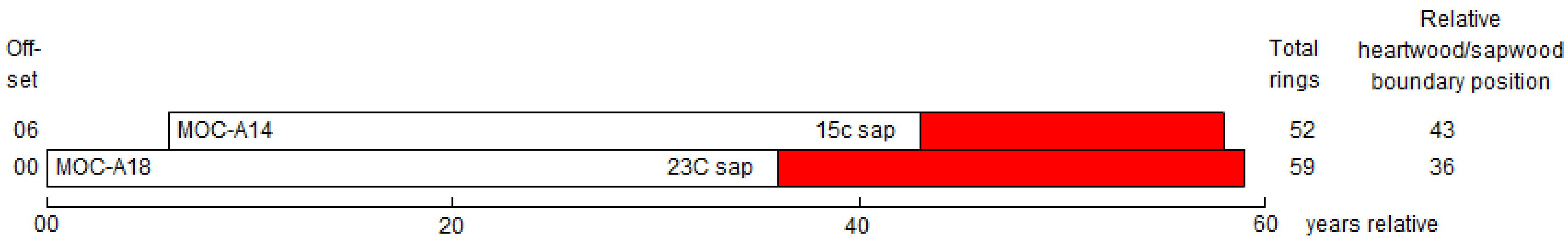


Figure 8: Bar diagram of the samples in site chronology MOCASQ02 at positions indicated by their grouping. The samples are again shown in the form of bars at positions where the ring variations of the samples cross-match with each other. The two samples were also combined to form a 'site chronology', which is dated by comparison with the 'reference' chronologies (Table 3).





blank bars = heartwood rings; shaded bars = sapwood rings
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the tree represented
C = complete sapwood is found on the timber, but all or part has been lost from the sample in coring
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figures 9 & 10: Bar diagrams of the samples in site chronologies MOCASQ03 (top) and SQ04 (bottom). The samples of each group are again combined to form site chronologies. Although compared to the full corpus of reference chronologies, there was no cross-matching and the samples must remain undated.