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(viewed from the south-west)

**TREE-RING ANALYSIS OF TIMBERS FROM
EDEN FARM BARN,
KIRKANDREWS ON EDEN,
NR CARLISLE,
CUMBRIA**

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SUMMARY

Tree-ring analysis of nine samples from this barn indicates the use of timbers with different felling dates.

The lower north blade of truss D is made of timber felled in 1527 and is probably reused here. The upper and lower sections of truss A (both showing evidence for reuse), and the south spur tie of truss D are made of timber felled in the period 1588 – 1607.

The upper north and south sections of truss C are each made of timber felled in 1735 which, given that there is no evidence for reuse on these, may represent the construction date of the barn. It is estimated that the south backing rafter of truss D was felled in the period 1760 – 65, but is reused here.

Two timbers, the upper north and south blades of truss B, both remain undated.

It would appear likely, therefore, that Eden Farm barn began life in the second quarter of the eighteenth century using some timber felled specifically for its construction and other timber which had been felled earlier.

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Introduction

Eden Farm and its buildings stand in the centre of the village of Kirkandrews on Eden, approximately 4.5 km north-north-west of Carlisle, the barn standing alongside a short length of road forming the north side of the triangular 'village green' (NY 35385 58420 – Fig 1). The barn is aligned north-east to south-west, although for the sake of clarity in this report this will be referred to as east-west.

The barn measures c 14.5 by 6 m externally; it has a porch on the south side of the threshing bay and outshuts to the north-east and south-west, and a two-storeyed brick stable-block of late-eighteenth or early-nineteenth century date is attached to its west end, see plan, Figure 2. The external walls of the barn are of varied fabric types (Fig 3). The east end is of cobbles, with red sandstone quoins to the lower parts of its angles, and quoining

simulated in brick above; the gable itself is of brick. The side walls have been of clay dabbin, with cobbling in the lower parts of the walls towards the east end.

To the west of the porch the south wall (within the outshut) has been rebuilt in relatively modern brick; the north wall has been extensively patched in brick on its external face, and its western bay rebuilt in late-twentieth century blockwork. The north-eastern outshut has rubble end walls and a north wall (and internal division) of brick, now removed; the south-western outshut is of rubble except for its east end which is brick. The west end of the barn is of brick, and clearly contemporary with the adjacent stable block. The present roof of the barn is of Welsh slates, with flagstones to the eaves.

The projecting pent-roofed porch on the south is in oldish brick; opposite in the north wall is a doorway with a timber lintel. The side walls originally appear to have had a slit vent — a simple unsplayed opening — in each bay, although these are now blocked or destroyed by later patching and rebuilding. The brick wall at the west end of the barn has a blocked doorway set against the north wall, and a central pitching door at the level of the loft/first floor of the adjacent stable block into which it opens. The south-western outshut is entered by a doorway within a relatively recent section of wall, within the barn porch, and has plain square-headed windows in its south and west walls.

Internally the barn has four cruck trusses, fairly evenly spaced, either springing from the clay dabbin walls a little above the ground, or having their lower parts encased in more modem brickwork (Fig 4a/b). All the trusses have roughly jointed upper and lower blade sections (Fig 5), collars halved onto their east faces, and type 'C' apexes with the blades being morticed into plated yokes, carrying a ridge set square. Spur ties, also halved against the east face of the trusses, carry or carried a wall-plate set into the top of the clay dabbin side walls; there is no evidence of any further wall framing.

Sampling

Sampling and analysis by tree-ring dating of timbers the cruck barn were commissioned by Peter Ryder, historic buildings consultant, on behalf of the owner, dendrochronology being undertaken in conjunction with a measured survey (Ryder 2008). This general programme of research in to its history and development was undertaken in part out of personal interest and concern for the building, and in part to fulfil certain planning application conditions prior to undergoing conversion into domestic accommodation.

Thus, from the timbers available a total of nine core samples was obtained. Each sample was given the code KRK-D (for Kirkandrews, site "D") and numbered 01 – 09. Given the nature of the structure, ie, that the crucks are jointed near their bases, and that there is some evidence for possible reuse, it is not certain that all the timbers are primary and integral to each other, and to be representative of a single-phase structure.

The positions of these samples were marked on plans and drawings taken from the measured survey provided by Peter Ryder. These are reproduced here as Figure 6a-f. Details of the samples are given in Table 1. In this Table, all trusses and the individual timbers have been numbered and/or identified following the schema of the plans provided.

arrangements for sampling, but also for the extensive use of his notes in the introduction above, and the use of his excellent drawings elsewhere 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 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. In the Tables and bar diagrams of this report, the retention of complete sapwood on a sample is denoted by upper case 'C'.

Sometimes, complete sapwood is found on a timber, but, because of its soft condition, some, or all of it, crumbles as the sample is cored. It is possible to measure how much of the sapwood part of the core has been lost and from this it is sometimes possible to estimate the number of rings the lost portion might have represented, From this it is possible to make a reasonable estimate the felling date of the timber. Such a state is represented by lower case 'c' in the Tables and bar diagrams.

Where the sapwood is not complete it is necessary to calculate a likely felling date range for 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% probable 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, not on the basis of each single individual sample, but from *all* the dated samples from each phase of a building and add 15 to 40 rings to this average to get the likely overall felling date of all the timbers used. In this calculation, wide variations in the position/date of the heartwood/sapwood boundary (possibly suggesting different felling dates) must be noted and taken into consideration.

Analysis

In the case of the nine samples obtained from Eden Farm barn, each was prepared by sanding and polishing, and their annual growth-ring widths were measured. The data of these

measurements were then compared with each other as described in the notes on tree-ring dating above.

At a minimum value of $t=4.0$ two groups of cross-matching samples could be formed. The first group comprises two samples, these cross-matching with each other at the relative positions shown in the bar diagram, Figure 7a and the accompanying graph, Figure 7b. The two cross-matching samples were combined at these indicated off-set positions to form a site chronology, KRKDSQ01, with an overall length of 97 rings. Site chronology KRKDSQ01 was then satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1491 to 1587. The evidence for this dating is given in the t-values of Table 2.

The second group comprises three samples which cross-match with each other at the relative positions shown in the bar diagram, Figure 8. The three cross-matching samples were combined at these indicated off-set positions to form a site chronology, KRKDSQ02, this having an overall length of 76 rings. Site chronology KRKDSQ02 was then satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1680 to 1755. The evidence for this dating is given in the t-values of Table 3.

The two site chronologies, KRKDSQ01 and KRKDSQ02, were then compared with each other, and with the four remaining ungrouped samples. There was, however, no further satisfactory cross-matching.

Each of the four ungrouped samples was, therefore, compared individually with the full range of reference chronologies. This process indicating a satisfactory cross-match and date for a further two samples, KRK-D07 and D08. The evidence for this cross-matching is shown in Tables 4 and 5.

Interpretation

Analysis by dendrochronology of nine samples from Eden Farm barn has resulted in five of them being combined to form one of two site chronologies, and a further two samples being dated individually. The tree-ring analysis would confirm the suspicions, intimated in the drawn survey, that there timbers with different dates used in the barn.

The earliest timber appears to be that represented by the individually dated sample, KRK-D07, from the lower north cruck blade of truss D. This sample retains complete sapwood (denoted by 'C' in Table 1). This means that it has the last ring produced by the tree it represents before it was felled. In this case the last measured, complete, sapwood ring, and thus the felling, is dated to 1527.

The next phase of felling appears to be represented by the two samples in site chronology KRKDSQ01 (KRK-D01 and D02 – see Fig 7a/b) from the north and south upper cruck blades respectively of truss A, and by the individually dated sample, KRK-D08, from the south spur tie of truss D. None of these three samples retains complete sapwood and the exact felling date of each cannot be precisely determined. However, they do retain some sapwood or the heartwood/sapwood boundary (which means that only the sapwood is missing from the sample). The average date of this boundary is 1567. It is reckoned that the 95% confidence limit for the amount of sapwood mature oaks trees in this part of Britain

might have had lies in the range 15 to 40 rings. Given the degree of cross-matching between samples KRK-D01 and D02, and allowing for the fact that the last ring on sample KRK-D01 is dated to 1587, such a sapwood range would suggest that the three timbers were felled some time in the period 1588 to 1607.

A third phase of felling is represented by two of the samples (KRK-D05 and D06 respectively from the north and south upper blades of truss C), in site chronology KRKDSQ02 (see Fig 8). Both samples retain complete sapwood, meaning that these also have the last ring produced by the trees they represent before they were felled. In this case the last measured, complete, sapwood ring, and thus the felling, of both is the same at 1735.

The fourth and final phase of timber is represented by sample, KRK-D09, from the south backing rafter of truss D, this also dated as part of site chronology KRKDSQ02. This sample has some sapwood, but it is not complete, about 5mm have being lost from the timber, which does have complete sapwood on it, in coring. It is estimated that such a loss represent between five and 10 rings (at the very most), which, given that the last extant ring on it is dated to 1755, suggests that the timber was felled sometime between 1760 and 1765.

Conclusion

It would appear just possible, therefore, that Eden Farm barn began life about the first quarter of the sixteenth century, such an interpretation being based on the dating of a single sample, KRK-D07, from the north lower cruck blade of truss D, it being accepted that this timber truly represents a part of the primary structure. Such an interpretation would mean that all the other dated timbers are additions, repairs, or replacements.
While this is of course not impossible, it is perhaps less likely than the alternative interpretation which is that the lower blade of truss D is in fact a timber felled in 1527, and reused some time later in the construction of the barn. This construction would date to the late-sixteenth or very early-seventeenth century at the earliest if it were believed that the timbers represented by samples KRK-D01, D02, and D08 (the north and south upper blades of truss A and the south spur tie of truss D respectively) are primary. The upper blades of truss A, however, do show some evidence for reuse by way of the empty lap-mortices below the present spur ties, and they are thus also likely to be reused here rather than being primary.

The next, and possibly most likely, candidate for the construction date of the barn, is represented by samples KRK-D05 and D06, from the north and south upper blades of truss C. Neither blade shows any evidence of reuse, and thus both may be primary, the felling of these two timbers dated to 1735.

The latest felling date of any timber found here is 1760 to 1765, represented by sample KRK-D09, from the south backing rafter of truss D. This timber, however, again shows evidence of reuse suggesting that although it was originally felled in the third quarter of the eighteenth century for some other structure, it has been inserted in to this barn as a repair or replacement at a later date.

It is suggested, therefore, that Eden Farm barn was built in the second quarter of the eighteenth century, reusing older timber, some of it felled in the late-sixteenth to early-seventeenth century, and at least one timber felled in the early-sixteenth century. Later pieces have been used for repairs.

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Table 1: Details of tree-ring samples from Eden Farm barn, Kirkandrews on Eden, nr Carlisle, Cumbria

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
KRK-D01	North upper blade, truss A	97	17	1491	1570	1587
KRK-D02	South upper blade, truss A	65	no h/s	1497	------	1561
KRK-D03	North upper blade, truss B	80	3	------	------	------
KRK-D04	South upper blade, truss B	84	no h/s	------	------	------
KRK-D05	North upper blade, truss C	56	15C	1680	1720	1735
KRK-D06	South upper blade, truss C	55	13C	1681	1722	1735
KRK-D07	North lower blade, truss D	146	20C	1382	1507	1527
KRK-D08	South spur tie, truss D	136	h/s	1429	1564	1564
KRK-D09	South backing rafter, truss D	73	16c	1683	1739	1755

*h/s = the heartwood/sapwood boundary is found on the sample, only the sapwood rings are missing
 C = complete sapwood is retained on the sample; where dated this is the felling date of the tree
 c = complete sapwood is found on the timber, all or part has been lost from the sample in coring

Table 2: Results of the cross-matching of KRKDSQ01 and relevant reference chronologies when the first ring on the site chronology is dated to 1491 and the last ring is dated to 1587

Reference chronology	t-value	Reference
St Peter's Church, Saltby, Leics	5.4	(Howard *et al* 1995)
Hulme Hall, Allostock, Cheshire	4.6	(Howard *et al* 2003)
Old Manor, Hartshorne, Derbys	4.6	(Arnold and Howard 2007 unpubl)
Kenilworth Castle Gatehouse, Warwicks	4.6	(Arnold and Howard 2007)
Old Hall, Church Broughton, Derbys	4.4	(Howard *et al* 1993)
Lamonby Farm, Burgh by Sands, Cumbria	4.2	(Howard *et al* 1998)

Table 3: Results of the cross-matching of KRKDSQ02 and relevant reference chronologies when the first ring on the site chronology is dated to 1680 and the last ring is dated to 1755

Reference chronology	t-value	Reference
Green's Mill, Sneinton, Nottm	5.9	(Laxton e*t al* 1982)
Old Barn, Shottery, Warwicks	5.9	(Howard *et* al 1996a)
The Mill, Kibworth Harcourt, Leics	5.5	(Arnold *et al* 2004)
Croome Court, Worcestershire	5.0	(Arnold *et al* 2004)
Bradgate Trees, Bradgate, Leics	4.7	(Laxton and Litton 1988)
6 – 12 Chain Lane, Newark, Notts	4.6	(Arnold *et al* 2002)

Table 4: Results of the cross-matching of KRK-D07 and relevant reference chronologies when the first ring on the sample is dated to 1382 and the last ring is dated to 1527

Reference chronology	t-value	Reference
Speke Hall, Merseyside	5.5	(Howard *et al* 1992)

Nether Levens Hall, Kendal, Cumbria	5.4	(Howard *et al* 1991)
All Hallow's Church, Kirkburton, W Yorks	5.0	(Arnold and Howard 2007)
Clifton Hall Tower, Clifton, Nr Penrith, Cumbria	4.6	(Arnold *et al* 2003)
England Master Chronology	4.6	(Baillie and Pilcher 1982 unpubl)
Hallfield House, Bradfield, S Yorks	4.4	(Howard *et al* 1996b)

Table 5: Results of the cross-matching of KRK-D08 and relevant reference chronologies when the first ring on the sample is dated to 1429 and the last ring is dated to 1564

Reference chronology	*t*-value	Reference
Hallgarth Pittington, Co Durham	5.2	(Howard *et al* 2001)
England Master Chronology	4.9	(Baillie and Pilcher 1982 unpubl)
St Mary's Church, Colston Bassett, Notts	4.7	(Howard *et al* 1995)
Nether Levens Hall, Kendal, Cumbria	4.5	(Howard *et al* 1991)
35 The Close, Newcastle upon Tyne	4.4	(Howard *et al* 1991)
All Hallow's Church, Kirkburton, W Yorks	3.9	(Arnold and Howard 2007)