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APETHORPE HALL, APETHORPE, NORTHAMPTONSHIRE
TREE-RING ANALYSIS OF TIMBERS

SCIENTIFIC DATING REPORT

Alison Arnold, Robert Howard and Cathy Tyers

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SUMMARY

Tree-ring samples were obtained from 396 timbers at Apethorpe Hall, analysis of 322 of these resulting in the successful dating of 289 timbers. Felling dates ranging from the later AD 1460s through to the later eighteenth century have been identified which, combined with the wider multi-disciplinary research programme undertaken, allow specific areas of the Hall and associated buildings to be related to the succession of owners of Apethorpe Hall over three centuries.

CONTRIBUTORS

Alison Arnold, Robert Howard, and Cathy Tyers

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A great many people have made contributions to, or helped with, this programme of tree-ring analysis. These range from those who have helped with access to Apethorpe Hall, opened up areas of roofing, or lifted floorboards etc.; those who have provided drawings and plans, assisted with interpretation or undertaken considerable work as part of the analysis and interpretation presented in this report. To name only a few, we would like to thank Mr George Kelly MBE, longstanding ground's man and caretaker at Apethorpe Hall, for his considerable help and assistance at all times; the members of various English Heritage teams including John Cattell, Nick Hill, Kathryn Morrison, and Pete Smith, and the English Heritage's Scientific Dating Team, particularly John Meadows. Thanks are due to these and many others.

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Wootton Hall Park
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INTRODUCTION

Apethorpe Hall, an expansive Grade I listed country house, lies on the south side of the village of Apethorpe within the former Royal Forest of Rockingham (Figs 1 and 2). The original house was erected by the courtier Guy Wolston in the late-fifteenth century. Subsequent centuries saw a series of major alterations and enlargements resulting in the current complex house arranged around three courtyards with the stables and granary block to the north-east (Figs 3 and 4). It was subject to a Compulsory Purchase Order in 2004 by the Department of Culture, Media, and Sport and hence became the responsibility of English Heritage. The role of English Heritage was to institute a programme of repairs and secure a viable future for Apethorpe Hall. This provided an opportunity to investigate this important but little known country house and its surroundings through an extensive multi-disciplinary study undertaken alongside the programme of major repairs. This has resulted in a series of reports on various aspects of the investigations (www.historicengland.org.uk/research/research-results/), of which this is one, as well as a monograph which brings the findings' together to reveal the intricacies of this complex house (Morrison 2015). This report was originally drafted in 2008, at the same time that the report on Apethorpe Church (Arnold and Howard 2008) was produced, but its production was held over to allow better understanding of the results obtained as the wider investigation proceeded, as well as to allow for additional dendrochronological analysis where appropriate. Thus, the information presented immediately below has been updated and is derived from Morrison (2015).

In 1468 Guy Wolston received a grant from the Crown comprising over 270 acres of land in the *'Hale by Abthorp'*, Hale being an abandoned hamlet just south of the village of Apethorpe. The core of Apethorpe Hall had been built by the end of 1472 by which time Guy Wolston was described as *'of Apethorpe'*. The initial building programme comprised the Great Hall with a cross-wing at the south (high) end and in-line service rooms at the north (low) end. Spanning the north end of the hall range was the north range containing the kitchen and other services to the west and lodgings and a gate tower to the east. To the south of the hall range was a detached block, probably high-end lodgings. To the west, and probably constructed towards the end of this initial period of construction, was a detached service range. At a slightly later date Wolston embarked on additional building works and embellishment during which the cross-wing was linked to the south lodging block with the addition of the parlour wing and the south-west lodgings. By *c* 1495 Wolston's house appears to have been largely completed.

Sir Guy Wolston died in 1504 and following the death of his third wife, Margaret, in 1505, Wolston's estates passed to his daughter Audrey who married Thomas Empson at about this time. In 1515 Apethorpe was sold to a group which included Henry Keble (alderman and merchant of London), his son George, and his son-in-law William Blount (4th Lord Mountjoy). Some remodelling, notably of the south lodgings, is thought to have occurred shortly after Apethorpe's acquisition at the behest of William, 4th Lord Mountjoy, but other alterations and additions centred around the Great Hall are thought to have been

undertaken by Charles, 5th Lord Mountjoy, after the death of his father in 1534. In 1543 Apethorpe was acquired by the Crown in a deal of exchange and became part of the holdings of Queen Katherine Parr and subsequently Princess Elizabeth following the death of the Queen in 1548.

Sir Walter Mildmay acquired Apethorpe, through exchange, in 1551. He undertook significant improvements, most notably the addition of a new south range with a state apartment, prior to entertaining Queen Elizabeth I at Apethorpe in 1566. He subsequently carried out refurbishment of the original house, including remodelling the south lodging block and infilling the north-west corner of the west courtyard including the creation of two attic rooms to the west side of the hall, later known as the Cock Loft. To the north-east of the house, the outbuildings, forming an irregular yard, are also attributed to Sir Walter Mildmay. These comprised stabling and also other outbuildings, including, what later became known as, the house and granary. The house was inherited by Sir Anthony Mildmay after the death of his father in 1589. No significant work on the house is attributed to Sir Anthony Mildmay in spite of a number of visits to Apethorpe by King James I, the first of which was in 1603.

In 1617, following the death of Sir Anthony Mildmay, the house was inherited by his only child, Mary, and her husband Sir Francis Fane, who later became the Earl of Westmorland. Since it appears that no substantial remodelling of the house had been undertaken after that by Sir Walter Mildmay, it is likely that the house appeared relatively outmoded in comparison to its counterparts. In May 1622 King James I, who had continued with his visits to Apethorpe, formally ordered Sir Francis Fane to enlarge the house. To this end the King gave Fane 100 oak trees from his Royal Forest of Rockingham and sold him 100 more. There followed an intensive building project which appears to have spanned only two or three years, which saw the construction of an east range, including the long gallery, refurbishment and partial rebuilding of the south range, and the creation of a new 'Old Dining Room' with a new roof at the junction of the hall range and north range.

Francis Fane died in 1629 and his son Mildmay Fane, 2nd Earl, inherited Apethorpe. King Charles I followed in his father's footsteps and visited Apethorpe but no significant further building works were undertaken. Charles Fane, 3rd Earl, succeed his father in 1666, and on his death in 1691 his half-brother Vere Fane held Apethorpe, albeit only briefly, as he died in 1693. Rachel, the wife of Vere Fane, ran Apethorpe through the minority of their son Vere, and then, following the early death of Vere, their son Thomas, ensuring that Apethorpe was maintained and repaired, whilst also undertaking some remodelling. Thomas Fane, 6th Earl, assumed responsibility for Apethorpe in 1705 following his coming of age. During the time he held Apethorpe work was carried out on the outbuildings and some rooms were refurbished but most notably he constructed what was later known as the Orangery. John Fane, 7th Earl, succeeded his older brother Thomas who died in 1736. He conceived plans to convert Apethorpe into a Palladian palace but the programme of works was severely curtailed and subsequently abandoned. Some remodelling works were carried out on the south range and the east end of the north range was rebuilt. Following

his death in 1762 Apethorpe was inherited by Thomas Fane, 8th Earl, whose great-grandfather was the second surviving son of the 1st Earl of Westmorland, Francis Fane. Thomas was succeeded in 1771 by his son John Fane, 9th Earl, who appears to have undertaken some modernisation works, notably the bay window that was added to the south side of Lady Westmorland's room at the south end of the hall range. However, he was rapidly succeeded by his son John, 10th Earl, in 1774 who held Apethorpe until 1841, during which time no major works were undertaken. When the 11th Earl, also John, inherited he initiated a large scale modernisation of the house and outbuildings but after his death in 1859 the 12th and 13th Earls suffered declining wealth and Apethorpe was bought by Mr Leonard Brassey in 1904. Apethorpe subsequently became a modern country home regaining much of its old splendour through sensitive restoration. In 1947 the house was sold and it became an approved school and then a community home which closed in 1982. Ownership of Apethorpe changed hands again twice before the Compulsory Purchase Order was confirmed in 2004.

Main ranges at Apethorpe Hall

The following provides basic information relating to areas identified as of specific interest with respect to the dendrochronological survey. In this report roofs, walls, floor-frames etc. are located by reference to their room numbers as given in Figures 5–8. These locations are designated by prefixes indicating the range of the house and the floor-level in which the rooms are found. The prefix 'N', or 'S', for example, always refers to rooms in the north or south range respectively, with 1, 2, or 3 referring to ground, first, and second floor respectively. Each room is then given an individual identifier number by floor. Figure 9 illustrates some of the typical truss forms in the various roofs.

Hall range

The hall and its associated rooms are the core of Apethorpe. The hall roof itself, above H2.03, is composed of six, rather simply decorated, cambered archbraced collar trusses with curved raking struts, the trusses supporting three butt purlins (Fig 9a), there being three tiers of windbraces to each pitch. To the south of the hall lies the Great Chamber/Old Parlour cross-wing (H2.06/07), roofed east to west by neat, well-carpentered frames with collars and archbraces to the collar on every other frame (Fig 9b). There is a single clasped purlin to each pitch. To the south again, running north to south over H2.10/12(part), the roof frames are identical to those over the Old Parlour cross-wing (Fig 9c), and are thus considered coeval.

To the south, yet again, is a further roof, running east to west, above H2.12. This contains one principal-rafter truss with a three-quarter span, the northern quarter having been cut to allow for the insertion of a later covering on that side. Associated with this area, but actually located in H2.14, is a timber-framed partition wall and a stairway which leads from the first to the groundfloor.

To the west of room H2.12 is a further east to west roof, above H2.11. The majority of frames here are very similar to those seen over H2.10 and H2.12 being archbrace trusses but with a slightly shallower vault. To the west end there is some evidence of a reworking of the roof. To the west of H2.14 lies Lady Westmorland's room (H2.13). The ceiling timbers to the bay window comprise two large parallel east–west oak beams spanning the opening of the bay, from the outer of which, run a series of smaller joists southwards into the bay itself the date of which is uncertain.

The northern end of the hall range, at its junction with the north range, contains two sets of rooms (H3.01 and H3.02/02a) usually referred to as the 'Cock Lofts'. The roof of H3.01 comprises close-set common rafter frames with collars, without bracing or archbraces, whilst the roof of H3.02 comprises three principal rafter trusses. Although of similar form, there is some evidence (one roof is set at a steeper pitch), that the roofs could be of slightly different dates.

Adjacent to the western courtyard, the matted passageway (H2.01/05a/05), runs north to south and virtually the length of the hall range (Fig 9d). Some timbers within the walls appear be possible later replacements or to have been moved and reused.

North range

There are two roofs to the west of the gatehouse (above N2.18/19/20, and above N2.21). These roofs are of slightly different forms to each other (Fig 9e), possibly representing slightly different phases, and their carpentry is of a more rudimentary character than that of, say those over the cross-wing, suggesting they were never intended to be seen. Given that plaster scarring relating to an earlier roof or ceiling survives within the roof spaces, it is believed that the present frames may represent a phase of re-roofing and may include some reused timbers.

In the roof of the adjacent rooms, above N2.16/17, is a further single truss, against the wall dividing this roof space from N2.18/19. This truss has a mildly cranked tiebeam with a collar and archbraces, and clasped purlins, above which level the principals are reduced. It is believed that this truss is of the same phase as those above N2.18–21 (above).

The roof of the 'Old Dining Room', N2.14/15, is of three bays formed by two trusses. These each have a lower and upper collar with the principals clasping the purlins.

Also within the north range is the Gatehouse (N2.22–24), and the rooms to the east. The underside of the gate opening contains a number of highly moulded and decorated timbers. There are also other timbers to the roof of the gatehouse and to its cupola. Within the adjacent rooms are floor and ceiling beams, sometimes covered by later lath-and-plaster work. There is little evidence for disturbance or replacement of these timbers.

The Library is located at the far east end of the first-floor north range, at its junction with the east range. The roof (N3.06) comprises four king-post trusses with struts from the

king posts to the principal rafters (Fig 9f). The timbers are very clean, and evenly and squarely sawn.

For the most part the roofs of the north range of the west courtyard have been replaced in modern, almost certainly twentieth-century, softwood timbers. There are, however, a few older timbers, mostly main bridging beams, to the ceilings of some of the ground-floor rooms of this range. There are also several large bridging beams and a number of common joists which form the floors of some of these rooms.

An area of surviving historic roof timbers, however, is that over what is termed the 'upper part of the kitchen' N1.14. This is of three bays formed by two triangulated butt-purlined principal rafter trusses with tiebeams and collars (Fig 9g). There is evidence for the reuse of some timbers here, however, and it is possible that they retain elements of an earlier roof.

East range

The roof of the east range(E3.01–13), incorporates a series of apparently reused timbers as well as primary-use timbers. The close-set frames of this roof comprise principal rafters with collars and tiebeams (Fig 9h). The east range also contains the long gallery, at first-floor level (E2.01) lined with oak panels and pilasters.

At the south end of this range (E2.02-05) is a complicated juxtaposition of floor, wall, and stair timbers.

West range

The roof of the west range appears to be of two parts, each with slightly different truss forms, although both parts are thought to be broadly coeval. The northern portion, of six bays above W2.05–08, forms two-thirds of the range, and comprises butt-purlin trusses with straight collars. The southern portion, of three bays above W2.09–10, forms the remaining one-third, comprising butt-purlin trusses with cranked collars and archbraces to alternating trusses (Fig 9i).The truss between rooms W2.08 and 09a is closed.

South range

The roof above rooms S3.05–13, although now truncated, probably originally comprised principal rafter trusses with tiebeams and collars, with the roof above S3.01–03 comprising common rafter frames and the partial remains of a single truss. The south range also retained joists holding a plaster ceiling above room S2.04/04a.

Orangery

Forming the western end of the southern range, and connecting the west range to the hall range is the 'Orangery' (O2.01–03e). The roof of this range is 'M'-shaped, with two vertical posts on each tiebeam supporting two ridges with a valley in-between (Fig 9j).

Outbuildings

This complex, lying to the north-east of the Hall itself, comprises the Stables, the Granary, and Granary House. The stables form a right angle to two sides, north and west, of a courtyard, whilst the granary buildings are set on a skewed angle, relative to the stables, to the east within the angle of the stable ranges (Figs 2, 4, and 8).

Stables

Large portions of the stables-range roofs have been replaced in what appear to be modern, probably twentieth-century, softwoods. There are, however, two roofs that retain some earlier oak timbers. Here, particularly in the roof of St2.12, is found a collection of timbers which show considerable evidence for reuse or insertion, with only a few timbers appearing as if they might be original. The roof above St2.13 appears more intact and the timbers coeval with each other. There are, though, some timbers which might be reused (Fig 9k).

A portion of an older roof also remains towards the south end of the west arm of the stables range, above St2.02–02b. Indeed, this roof appears to contain two roofs. The extant covering is represented by a principal-rafter truss roof, the trusses having tiebeams and collars. There are double purlins to each roof, these supporting common rafters. The roof also retains the remains of an earlier roof in a series of cut-off principal rafters and possibly wall plates.

Granary

Although these buildings are traditionally called the 'Granary' and 'Granary House' their true original functions, possibly as a store of some sort, or maybe a distillery is, in reality, unknown. The roof of Granary House, above HG2.03–07, is composed of four principal-rafter trusses with tiebeams, collars, and queen posts (Fig 9l). The trusses support single purlins to each pitch, which in turn support common rafters.

The neighbouring granary (HG2.01) has a similar roof (Fig 9m) that is believed to be coeval with that of the Granary House. Unlike Granary House, however, there is also a series of substantial timbers throughout the lower levels, forming floor and ceiling frames.

SAMPLING

Sampling and analysis by tree-ring dating of timbers within the many component elements of Apethorpe Hall and its outbuildings were commissioned by English Heritage. Tree-ring analysis formed an integral part of the major multi-disciplinary research programme being undertaken by the teams across English Heritage. It was hoped that it would provide independent dating evidence to underpin the research programme and hence inform repair and conservation decisions, while also contributing to the overall understanding of the development of Apethorpe Hall.

Sampling was targeted on the basis of the on-going research programme and works in order to address key questions relating to the development of the complex. An initial survey was made of a series of key areas in order to assess the suitability of the timbers and to develop an appropriate sampling strategy. It was seen at this stage that while many areas did contain sufficient suitable timbers, there were other areas for which sampling had been requested that were less satisfactory. Such areas contained either very few accessible timbers or timbers that were borderline or appeared unsuitable with respect to the number of rings present.

A small number of areas of interest within the overall research programme were not sampled as the timbers were clearly unsuitable for tree-ring analysis. These included the roofs of the north range above rooms N2.01/02 in the north-east corner, the roofs above N2.16 and N2.17, and those in the hall range above rooms H2.11. In addition, where it was deemed appropriate (ie areas of very significant interest), a small number of test cores were taken to confirm the initial assessment. These areas are detailed in the Interpretation section (see below).

Thus, samples from a total of 396 timbers were obtained. Each sample was given the code APT-A (for Apethorpe, site 'A') and numbered between 1 and 517, gaps having been intentionally left in the sequences of sample numbers to allow for the possibility that additional sampling would be required in certain areas, notably those areas where access was initially restricted.

The location of each sample was recorded at the time of collection on outline building plans made by the Architects Rodney Melville and Partners which were supplied by English Heritage, and on sketch drawings made at the time of sampling.

Details of the areas sampled, grouped by range, are given in Table 1, with further details of each individual sample being given in Table 2. The samples are located according to the room or location contexts given in Figures 5–8 and shown on Figures 10–48. Sampling was carried out during a series of site visits in tandem with analysis in order that the sampling strategy could be continually updated.

ANALYSIS

Each of the 396 samples obtained was prepared by sanding and polishing. The number of growth-rings needed on any individual sample for reliable tree-ring dating is usually in the order of 50+. However, given the unusually large number of samples obtained from this site and the quantity of data thus provided, it was felt that this limit could be reduced to 40 rings. Even at this lower limit, however, it was seen at this time that 74 samples, just under 19% of those obtained, had less than 40 rings, and these were, therefore, rejected from the analysis (Table 2). This rejection percentage is relatively high, especially as some areas or elements considered of prime importance to the overall research programme had been assessed as marginal at best, and following on from discussion were test cored to inform the initial assessment (see above).

The annual growth-ring widths of the remaining 322 samples were then measured, the growth-ring widths of all such samples were then compared with each other by the Litton/Zainodin grouping procedure (see Appendix). By this comparative process, two main groups of cross-matching samples were formed, accounting for 289 samples. In addition a further seven groups were identified accounting for 15 samples. The final 18 samples remain as ungrouped singletons.

The samples of each cross-matching group were combined at the indicated off-set positions to form site chronologies APTASQ01–SQ09 (Figs 49–59). Each site chronology was then compared with the remaining individual ungrouped samples. There was, however, no further reliable cross-matching. Each of the nine site chronologies was then compared with a full range of reference chronologies for oak. This indicated cross-matches and dating for two site chronologies, notably the most replicated and longest chronologies, the evidence for this dating being given in Tables 3 and 4. Each of the 18 measured but ungrouped samples was than compared individually with the full range of reference chronologies for the oak. There was, however, no reliable cross-matching and all these individual samples must remain undated.

Analysis by dendrochronology of 322 measured samples has produced nine site chronologies, two of which, accounting for a total of 289 samples, can be dated. The first dated site chronology, APTASQ01(Fig 49–51), comprises 216 samples, its 348 rings dated as spanning the years AD 1292–1639. The second dated site chronology, APTASQ02 (Fig 52), comprises 73 samples, its 176 rings spanning the years AD 1574–1749. Site chronologies APTASQ01 and APTASQ02 overlap by 66 years and cross-match each other with a *t*-value of 4.2. Site chronologies APTASQ03–SQ08 (Fig 53–58) comprise two samples each, whilst site chronology APTASQ09 (Fig 59) comprises three samples. In length, these site chronologies range from 61 rings to 160 rings but none of them can be dated.

This analysis can be summarised as follows:

Site chronology	Number of samples	Number of rings	Date span(where dated)
APTASQ01	216	348	AD 1292–1639
APTASQ02	73	176	AD 1574–1749
APTASQ03	2 (46/148)	108	undated
APTASQ04	2 (100/367)	61	undated
APTASQ05	2 (108/301)	153	undated
APTASQ06	2 (134/252)	66	undated
APTASQ07	2 (300/304)	106	undated
APTASQ08	2 (99/105)	64	undated
APTASQ09	3 (232/306/351)	160	undated
singles	18	---	undated
unmeasured	74	---	undated

INTERPRETATION

The following section presents the dendrochronological interpretation for dated timbers in each area/room sampled within the Apethorpe Hall complex. It is organised initially by range and then by each area/room. The bar diagrams (Figs 60–64) show all dated timbers from each range.

Where sapwood is complete to the bark edge, a felling date (or felling dates; see below), precise to the year is provided for a related group of timbers. In the absence of complete sapwood, a felling date range can be calculated for the group of timbers by using the average date of the heartwood/sapwood boundary (where it exists) and applying the 15–40 (95% confidence limits) sapwood estimate. Where there is no trace of sapwood, it is only possible to provide a date after which the timber or timbers were likely to have been felled. This is calculated by applying the minimum number of expected sapwood rings to the date of the outermost measured heartwood ring. The potential presence of timbers within a group that are potentially derived from the same-tree, as indicated by very high *t*-values (see Appendix), is highlighted where this aids interpretation.

The overall interpretation is complicated here by the presence of timbers within groups that have different precise felling dates but nevertheless appear to represent a single phase, or programme, of felling. Variation of precise felling dates by a few years within a clearly coherent group of timbers is not unexpected, when associated with large and potentially complex building projects such as here at Apethorpe Hall. A further complication is the potential, and indeed likely, reuse of timbers during rebuilding and modification work, as well as the presence of inserted timbers associated with potentially undocumented minor repairs or modifications.

Hall Range

Relative positions of the dated samples from the Hall range grouped by area are shown on bar diagram Figure 60.

Hall roof

In total, 12 samples were obtained from the hall roof timbers (H2.03). Four of these were considered unsuitable for reliable dating and were rejected from this programme of analysis. From the remaining eight, APT-A119–24 and A421–6 (Figs 12 and 13), all of which dated, the heartwood/sapwood boundary is found on only two, the average date of this being AD 1451. This produces an estimated felling date in the range AD 1466–91 for these two queen struts. The felling date range of the other six dated timbers, including queen struts, a collar, an archbrace, and a windbrace, cannot be calculated because they do not retain the heartwood/sapwood boundary. These are broadly of the same date, however, to suggest the same programme of felling.

Hall porch floor

A small number of samples was obtained, APT-A125–7 (Fig 10) from the joists available in the first-floor frame of the east porch (H2.04) in order to confirm the dendrochronological assessment of its potential. As anticipated, none of the samples had sufficient rings for reliable dating and all the samples were rejected. These timbers thus remain undated, and more extensive sampling was not deemed appropriate.

Great Chamber/cross-wing roof

A total of 12 samples, APT-A01–12, was obtained from a number of different frames in this roof H2.06/07 (Figs 16–18). All 12 were measured and dated. None of the samples retains complete sapwood and it is thus not possible to give an exact felling date for any of the timbers. Several samples, however, do retain some sapwood or at least the heartwood/sapwood transition (Fig 60; Table 2). The average date of the heartwood/sapwood boundary on the nine dated samples where it exists is AD 1458. Hence, allowing that the latest dated sapwood ring of AD 1473 on sample APT-A09 is not complete to the bark edge, the timbers represented have an estimated felling date in the range AD 1474–98. The date of the heartwood/sapwood transition varies by only four years. Such similarity is indicative of timbers cut as part of a single phase of felling. This interpretation is supported by some very high *t*-values between individual samples that suggest that some of the timbers were potentially derived from the same tree. A felling date range for the remaining three samples cannot be calculated because they do not retain the heartwood/sapwood transition. They are clearly broadly of the same date, however, and this, combined with the level of cross-matching within this group of timbers, suggests that they were also probably felled at the same time in the latter part of the fifteenth century.

Old Parlour/cross-wing roof

A total of ten samples, APT-A13–22 (Figs 18–20); was obtained from this roof H2.10/12. All ten were measured, cross-matched, and dated. None of the samples retains complete sapwood but five samples have some sapwood or the heartwood/sapwood boundary. The average date of the boundary on these five samples is AD 1455. Hence the timbers represented have an estimated felling date in the range AD 1470–95. Although the variation in the heartwood/sapwood transition date is greater than that on the timbers from the Great Chamber roof, varying by 11 years, it is still very likely that these timbers were felled as part of a single programme of felling. The felling date range of the remaining five samples is uncertain because they do not retain the heartwood/sapwood transition. However, it again seems likely that these were probably felled at the same time as the rest of the dated material from this roof, and simply represent slightly more heavily trimmed timbers.

Floors

From a series of rooms to the southern end of the hall range, H2.10/11/12, a total of 12 samples was obtained from a number of floor joists and main beams APT-A441–52 (Fig 11). One of these samples was, however, unsuitable for dating and was rejected from this programme of analysis. Only eight of the 11 measured samples were found to date. None of the dated samples retain complete sapwood but six of them retain the heartwood/sapwood transition and it is likely that at least two, and possibly three or more, different phases of felling, spanning up to about a century, are represented.

The earliest phase of felling appears likely to be represented by three samples, APT-A442, A451, and A452, all from joists in H2.10 and H2.12. The date of the heartwood/sapwood boundary varies by only two years on these three samples and hence it appears likely that they represent a single felling period. Their average heartwood/sapwood boundary date of AD 1447 which, allowing that the latest dated sapwood ring of AD 1467 on sample APT-A442 does not mark the bark edge, produces an estimated felling date range of AD 1468–87.

A potentially slightly later phase of felling may be represented by sample APT-A444 (H2.10) with a heartwood/sapwood boundary date of AD 1461 and thus an estimated felling date range of AD 1476–1501. This felling date range overlaps with that of the other three dated joists felled in the latter half of the fifteenth century, and the total variation in heartwood/sapwood boundary date is 15 years. Hence, it is possible that all four of these joists could have been felled at the same time.

A significantly later phase of felling is clearly represented by samples APT-A445 and A446, both main beams in H2.11, which have an average heartwood/sapwood boundary date of AD 1537 and an estimated felling date range of AD 1552–77.

The felling date ranges of the two other dated samples (APT-A449 and APT-A450), both joists in H2.12, cannot be determined because they do not have the heartwood/sapwood boundary. These were both felled at the very earliest in the last decade of the fifteenth century and, whilst they could represent yet another different felling phase, it seems more likely that they are associated with the felling period occurring in the earlier decades of the sixteenth century (see Lady Westmorland's room floor H2.13) or, if they are more heavily trimmed timbers, it is feasible that they are associated with the mid sixteenth-century felling period.

Lady Westmorland's room floor

A total of eight samples (APT-A261–8; Fig 11) was obtained from the joists of the floor frame to this room H2.13. One sample was rejected from this programme of analysis. None of the seven measured and dated samples retains complete sapwood and it is thus not possible to give an exact felling date for any of the timbers. Four samples, however, do retain at least the heartwood/sapwood boundary, this varying by only four years. The average heartwood/sapwood boundary date is AD 1498, which provides the timbers represented an estimated felling date in the range AD 1513–38. It is likely that these timbers were felled at the same time. The felling date range of the timbers represented by the other three dated samples is uncertain, because they do not retain the heartwood/sapwood boundary. However, they are clearly broadly of the same date, and this, combined with the high level of similarity within this group of seven dated timbers, including several potential same-tree matches, suggests that all were probably felled at the same time.

Lady Westmorland's bay window ceiling

These timbers comprise two large parallel east-west oak beams spanning the opening of the bay in this room H2.13 (separated by a single softwood beam or board), from the outer of which run a series of smaller joists southwards into the bay itself. From the suitable timbers available (two ceiling joists being obscured by plasterboard) a total of seven samples, APT-A511–17 (Fig 21), was obtained, although three samples were rejected as having too few rings for reliable analysis. None of the four samples which then dated retains complete sapwood and it is thus, not possible to determine the exact felling date of any of the timbers with reliability. All four samples do, however, retain the heartwood/sapwood boundary, the average date of this being AD 1747. This gives the timbers represented an estimated felling date in the range AD 1762–87 and, given that the heartwood/sapwood boundary on the four samples varies by so little, only three years, it is almost certain, that all the timbers were felled at the same time as each other.

Newel stair partition wall

Only four suitable timbers were identified in this partition wall H2.14. All four were measured, cross-matched, and dated APT-A81–4 (Fig 11). All four retain the

heartwood/sapwood boundary but one of the samples, APT-A81, retains complete sapwood with a last measured ring date, and hence a felling date, of AD 1559. The dates of the heartwood/sapwood boundaries vary by only five years, so it would appear that these four timbers represent a single programme of felling. However, sample APT-A82 also has a last measured ring date of AD 1559, but its sapwood is not complete. The average date of the heartwood/sapwood boundary for the three samples without bark edge is AD 1546, which produces a felling date range of AD 1561–86. This suggests that this single programme of felling represented by all four timbers probably took place over a few years starting in the late AD 1550s.

Cock Loft roof

Five out of the six samples from common rafters were measured APT-A85–90 (Fig 14) from the small number of timbers available in this roof (H3.01), one being rejected. All five measured samples were dated and the results indicate that more than one felling programme is represented.

Three of these samples have last, complete, sapwood ring dates and hence felling dates, of AD 1559, AD 1560, and AD 1560. One sample, however, has a heartwood/sapwood boundary date of AD 1495 and thus, an estimated felling date in the range of AD 1510–35, several decades earlier. The felling date of the final dated sample, without the heartwood/sapwood boundary, cannot be determined, but bearing in mind the date of its last measured heartwood ring, it appears reasonable to assume that it may also have been felled in the late AD 1550s or early AD 1560s.

Roof adjacent to Cock Loft

Eight samples, APT-A91–8 (Fig 14), were obtained from this roof (H3.02) of which, one was rejected. None of the samples retains complete sapwood but the average heartwood/sapwood boundary date of the six where it exists is AD 1551. Using the usual sapwood estimate, and allowing that the latest dated ring of any sample here is AD 1566, would give the relevant timbers an estimated felling date in the range AD 1567–91. The heartwood/sapwood boundary on these samples is, however, relatively wide, varying by 19 years. Whilst is it feasible that these timbers were all felled at the same time, it is possible, although not certain, that these timbers were felled over a period of several years in the latter part of the sixteenth century.

Matted Passage roof

Only a small number of timbers of this roof (H2.05) were accessible. A total of eight samples was obtained (APT-A39–46; Fig 15), two of which were rejected prior to measurement. Five of the six measured samples were dated. Three of these samples retain complete sapwood, these having felling dates of AD 1688, AD 1690, and AD 1692 respectively. A fourth sample has a heartwood/sapwood boundary date which is consistent with these precise felling dates. It should be noted that the overall

heartwood/sapwood boundary date varies by only seven years amongst these four samples, which is suggestive of a single programme of felling. The final dated sample consists of heartwood only, but it is broadly of the same date. It was not felled before AD 1674, and this, combined with the high level of cross-matching within this group of five timbers, implies that it is likely to have been felled at the same time in the late AD 1680s or early AD 1690s.

Matted Passage east wall

A total of ten samples, APT-A146–8 (not shown) and A271–7 (Fig 11) was obtained from the exposed timbers in this passageway H2.05. Four of these were unsuitable for dating and were rejected from this programme of analysis. Six samples were measured and analysed but one remains undated. The five dated samples appear to represent timbers of at least three different felling dates.

One sample has a last, complete, sapwood ring date, and thus a felling of AD 1682, whilst two other samples, also with sapwood complete to the bark edge, have felling dates of AD 1691. A further sample has a heartwood/sapwood boundary date of AD 1691 and thus, an estimated felling date in the range AD 1706–31. The felling date of the fifth dated sample cannot be determined with accuracy because it does not have the heartwood/sapwood boundary. It is unlikely, however, to have been felled before AD 1679, and is thus broadly coeval with the late seventeenth- or early eighteenth-century felling dates indicated by the other samples. It would thus, appear that this wall incorporates timber felled over a relatively extensive period in the late-seventeenth century and early eighteenth century.

Floor

The four cores, APT-A458–61 (Fig 10), obtained from amongst a small collection of joists in this room, H2.02, confirmed their poor suitability for tree-ring analysis in that they would not provide sufficient numbers of rings for reliable analysis. The samples were, therefore, not measured and remain undated by dendrochronology.

North Range

Relative positions of the dated samples from the North range grouped by area are shown on bar diagram Figure 61.

Old Dining Room floor

A total of nine samples, APT-A431–9 (Fig 10) was obtained from the floor joists in N2.15. Two of these were rejected as being unsuitable for dating, whilst the remaining seven were measured and dated. One of these dated samples retains complete sapwood, with a last measured ring date and thus, a felling date of AD 1469. The date of the

heartwood/sapwood boundary on the remaining four samples, where it exists, is consistent with this precise felling date. The overall heartwood/sapwood boundary date on all five of these samples varies by only five years. It is thus highly likely that all these timbers were cut as part of a single phase of felling. The two other dated samples have no heartwood/sapwood boundary, but the identification of potential same-tree matches within this group suggests that they are likely to have been felled at the same time as the rest of the dated joists.

Old Kitchen roof

Ten samples, APT-A23–32 (Fig 10),were taken from the roof timbers of this room N2.11. All were measured but one remains undated. Interpretation of the sapwood indicates that two phases of felling are present.

The earlier phase is represented by samples APT-A25 and A30, both are purlins. Sample APT-A30 has complete sapwood with a last measured sapwood ring, and hence felling date, of AD 1639. With an estimated felling date range of AD 1620–45, it appears likely that APT-A25 was felled at the same time as this and as part of a single programme of felling.

The later phase of felling is represented by a further seven dated samples from common and principal rafters. All seven have either some sapwood or the heartwood/sapwood boundary. The date of this varies by only four years, the average date being AD 1689. The timbers represented therefore have an estimated felling date in the range AD 1704–29. It is, again, very likely that all such timbers were felled at the same time.

Old Dining Room roof

Only a small number of suitable timbers was available from this roof (N2.14/15), a total of six samples APT-A33–8 (Fig 14) being obtained. All six were measured, with five being dated. None of these five dated samples retains complete sapwood and it is thus not possible to give an exact felling date for any of the timbers. All of them do, however, retain sapwood or the heartwood/sapwood transition. The date of the heartwood/sapwood boundary varies by 17 years, so it is, again, possible that more than one felling programme is represented by these five samples, and given the distribution of these heartwood/sapwood boundary dates, this seems quite likely.

Three samples, all common rafters from the east side of the roof, have a variation in heartwood/sapwood boundary date of only two years, the average date being AD 1606. It seems likely that these were felled at the same time and hence these timbers have an estimated felling date in the range AD 1621–46.

The potentially slightly later phase of felling is represented by a further two samples, both common rafters from the west side of the roof, whose heartwood/sapwood boundaries are only four years apart. These have an average heartwood/sapwood boundary date of

AD 1620, giving the timbers represented an estimated felling date in the range AD 1635–60.

It will be seen that these two estimated felling date ranges for the east and west side common rafters overlap, and it is likely that all the timbers represented were felled in the mid-seventeenth century.

Gatehouse vice

Five samples, APT-A47–51 (Fig 22), were taken from this roof N3.05, one was rejected with the remaining four being measured and dated. These four samples represent timbers felled at three different times.

Two samples, both from joists, have heartwood/sapwood boundaries only two years apart, and hence appear likely to have been felled at the same time. Their average heartwood/sapwood boundary date is AD 1545, giving an estimated felling date in the range AD 1560–85. On a further sample, from a main beam, the date of the heartwood/sapwood boundary is AD 1596, which, given that the last sapwood ring on the sample, which is not complete to bark edge, is dated to AD 1612, gives an estimated felling date in the range AD 1613–36. The final sample, from a cross-beam, retains complete sapwood with a last measured ring date, and thus a felling date of AD 1684.

Roof

The timbers of this roof over N2.16–21 mostly appeared to be derived from fast-grown timbers and unlikely to provide suitable samples. However, three samples were obtained APT-A99–101 (Fig 23), one of which was rejected and the other two were measured but failed to date. No dendrochronological dating evidence has therefore been produced for this roof.

Floor

Four samples, APT-A102–5 (Fig 24) were obtained from the small number of timbers associated with the floors in rooms N2.16-21. Two samples were rejected as unsuitable for dating purposes. Only one of the two measured samples was dated. This sample, from the north–south ceiling beam spanning rooms N2.18/19, does not retain the heartwood/sapwood boundary and its felling date range cannot, therefore, be determined. Given that its last measured, heartwood, ring date is AD 1549, it is unlikely to have been felled before AD 1564. Taking into account the nature of the material used throughout the Apethorpe Hall complex, combined with the fact that the highest *t*-values are obtained with other timbers felled in the mid/late sixteenth century, it seems possible that this timber was also felled, and initially used, in the latter half of the sixteenth century.

Kitchen ceiling

Samples were obtained from five timbers, APT-A149–153 (Fig 25) forming the ceiling of the north kitchen N1.14. Only one of these samples was measured, the others being rejected as unsuitable. The measured sample was dated, indicating a last measured, heartwood, ring date of AD 1609. Given that this sample does not retain the heartwood/sapwood boundary, its felling date range cannot be determined, but it is unlikely to have been felled before AD 1624. Whilst this joist could represent the inner part of a long-lived tree, it seems more likely, although clearly uncertain, that it was felled in the mid/late seventeenth century.

Cellar

Eight samples APT-A281–8 (Fig 26) were taken from various timbers available in the cellars of the north range N0.01. All eight were measured and dated, but none of the samples retains complete sapwood and it is thus not possible to give an exact felling date for any of the timbers. Five samples, however, do retain at least the heartwood/sapwood boundary, this varying overall by 12 years. The heartwood/sapwood boundary of the four dated joists, where it exists, varies by only two years, whereas that of the dated main beam with heartwood/sapwood boundary is ten years after the latest joist. The average date of this on the four joists is AD 1554 which would give the timbers represented, taking into account the outermost measured sapwood ring, an estimated felling date in the range AD 1570–94. The felling date range produced by the main beam with heartwood/sapwood boundary is AD 1580–1605. These two estimated felling date ranges clearly overlap and given the level of similarity between the timbers represented it is likely that all these timbers were cut at a similar time as part of a single or closely related programme of felling in the latter part of the sixteenth century. The felling date of the three other samples, two joists and one main beam, cannot be determined with accuracy because they do not have the heartwood/sapwood boundary. However, they are clearly broadly of the same date and this, combined with the level of cross-matching which includes some potential same-tree identifications, suggests that they were probably felled at the same time as the rest of the dated material from the cellar.

Cottage roof

A total of ten samples was obtained APT-A471–80 (Fig 28 - A472 not shown) from the roof to the north-west cottage N2.01 (Fig 9n), of which two were found to be unsuitable for dating and were rejected from the analysis. All eight measured samples provided a date. Although none of these eight dated samples retains complete sapwood and it is thus not possible to indicate an exact felling date for the timbers represented, a number of them retain the heartwood/sapwood boundary, demonstrating that several periods of felling are represented.

Two timbers, both common rafters, were felled in the sixteenth century. The earliest of these is sample APT-A480, which has an estimated felling date range of AD 1542–67, whilst sample APT-A479 has a slightly later estimated felling date range of AD 1570–95.

Five of the remaining six dated timbers, representing principal rafters and a tiebeam, all appear likely to have been felled in the early/mid eighteenth century. The overall heartwood/sapwood variation, on the five samples where it exists, is 18 years which suggests the possibility that the timbers could have been felled over a number of years. The two earliest heartwood/sapwood boundaries on samples APT-A477 and A478, vary by only three years and produce an average date of AD 1702. This would give them an estimated felling date range of AD 1717–42. The three remaining samples with heartwood/sapwood boundaries, APT-A471, A473, and A474, produce an average date of the boundary of AD 1716 and only vary by five years. This would give the respective timbers an estimated felling date range of AD 1731–56. It is thus, possible that these five samples could either have been felled at slightly different times or that they represent a common felling programme in the early/mid eighteenth century.

The felling date range of the final dated sample, another tiebeam, cannot be determined because it does not have the heartwood/sapwood boundary. However, given that it is unlikely to have been felled before AD 1706 and the high level of similarity between it and the other eighteenth-century timbers, it appears likely that it was also felled at a similar date in the early/mid eighteenth century.

Floor

Four samples, APT-A491–4 (Fig 10) were obtained from the small number of joists available in the partially exposed floor frame of room N2.12. All four were measured and dated but none has complete sapwood, and it is not possible to determine their exact felling date. Two of them, however, retain the heartwood/sapwood boundary. This boundary varies by six years, the average date of it being AD 1532. Such a date would give the timbers represented an estimated felling date in the range AD 1547–72. The felling date range of the other two dated timbers cannot be determined because they do not have the heartwood/sapwood boundary. However, given that they are clearly broadly of the same date and with the high level of similarity within this group of samples, it seems likely that all four timbers represent a single programme of felling.

Library roof

All 14 samples, APT-A401–14 (Figs 22 and 27), from this roof N3.06 were measured and dated. Six samples retain complete sapwood, providing exact felling dates of AD 1737, AD 1737, AD 1738, AD 1738, AD 1738, and AD 1739. Four of the other samples retain the heartwood/sapwood boundary, the dates of which are consistent with these precise felling dates. The overall variation in date of the heartwood/sapwood boundary, where it exists on these ten samples, is only nine years. Such a similarity is usually indicative of timbers cut over a very short period of time, and it is likely that all of the timbers

represented here were cut in the late AD 1730s. The range of the felling dates of the remaining four dated timbers is uncertain because they do not retain the heartwood/sapwood boundary. They are clearly broadly of the same date, and this, combined with the high level of similarity within this group of 14 dated timbers, including several potential same-tree matches, suggests that they were all part of the same programme of felling, spanning a small number of years.

East Range

Relative positions of the dated samples from the East range grouped by area are shown on bar diagram Figure 62.

Roof

All 11 samples, APT-A52–62 (Fig 29–30; A60–61 not shown), obtained from roof E3.01–13, predominantly from principal rafters but also tiebeams and a common rafter. were measured and dated. Two of these samples, a principal rafter and a tie beam, retain complete sapwood, both with the same last sapwood ring date, and thus a felling date of AD 1621. The heartwood/sapwood boundary on seven of the other samples is consistent with this precise felling date. The date of the heartwood/sapwood boundary varies by only seven years in this group of nine samples. This implies that they represent a single programme of felling. The high level of similarity between these samples and APT-A62, which has no heartwood/sapwood boundary, suggests that this sample also shares a common felling date.

One sample from a principal rafter, APT-A58, however, appears to have been felled later. It has a heartwood/sapwood boundary date of AD 1679. Allowing for the fact that it has a last measured sapwood ring date of AD 1695, this would give the timber an estimated felling date in the range AD 1696–1719.

Roof, reused timbers

From a series of collars and principal rafters within this roof E3.01–13, which show evidence of reuse, a total of 12 samples was obtained APT-A331–42 (Figs 29 and 33). All 12 were measured and dated. Three of these samples retain complete sapwood, having felling dates of AD 1620, AD 1621, and AD 1621. The date of the heartwood/sapwood boundary on the seven remaining samples, where it exists, is consistent with these precise felling dates. The date of the heartwood/sapwood boundary on all ten samples varies by 15 years. Such a similarity is indicative of timbers, perhaps not being cut at exactly the same time, but certainly over a short period of time, and probably as part of a single programme of felling, this apparently taking place in the early AD 1620s. The remaining two timbers, neither of which have heartwood/sapwood transitions, are clearly broadly coeval with the rest of the dated material. The identification of potential same-tree

matches between these two, and other samples in this group, indicate that they were also likely to be felled in the early AD 1620s.

Floor adjacent to Oak Stair

Seven samples, APT-A211–12, A453–7 (Fig 31), were obtained from two main beams and five common joists in this area E2.02, adjacent to the main south staircase of the east range, however, the samples from the joists were all rejected from this analysis whilst both samples from the main beams dated. Sample APT-A212 retains complete sapwood, indicating an exact felling date of AD 1620. Sample APT-A211 retains the heartwood/sapwood boundary, at a date of AD 1606. Such a date would give the timber represented an estimated felling date in the range of AD 1621–47. It is likely that both timbers were felled at the same, or at a very similar time.

Long Gallery wall panelling

From a series of wall panels, columns, and coving in the long gallery E2.01, a total of 21 ring-sequences were measured on site by graticule eye-piece readings, APT-A300–12 and A501–8 (not shown). Seventeen of these can be dated. Given the nature of this material it is not surprising to find that only three of the dated series have any sapwood, the date of the heartwood/sapwood boundary on them varying by six years. The average date of the heartwood/sapwood boundary on these three series is AD 1608, and if it is assumed that the timbers represented were all felled as part of the same felling programme, it is estimated that this would have taken place in the period AD 1623–48. The felling date ranges of the 14 other dated series cannot be determined because they do not have the heartwood/sapwood boundary. It appears likely, given the range of end dates of the majority of these series, that they were also felled at a similar date. The potential exceptions are APT-A302 and A305, although, given the nature of the type of material used for wall panelling, it seems that these are most likely to simply represent the inner parts of long-lived trees.

Roof, east dormers

A small number of samples, APT-A321–5 (Figs 29 and 30), was obtained from the few suitable timbers of the east dormer windows to roof E3.01–13, which were all sill beams. Two of the five samples obtained, were rejected as unsuitable for analysis. The remaining three samples were measured and dated. One sample retains complete sapwood, this having a last ring date, and thus a felling date of AD 1694. The felling date range of the two other dated samples cannot be determined because they do not have the heartwood/sapwood boundary. It is unlikely that one was felled before AD 1677 and unlikely that the other was felled before AD 1712. It is thus clear that timbers with different felling dates are to be found here.

West roof off main roof

Six samples, APT-A351–6 (Figs 30 and 32), were obtained from a small number of accessible timbers in a roof, E3.12, to the west side of the main east range roof at its southern end. All six samples from these common rafters were measured but only two of these can be dated. Both of these samples have the heartwood/sapwood boundary, this being only six years apart, producing an average date of AD 1566. Such a date would give an estimated felling date in the range AD 1581–1606 for the timbers represented.

Roof, west pitch common rafters

A total of 12 samples, APT-A361–72 (Fig 29 and 30), was obtained from the common rafters to the west pitch of the east range roof E3.07–13. Four of these were rejected as being unsuitable for tree-ring analysis, and three of the remaining eight that were analysed failed to date. None of the five samples which did date retain complete sapwood and it is thus not possible to indicate an exact felling date for the timbers represented. All five dated samples do, however, retain the heartwood/sapwood boundary, the average date of this being AD 1676. Such a date would give the timbers an estimated felling date in the range AD 1691–1716. The heartwood/sapwood boundary is, however, spread over a range of 17 years. While such a range can be found on timbers of a single felling date, it is potentially indicative of timbers felled over a period of a few years, but still, probably, part of a single programme of works.

Partition sills and door jambs

A total of five samples, APT-A381–5 (not shown) was obtained from a selection of miscellaneous timbers temporarily accessible in the upper floors E3.10–13. Three of these samples were not measured but the remaining two samples cross-matched and dated. One of these samples, from a timber forming part of a partition sill, retains complete sapwood, with a last ring date of AD 1622. This is, thus, the felling date of the timber represented. The second dated sample, from a door jamb, has a heartwood/sapwood boundary date of AD 1614 and 14 sapwood rings, giving the timber represented an estimated felling date in the range AD 1629–54. It is clear that these odd timbers represent different phases of felling.

West Range

Relative positions of the dated samples from the West range grouped by area are shown on bar diagram Figure 63.

Roof, south end

A total of ten samples APT-A128–37 (Fig 34) was obtained from the roof timbers of the southern part of roof W2.09–10. All samples were measured and only one failed to date.

None of the samples retains complete sapwood, but several of them have the heartwood/sapwood boundary, the interpretation of which indicates the presence of more than one felling period.

The average date of the heartwood/sapwood boundary on six of the samples where it exists is AD 1453. Such a date would give the relevant timbers an estimated felling in the range AD 1468–93. The variation in heartwood/sapwood boundary date by 11 years on these timbers suggests that they were all felled at the same or a similar time. Two other samples do not have the heartwood/sapwood boundary and it is, therefore, not possible to calculate their felling dates with reliability. However, with last measured ring dates in the late-fourteenth and early fifteenth centuries, it seems most likely that they are associated with this fifteenth-century felling period.

On a further, single, sample the heartwood/sapwood boundary is dated to AD 1598 giving a clearly later felling date range of AD 1613–38.

Roof, north end

Eight samples, APT-A138–45 (Fig 34), were obtained from the roof timbers of the northern part of the west range (W2.04–08), three of which were not measured. The five remaining samples all dated and, again, indicate the presence of more than one felling period.

One of the dated samples retains complete sapwood, with a last ring date, and thus a felling date, of AD 1476. The date of the heartwood/sapwood boundary on three of the other samples is consistent with this precise felling date. The overall variation in heartwood/sapwood boundary date of nine years in this group of four timbers suggests that they are likely to represent a single programme of felling.

The fifth, and final, measured sample from this roof, however, has a heartwood/sapwood boundary date of AD 1549, giving an estimated felling date in the range AD 1564–89.

Archway roof

A total of eight samples, APT-A481–8 (Figs 35–37), was obtained from a collection of timbers in the roof of the archway to the west courtyard (W2.01; Fig 9o). Three of these were rejected from this programme of analysis. Four of the remaining five measured samples date, with all retaining the heartwood/sapwood boundary. This boundary varies by only two years, the average date of it being AD 1693. Such a date, allowing that the latest date on any ring of this group is AD 1714, would give the common rafters and collars represented an estimated felling date in the range AD 1715–33, all such timbers probably being felled at the same time.

South Range

Relative positions of the dated samples from the South range grouped by area are shown on bar diagram Figure 63.

Truncated trusses, floor level

A total of ten samples (APT-A63–71, A215; Fig 39) was obtained from a series of truncated trusses remaining at floor level in passageway S3.05, S3.13, and rooms S3.06–12. All ten were measured and dated. Four of these have the heartwood/sapwood boundary, the average of this being AD 1590. Allowing that the latest ring of any of these samples is dated to AD 1612, this would give these four timbers an estimated felling date in the range AD 1613–30. The heartwood/sapwood boundary date varies by 14 years, suggesting a single programme of felling. The six remaining samples are without the heartwood/sapwood boundary, but it seems likely that they simply represent more heavily trimmed timbers that were felled in the early seventeenth century as well, with the possible exception of APT-A215, a collar, which is clearly from slower-grown tree and hence of a slightly different nature.

Roof

Nine samples (APT-A72–80; Fig 40) were taken from the common rafter frames and a single main truss in roof S3.01–03, one of which was rejected. Seven of the eight measured samples were dated and clearly represent timbers with two different felling dates, which support the structural evidence for alteration here.

The earlier phase is represented by five samples, which have an average heartwood/sapwood boundary date of AD 1543 providing the relevant timbers an estimated felling date in the range AD 1558–83. The heartwood/sapwood boundary variation is 19 years, which suggests that whilst they are likely to represent a single programme of felling, this may have occurred over a number of years.

The later phase is represented by two further samples, one of which has complete sapwood with a last measured ring date of AD 1630, and the other of which is clearly likely to be of the same, or similar, date with an estimated felling date in the period AD 1622–47.

Ceiling of King's Chamber and passageway ceiling

A total of 13 samples (APT-A154–66; Fig 41) was obtained from the joists forming the ceilings of the King's Chamber and the passage adjoining it (S2.04/04a). Five samples were rejected from the programme of analysis, whilst only seven of the remaining eight could be dated. None of them have complete sapwood but six retain the heartwood/sapwood

boundary, the average date of this being AD 1600. Such a date would normally give the timbers an estimated felling date in the range AD 1615–40. However, during sampling the outermost one or two sapwood rings to bark edge were lost from APT-A155, indicating a felling date of AD 1620–1, given that the last extant ring is AD 1619. It is likely that all six of these timbers were cut as part of a single programme of felling, the heartwood/sapwood boundary date varying by only five years. The sixth sample does not have the heartwood/sapwood boundary. It is broadly of the same date and was not felled before AD 1600, so there is no reason to suspect that it was not felled at the same time as all the other timbers here.

Floor of Dining Room, Drawing Room, King's Chamber and passageway

A total of 11 samples (APT-A200–10; Fig 38) was obtained from the floor joists of the row of rooms S2.02–04a, with all but one sample being measured. Eight of the measured samples could be dated and represent more than one felling date.

Three of these samples retain complete sapwood, with a last measured ring date, and thus a felling date, on all three being the same at AD 1621. Two other samples retain the heartwood/sapwood boundary, at a date which is consistent with this precise felling date. The overall variation in heartwood/sapwood boundary date on these five samples is ten years, which implies that they are all likely to represent a single programme of felling. A further sample, APT-A204, does not have the heartwood/sapwood boundary, but, given that it is broadly of a similar date to these timbers and cross-matches well within this group, it seems likely to have been felled at the same time.

Two other samples, however, were felled significantly later. APT-A206 has a heartwood/sapwood boundary date of AD 1729, producing an estimated felling date in the range of AD 1744–69, whilst APT-A208 has a complete sapwood ring date of AD 1740. It is possible, therefore, that more than one phase of felling is represented by these two timbers, although, if APT-A206 has fewer sapwood rings than expected it could also have been felled in AD 1740.

Floor

A total of nine samples (APT-A250–8; Fig 39) was obtained from the second-floor joists of the south range (S3.06–11). One of these samples was unsuitable and was rejected from this programme of analysis and seven of the remaining eight, which were measured, were dated. One of these dated samples retains complete sapwood with a last ring date, and thus a felling date, of AD 1621. Only one other sample in this group retains the heartwood/sapwood boundary, dated to AD 1607, which would produce an estimated felling date of AD 1622–47. It is, however, possible that this timber was felled in AD 1621 as well, but it would only have had 14 sapwood rings, were this the case, and hence outside of the usual 95% confidence limits applied. It is not possible to be sure of the felling date of any of the other five dated samples because they do not retain the heartwood/sapwood boundary. The range of end dates is quite wide, but the nature of

this material means that it is likely that some of these joists simply represent the inner sections of longer-lived trees and hence are the product of the method of conversion used to turn a tree into a series of relatively small timbers. It, therefore, seems perfectly feasible for these five timbers to have been felled around AD 1621 as well.

Orangery

Relative positions of the dated samples from the Orangery grouped by area are shown on bar diagram Figure 63.

Orangery roof

A total of 13 samples (APT-A106–18; Fig 42) was obtained from the timbers of the Orangery (O2.01–03e), one of which was not measured. Eleven of the 12 measured samples were dated. Ten of these retain complete sapwood, with felling dates of AD 1706, AD 1707, AD 1713, AD 1715, AD 1715, AD 1716, AD 1716, AD 1716, AD 1716, and AD 1724. A further sample, with a heartwood/sapwood boundary at AD 1701, is clearly consistent with these various precise felling dates and is hence likely to be contemporary with the rest of the dated samples. It is of interest to note that the heartwood/sapwood boundary dates of the entire group varies by only 11 years, even though it is known that felling occurred over a total period spanning 18 years.

Granary

Relative positions of the dated samples from the Granary complex grouped by area are shown on bar diagram Figure 64.

Granary House roof

A total of nine samples (APT-A167–75; Figs 44 and 45) was obtained from the roof timbers of building HG2.03–07, one of which was not measured. The remaining eight samples were dated. One of these retains complete sapwood with a last measured ring date, and thus a felling date, of AD 1563. Overall the heartwood/sapwood boundary, where it exists, varies in date by 15 years. This, combined with a number of same-tree matches between the timbers, implies a single programme of felling dating to around AD 1563 but, bearing in mind the latest heartwood/sapwood boundary date of AD 1558, it probably spanned several years in the mid AD 1560s. The final dated sample does not retain the heartwood/sapwood boundary. It was unlikely to have been felled before AD 1535 and could, therefore, also have been felled at the same time as the other timbers in the mid-sixteenth century.

Granary floors

Five samples (APT-A176–80; Fig 43) were obtained from the small number of timbers available in floor frame HG1.01/2.01. All five were measured and dated. Two of these samples retain complete sapwood, with a last measured ring date, and thus a felling date, of AD 1713 and AD 1714 respectively. The date of the heartwood/sapwood boundary on the remaining three samples is consistent with these precise felling dates. As the overall variation in heartwood/sapwood boundary date is only six years, there is again no reason to suspect that all these timbers are not of a single programme of felling.

Granary roof

A total of eight samples (APT-A181–8; Fig 46) was obtained from the roof HG3.01, with all eight samples being measured and only one failing to date. One of the seven dated samples retains complete sapwood with a last measured ring date, and thus a felling, of AD 1568. The date of the heartwood/sapwood boundary on the six remaining samples is again consistent with this precise felling date. The overall variation is nine years, so there is again no reason to suspect that all of these timbers are not of a single programme of felling.

Stables

Relative positions of the dated samples from the Stables grouped by area are shown on bar diagram Figure 64.

North-west stable, west roof

A total of seven samples (APT-A220–6; Fig 48) was obtained from the timbers in the roof of the west portion of this building (St2.12). All seven were measured and five were dated. The results indicate that two phases of felling are likely to be represented.

Sample APT-A222 has a heartwood/sapwood boundary of AD 1498 and thus, an estimated felling date range of AD 1513–38.

The second phase of felling is represented by two samples with an average heartwood/sapwood boundary date of AD 1601, and an estimated felling date range of AD 1616–41.

The two other dated samples do not have the heartwood/sapwood boundary, but it appears likely that APT-A221 is of a similar date to the early/mid sixteenth-century felling date identified and that APT-A225 is associated with the early/mid seventeenth-century felling date identified.

North-west stable, east roof

Seven samples (APT-A231–7; Fig 48) were obtained from the timbers in the roof of the east portion of this building (St2.13). All seven were measured and only one failed to date. It is again probable that two phases of felling are represented.

The earlier phase is represented by sample APT-A236, which has a heartwood/sapwood boundary of AD 1509 and thus an estimated felling date range of AD 1524–49.

The later phase is probably represented by all five of the remaining dated samples, four of which have their heartwood/sapwood boundary. The date of this varies by ten years suggesting that they are all of a single programme of felling. One of these samples, APT-A237, has a complete sapwood ring date and thus, a felling date of AD 1565, which is probably representative of the felling date for the majority of the timbers here. The fifth sample in this group, with no heartwood/sapwood boundary, was not felled before AD 1549. Taking into account the potential same-tree match identification, it seems likely that it was also felled at the same time in the AD 1560s.

West stable range roof

An attempt was made to obtain some suitable samples from the considerable quantity of timber found in the roof of this range (St2.06–10). However, despite targeting the most promising timbers, eight test cores (APT-A240–7; Fig 47) confirmed the poor suitability of the timbers for tree-ring analysis. They could clearly not provide sequences of sufficient length for reliable dating and thus, the samples were not measured. These timbers, therefore, remain undated by dendrochronology.

SUMMARY INTERPRETATION

The following sections summarise the results obtained from each range in overall date order (Figs 65–69). The variation seen in bark edge dates within groups of timbers from a single area means that where those quoted are based on a single timber it should be assumed that construction took place within a few years of the date given rather than immediately following the felling of that particular timber.

Hall range

A total of 75 timbers representing various areas within the hall range has been dated (Fig 65). These indicate a series of felling periods, dating from the late-fifteenth to the mid/late-eighteenth century.

Thirty-four timbers (45%), from the roofs of the hall (H2.03), the Great Chamber/cross-wing (H2.06/07) and the Old Parlour/cross-wing (H2.10/12), as well as a number of floor joists in rooms H2.10 and H2.12, were felled in the latter decades of the fifteenth century.

These dates, therefore, imply that these roofs contain primary-use timber associated with the original construction of Apethorpe Hall and, hence, appear likely to be part of the works commissioned by Sir Guy Wolston.

Two timbers (3%), both joists from H2.12, were felled, at the very earliest, in the last decade of the fifteenth century, and hence could be associated with the initial construction of Apethorpe Hall by Sir Guy Wolston. However, it seems more likely that they are associated with the works to the floor of the adjacent room, Lady Westmorland's room (H2.13), and were, thus, felled in the early decades of the sixteenth century.

Eight timbers (11%) were felled in the early decades of the sixteenth century and, hence, appear likely to have been originally associated with works undertaken either, towards the later part of Thomas Empson's ownership or, perhaps more likely, when the group including Henry Keble and William Blount, 4th Lord Mountjoy, owned Apethorpe Hall. With one exception, these timbers are floor joists from Lady Westmorland's room (H2.13). The exception is a single common rafter present in the roof over the Cock Loft (H3.01), which appears likely to represent a reused timber in a later roof.

Seventeen timbers (23%) were probably felled in the mid/late sixteenth century and, hence, appear to be associated with works commissioned by Sir Walter Mildmay. The majority of these are what appear likely to be primary-use timbers from the roof over the Cock Loft (H3.01) and the adjacent roof (H3.02/02a), with the remaining timbers being from the newel stair partition wall (H2.14) and two main floor beams in room H2.11. Some timbers from the cock loft and the newel stair partition share common felling dates, and others from the cock loft and adjacent roof produce *t*-values of a level that could indicate same-tree derivation. Thus, it appears that the works in these areas are closely related.

Ten timbers (13%) were felled in the late-seventeenth or early eighteenth century. All of these are associated with the roof or the east wall of the matted passage (H2.05). The majority of these timbers appear likely to have been felled in the AD 1680s and early AD 1690s, although, at least one was felled later in the early decades of the eighteenth century. The felling of most of these timbers, therefore, appears to coincide with a series of ownership changes in the last decade of the seventeenth century. These could, therefore, have been initially used in the early AD 1690s or alternatively they could have been stored during the upheavals and used in the early decades of the eighteenth century when Apethorpe Hall had settled under the ownership of the Thomas Fane, 6th Earl of Westmorland.

Four timbers (5%) from the ceiling of the bay window in Lady Westmorland's room were felled in the mid/late eighteenth century. It seems most likely that these are associated with the John Fane, 9th Earl of Westmorland, who took charge of Apethorpe Hall in 1762.

North range

A total of 61 timbers representing various areas within the north range (Fig 66) have been dated. These indicate a series of felling periods dating from the latter decades of the fifteenth century to the mid-eighteenth century.

Seven timbers (11%) were felled in the latter decades of the fifteenth century and, hence, appear to be associated with the works commissioned by Sir Guy Wolston. These timbers are all floor joists from the Old Dining room (N2.15) and include one timber felled in AD 1469 which is the earliest, and indeed only, precise felling date obtained for timbers from this period in the history of Apethorpe Hall.

Seventeen timbers (24%) were probably felled in the mid/late sixteenth century. The majority of these appear most likely to have been originally associated with the works commissioned by Sir Walter Mildmay, particularly when taking into account the generally low sapwood numbers present in the Apethorpe Hall material (see below). They include floor joists from room N2.12, various timbers in the cellar (N0.01), some of the timbers from the gatehouse vice roof (N3.05), some of the timbers from the roof of the cottage (N2.01), and the only dated floor beam from N2.16–21. Those from room N2.12 and the cellar appear likely to be primary-use timbers with the possibility that the former could be associated with Queen Katherine Parr or Princess Elizabeth's ownership and the latter could be associated with Sir Anthony Mildmay's ownership. Those from the gatehouse vice are in a structure that also includes timbers felled at different times in the seventeenth century and hence could easily represent reused timbers. It also seems likely that those timbers from this period used in the roof of the cottage are reused. It is uncertain whether the only dated timber from N2.16–21 represents a primary use or reused timber, although there were no obvious signs of reuse.

Ten timbers (16%) were probably felled during the seventeenth century. These are mostly likely to have been felled in the early/mid seventeenth century, with one clear exception from the gatehouse vice that was felled in AD 1684. The dated timbers from the Old Dining Room roof (N2.14–15) represent two, potentially, slightly different felling periods with the initial use of the timbers forming the east common rafters most possibly associated with works by Sir Francis Fane, 1st Earl of Westmorland, or by his son, Sir Mildmay Fane, 2nd Earl of Westmorland, and those forming the west common rafters likely to be exclusively associated with Sir Mildmay Fane. It is likely that both sets of timbers are reused in their present positions. Some of the timbers associated with the roof above the kitchen appear to have been initially felled and used during Sir Mildmay Fane's ownership but these appear likely to have been reused. It remains uncertain whether the only dated timber from the ceiling to the kitchen (N1.14) represents a primary use or reused timber. Its initial use is, however, associated with either Sir Francis Fane or Sir Mildmay Fane. The earlier of the two seventeenth-century timbers in the gatehouse vice is such that it could have been initially used during a period spanning the ownership of Apethorpe Hall by Sir Anthony Mildmay, Sir Francis Fane, and Sir Mildmay Fane, whilst the later of these in AD

1684, coincides with other fellings undertaken towards the end of the seventeenth century, this being just prior to a period of rapid change of ownership when Charles Fane, 3rd Earl of Westmorland, was still incumbent. The dendrochronological dating evidence for the gatehouse vice is such that it is uncertain if any of the few dated timbers are primary use or whether all are reused.

Twenty seven timbers (44%) were probably felled during the first half of the eighteenth century. These timbers are from the roofs of the old kitchen (N2.11), the cottage (N2.01), and the Library (N3.06). Those from the old kitchen appear likely to be associated with works commissioned by Thomas Fane, 6th Earl of Westmorland. These seem likely to be primary-use timbers, although clearly this roof does contain some earlier reused elements. The roof of the cottage (N2.01) potentially contains two groups of timbers with slightly different felling dates, the initial use of which could be associated with works undertaken either during the ownership of Thomas Fane or his brother John Fane, 7th Earl of Westmorland. It is likely that these timbers, although possibly felled at different times, are in their original or primary positions, the potentially later felling representing the date of the works. The library roof (N3.06), with a series of fellings in the late AD 1730s, is clearly associated with works undertaken by John Fane who is known to have built the Library after AD 1736.

East range

A total of 54 timbers have been dated from the east range (Fig 67). These represent a number of felling periods dating from the late-sixteenth/early seventeenth century to the early eighteenth century.

Two timbers (4%) were probably felled in the late-sixteenth or very early seventeenth century and were, thus, initially associated with works undertaken by either Sir Walter Mildmay or his son, Sir Anthony Mildmay. These are the only dated timbers from the west roof off the main east range roof, and both timbers are probably reused here.

Forty three timbers (80%) were probably felled in the early/mid-seventeenth century. Twenty-two of these are from the east range roof and represent two groups of timbers. The first group showed no evidence for reuse but the second group had clear evidence for reuse, or at least resetting. All of these, however, appear to have been felled at the start of the AD1620s, with some potential same-tree matches identified between the two groups and, thus, seem likely to be associated with the works commissioned by Sir Francis Fane, 1st Earl of Westmorland. Three other timbers, two from the floor frame adjacent to the Oak Stair (E2.02) and one from a partition sill (E3.10/13) also appear to form part of this major felling period at the start of the AD 1620s. Seventeen timbers associated with the wall panelling in the Long Gallery (E2.01) appear likely to post-date the roof timbers but, potentially, by only a few years. These timbers are also, therefore, most likely to be associated with the works undertaken by Sir Francis Fane but could, possibly, represent work undertaken by his son, Sir Mildmay Fane, 2nd Earl of Westmorland. The remaining

dated timber, a jamb from the central door, appears to post-date the works of Sir Francis Fane. However, bearing in mind the relatively low numbers of sapwood rings present in the material from the Apethorpe Hall complex (see below), it is just possible that this timber could be associated with the latter years of ownership by Sir Francis Fane.

Nine timbers (17%) were felled in the late-seventeenth or early eighteenth century and, hence, are potentially contemporary with the series of ownership changes in the last decade of the seventeenth century finishing with Thomas Fane, 6th Earl of Westmorland. These timbers include a series of common rafters from the west pitch of the main roof to the east range (E3.12) and a single principal rafter from this roof, suggesting alterations or, more likely, repairs during this period. The sill beams in the east dormers of the main roof (E3.10–13) include at least one felled in AD 1694 but also a clearly later one, probably, felled at least two decades later, at the earliest.

West range

A total of 18 timbers from three areas of the west range (Fig 68) has been successfully dated. These represent felling periods dating from the late decades of the fifteenth century through to the early eighteenth century.

Twelve timbers (67%) were probably felled in the latter decades of the fifteenth century, one of which, has a precise felling date of AD 1476. These are, thus, originally associated with the initial construction of Apethorpe Hall by Sir Guy Wolston. These timbers are from throughout the entire length of the west range roof with no clear evidence to distinguish between the northern (rooms W2.04–08) and southern (rooms W2.09–10) sections.

A single timber (6%), a common rafter from the northern end of the west range roof, was felled in the second half of the sixteenth century during Sir Walter Mildmay's ownership. This indicates at least some later intervention to this roof.

A single timber (6%), again, a common rafter but this time from the southern end of the west range roof, was felled in the early/mid seventeenth century, during the ownership of Sir Francis Fane, 1st Earl of Westmorland, or Sir Mildmay Fane, 2nd Earl of Westmorland, indicating at least some later intervention to this section of roof.

Four timbers (22%) were felled in the early decades of the eighteenth century and hence appear to be associated with the works commissioned by Thomas Fane, 6th Earl of Westmorland. All are from the roof over the archway (W2.01) and appear likely to represent primary-use timbers.

South range

A total of 39 timbers from five areas of the south range (Fig 68) has been successfully dated. These represent felling periods ranging in date from the mid-sixteenth to mid-eighteenth century.

Five timbers (13%) were felled in the mid-sixteenth century and were, therefore, initially associated with the works commissioned by Sir Walter Mildmay. These are all from the roof at the west end of the south range (S3.01–03).

Thirty-two timbers (82%) were felled in the early decades of the seventeenth century, all within, at most, less than two decades of each other. Twenty timbers from the floor frame of the Dining Room, the Drawing Room, the King's Chamber, and its adjoining passageway (S2.02–04a), from the ceiling frame of the King's Chamber and its adjoining passageway (S2.04/04a), and from the floor frame of rooms S3.06–11 (these second-floor ceiling and third floor floor-frames being separated by a void), all appear likely to have been felled at the start of the AD 1620s. These, therefore, appear to be associated with the works commissioned by Sir Francis Fane, 1st Earl of Westmorland. A series of ten timbers from the cut-off, or truncated, frames of what was once the roof over rooms S.2.02–04a, accessible from the passageway of the second floor (S3.05–12), are also probably associated with the works commissioned by Sir Francis Fane (who rebuilt the roof and floors of this range at the same time) particularly bearing in mind the relatively low sapwood numbers found within the Apethorpe Hall complex (see below). However, two timbers from the west end of the roof of the south range (S3.01–03), one of which was felled in AD 1630, appear likely to represent alterations, undertaken by Sir Mildmay Fane, 2nd Earl of Westmorland, in this apparently predominantly mid-sixteenth century roof structure. This accords well with structural evidence for alterations within this roof.

Two timbers (5%) were felled in the mid-eighteenth century. The mid-eighteenth century joists, one of which was felled in AD 1740, present in the otherwise early seventeenth-century floor frame of the Drawing Room (S2.03), are probably representative of the substantial alterations known to have been undertaken in these rooms *c* 1740 by John Fane, 7th Earl of Westmorland. This included the complete rebuilding of the north wall of the south range and the partition wall between rooms S2.02/03. It is, thus, in theory at least, possible that the entire floor of these rooms was reset at this time, using mostly early seventeenth-century timber.

Orangery

Eleven timbers from the Orangery were successfully dated (Fig 68) and, with one exception, were all felled in the first and second decades of the eighteenth century. Hence, the tree-ring analysis supports the AD 1718 date indicated for The Orangery by documentary evidence. All appear, therefore, to be associated with the works undertaken

by Thomas Fane, 6th Earl of Westmorland. The exception amongst these samples is the common rafter felled in AD 1724, the implication being that it is an early repair to the structure.

Granary

A total of 20 timbers have been successfully dated from the granary complex (Fig 69). These represent felling periods in the mid-sixteenth century and the early eighteenth century.

Fifteen timbers (75%) were probably felled in the AD 1560s and hence appear to be associated with the works undertaken during Sir Walter Mildmay's ownership. These timbers are from the roofs of the Granary House (HG2.03–07) and the Granary (HG3.01). The two precise felling dates obtained could be taken to suggest that those from the Granary House potentially just predate those from the Granary by a few years. However, taking into account the variation in precise felling dates seen throughout the later periods of building works at Apethorpe Hall, and the variation in the heartwood/sapwood boundary dates within each group, this seems relatively unlikely.

Five timbers (25%) were probably felled in the early part of the second decade of the eighteenth century. These are from the main floor beams of the Granary (HG1.01/2.01), which appear to be associated with works commissioned by Thomas Fane, 6th Earl of Westmorland.

Stables

A total of 11 timbers was dated from the roofs of the north-west stables (Fig 69). These represent felling periods in the early/mid-sixteenth century and the first half of the seventeenth century.

Eight timbers (73%) appear to have been felled during the early/mid-sixteenth century. Both roofs of the stable areas (St2.12 and St2.13) contain timbers felled in the first half of the sixteenth century. The initial use of these timbers therefore coincides with the ownership of Apethorpe Hall by the group including Henry Keble and William Blount, or possibly when it had become the property of Queen Katherine Parr and Princess Elizabeth. The bulk of the dated timbers from the east section roof (St2.13) date to the AD 1560s, when Apethorpe Hall was owned by Sir Walter Mildmay. There is no clear evidence that these timbers have been reused and it is, thus, possible that they represent the construction of this range of buildings.

Three timbers (27%) appear to have been felled during the first half of the seventeenth century, and are hence likely to have initially been used during works commissioned by either Sir Francis Fane, 1st Earl of Westmorland, or Sir Mildmay Fane, 2nd Earl of

Westmorland. These are from the west roof section (St2.12), an area that appears to have been altered and which contains what appear to be reused timbers. It is, thus, possible that the dated timbers are later insertions.

DISCUSSION

Dating

The successful dating of 289 timbers (Figs 49–70) has provided evidence of a series of periods of felling that can be related to phases of development of Apethorpe Hall and its associated outbuildings identified through documentary and architectural survey. These 289 timbers reveal five main periods of felling, some of which encompass more than one phase of construction. For some groups of dated timbers from specific elements/rooms it is possible to directly compare the original expected date of construction based on initial documentary and architectural survey work to the dendrochronological date subsequently obtained (Table 5). However, clearly during the early stages of this major programme of investigation there was much that was unclear and, hence, the expected date of many of the specific elements that underwent dendrochronological analysis was uncertain at that time.

The five main periods of felling are:

- Later fifteenth century
- Early sixteenth century
- Mid/later sixteenth century
- Early seventeenth century
- Late seventeenth/eighteenth century

Approximately 18% of dated timbers were felled in the later fifteenth century, the majority of them are from the hall range, but there are also timbers from the north and west ranges (Figs 65, 66, 68, and 70). The earliest precise date for a timber being felled is AD 1469 and there is another precise felling date of AD 1476. These, along with the other felling date ranges obtained, suggest that construction work began at Apethorpe Hall shortly after Sir Guy Wolston acquired the 270 acres of land in *'Hale by Abthorp'* in the 1468. These timbers, therefore, form part of the initial construction of Apethorpe Hall by Sir Guy Wolston, namely the core of the house, the west service range, and a detached south lodging range being completed *c* 1470–80, with further additions in the 1480s and early/mid 1490s which saw the cross-wing being linked to the south lodging block with the addition of the parlour wing and the south-west lodgings (Morrison 2015).

In contrast, a much smaller proportion of dated timbers, approximately 5%, were felled in the earlier sixteenth century (Figs 65, 69, and 70). These timbers are mostly from the floor of Lady Westmorland's room (H2.13) but include a single timber in the roof of the

Cock Loft (H3.01), three timbers from the roofs of the north-west stables (St2.12, St2.13), and probably two floor timbers from room H2.12. Thus, the timbers were associated with works undertaken by Sir Thomas Empson or, more probably, by the group led by Henry Keble which included his son-in-law William Blount 4th Lord Mountjoy, following their purchase of the site in 1515, and who are believed to have undertaken only relatively small-scale works in the overall development of Apethorpe Hall.

Approximately 21% of the dated timbers were felled in the mid/later sixteenth century, these representing all ranges of Apethorpe Hall and outbuildings analysed, although dominated by timbers from the north and hall ranges, as well as that of the granary (Figs 65–69 and 70). There are a number of precise felling dates ranging from AD 1559 (H2.14, H3.01) to AD 1568 (HG3.01) which, combined with the other felling date ranges obtained suggest a period of major construction in the late AD 1550s and AD 1560s but with some construction activity in the subsequent decades. These timbers are, therefore, mostly likely to be associated with the building activity attributed to Sir Walter Mildmay who in the early 1560s undertook large-scale improvements, including the construction of a complex of outbuildings, prior to the visit to Apethorpe Hall of Queen Elizabeth I in 1566, and then in the late 1560s undertook further additions (Morrison 2015). However, the dendrochronological analysis shows that some of these timbers may be related to minor works undertaken by Sir Walter Mildmay's son, Anthony, who inherited the site in 1589.

A large number of dated timbers, approximately 30%, were felled in the earlier decades of the seventeenth century (Figs 66–69 and 70). The vast majority of these timbers are from the east and south ranges, but there are also some timbers from the north range as well as a small number form the west ranges and the north-west stables. There are a series of precise felling dates ranging from AD 1620 (E2.02, E3.01–13) to AD 1622 (E3.10–13), as well as precise felling dates of AD 1630 (S3.01–03) and AD 1639 (N2.11). These precise felling dates, combined with the other felling date ranges suggest a period of major building activity in the early AD 1620s, particularly to the east and south ranges, but also indicate that building activity occurred in the subsequent two or three decades. The majority of these timbers are therefore likely to represent works undertaken by Sir Francis Fane who acquired Apethorpe Hall through marriage in 1617, at a time when it became a favourite retreat of King James I (Morrison 2015). However, the dendrochronological analysis shows that some of these timbers are related to works undertaken by Sir Mildmay Fane, 2nd Earl of Westmorland, who inherited Apethorpe Hall in 1629.

Approximately 25% of the dated timbers were felled in the late-seventeenth and eighteenth century (Figs 65–69 and 70). The vast majority of these were felled in the late-seventeenth century and early decades of the eighteenth century. Precise felling dates ranging from AD 1682 (H2.05) to AD 1724 (O2.01–03e), along with various other felling date ranges produced, indicate various periods of building activity, some of which appear

to be associated with Charles Fane and Vere Fane, the 3rd and 4th Earls of Westmorland respectively, but probably mostly with the Dowager Countess of Westmorland when she was running the estate and her son, Thomas Fane, 6th Earl of Westmorland, when he became of age, and who's works included the construction of the Orangery (Morrison 2015). A series of precise felling dates in the late AD 1730s relate to the rebuilding of the Library (N3.06) by John Fane, 7th Earl of Westmorland. The only other timbers that appear likely to be associated with John Fane are two from the floor of room S2.03. The latest dated timbers from Apethorpe Hall are those from the ceiling of the bay window in Lady Westmorland's room (H2.13). These have a felling date range of AD 1762–87 and, hence, could be associated with building works undertaken by either the 8th, 9th, or 10th Earls of Westmorland. However, John Fane, 9th Earl of Westmorland, modernised first-floor rooms at the south end of the hall range and it is known that this was completed by his death in 1774 (Morrison 2015).

Same-tree timbers

The dendrochronological identification of timbers that are potentially derived from the same-tree can be of use in determining whether certain areas of a building are likely to be coeval, in the absence of precise felling dates. Judging by the level of cross-matching between some samples, the analysis shows that on occasion more than one of the dated timbers are likely to have been derived from the same-tree, as suggested by *t*-values in excess of 10.

As might perhaps be expected, this phenomenon is most frequently seen amongst groups of timbers from the same area of sampling. This is, perhaps, best illustrated by the highest, between sample cross-matching, of all, between APT-A255 and A266, two adjacent floor joists in room S3.11where a remarkably high value of t=37.6 is obtained. However, while a few values in excess of t=18.0 to t=20.0 are seen, values ranging from t=10.0 to t= 15.0 are more common. All such values, again, suggesting timbers potentially derived from the same tree. Thus, while samples APT-A492 and A493, both floor joists in room N2.12, cross-match each other with a value of t=20.4, a value of t=12.2 between samples APT-A505 and A507, wall panelling from room E2.01, is more typical.

Examples of likely same-tree timbers found in different parts of Apethorpe may be evidenced by samples APT-A205 and A331, which cross-match with a value of t=11.0. Sample APT-A205 represents a floor joist in room S2.03, while sample APT-A331 is from a timber reused as a principal rafter in the east range roof (E3.01–13).

An illustration of both intra- and inter-area cross-matching may also be seen between samples APT-A91 and A96, and samples A491 and A494. The former are from principal rafters of the roof (H3.02) adjacent to the Cock Loft, cross-matching with each other with a value of t=14.4. The latter two are from floor joists in room N2.12 and cross-match with a value of t=14.7. The two pairs of samples from these different areas cross-

match with each other with a minimum value of *t*=11.8. Such values would suggest that all four timbers are potentially derived from the same-tree.

A number of timbers from the roof of the Library (N3.06) are probably derived from single trees having cross-matching values in excess of *t*=11.0. However, these timbers also illustrate the probable use of trees growing closely together, probably in the same copse or stand of woodland as, apart from the *t*-values indicating probable same-tree timbers, there are a whole series of *t*-values in excess of 7.0, indicating a very similar growth regime for the trees concerned. Similarly, the cross-matching between the timbers of the Cock Loft roof (H3.01) and the roof adjacent (H3.02) highlights potential same-tree derivation for timbers from both roofs, but again suggests that it is likely that the timbers in the two roofs represent trees growing closely together and also indicates that these two roofs were likely to have been built in close succession. It is also of note, that, there are a number of potentially same-tree timbers in the east-range roof (E3.01–13), which represent the primary-use timbers and the series of timbers thought to have been reused, thus, linking these two groups, which both include timbers felled in AD 1621, even more strongly.

Other groups of timbers, such as those from the Orangery (O2.01–03e) and the west range roof (W2.04–10), are more disparate. With respect to the Orangery this is perhaps not surprising given the variation in felling dates of the timbers and may suggest that they were derived from differing sources, albeit still clearly local sources. However, these timbers also highlight the difficulties of positive same-tree identification based on the *t*-values alone, rather than using visual characteristics of two actual timbers as well. Timber APT-A113 (felled AD 1707) produces a *t*-value of 18.7 with APT-A111 (felled AD 1713). In this case they clearly cannot be the same-tree but are highly likely to have grown in close proximity within the same stand of woodland. Thus, where potential same-tree identifications are vital to the interpretation it may well be appropriate to return to the site to visually inspect the timbers in question. The timbers from the north (W2.04–08) and south (W2.09–10) ends of the west range roof, with one exception, are very similar in date, although whether there is any variation in precise felling dates of timbers within each group is not known. However, both groups are clearly somewhat disparate, again suggesting that the timbers were derived from a wider source area.

Whilst there are some very high *t*-values between timbers, overall there is a surprising lack of same-tree identifications between groups of clearly coeval timbers. This is possibly related to the size of many of the timbers found at Apethorpe, which are large and, of necessity, represent single trees. However, it also potentially highlights the small percentage of timbers sampled overall when one considers the size of Apethorpe and the amount of trees subsumed into such an extensive building programme. The reuse of timbers is therefore not a surprise as they are a valuable resource in the later periods of building activity.

Sources of timber

The locations of the source woodlands for the timber used at Apethorpe cannot be determined with precision by tree-ring analysis. However, as may be seen from Tables 3 and 4, which list the reference chronologies against which the two dated Apethorpe site sequences cross-match, the greatest degree of similarity with sites in Bedfordshire, Leicestershire, Northamptonshire, and Warwickshire, are frequently seen. Such strong similarities would suggest that the timbers used throughout the 300+ year period, for which there are dated timbers at Apethorpe, are of reasonably local origin, although, as might be expected in a project of this size and of so many phases, the timbers are likely to have come from a variety of sources. These sources clearly include the Royal Forest of Rockingham and the 100 oak trees gifted in 1622 by King James I (Morrison 2015).

Sapwood

A total of 49 samples retain complete sapwood. This means that they have the last ring produced by the tree represented before it was cut down and that this last ring date is the felling date. The largest number of such samples, 27, date from the late seventeenth/eighteenth century, with 13 more dating to the early seventeenth century. Seven samples with bark edge date to the mid-sixteenth century and two to the later fifteenth century. It is possible that the significantly larger number of such samples from the more recent centuries is due to the effects of decay on the older timbers being greater than on those from the seventeenth and eighteenth century, but the reuse of timber may be a contributory factor leading to loss of bark edge, as well as the possibility that the later timbers were less heavily trimmed as they were smaller in size overall than those used in earlier centuries.

Within the 49 timbers that have bark edge there is an absolute variation of 12–32 sapwood rings, with a 95% confidence limits range of 12–29. This would, therefore, have the effect of narrowing the quoted felling date ranges, as well as shifting them very slightly earlier. However, given that, as seen above and below, there is the clear potential for a variation in precise felling dates within groups and hence the fact that a single programme of felling may have been carried out over a small number of years (plus the possibility of stockpiling on such a large project), it is probably more appropriate to use the generic 95% confidence limit range of 15–40 sapwood rings standardly applied by the Nottingham Tree-ring Dating Laboratory.

As indicated above, with respect to the timbers with complete sapwood, it is noticeable that there is, on occasion, wide variation in the felling date amongst some of those believed to represent a probable single programme of work. This is, perhaps, most notable amongst the samples from the Orangery (O2.01-03e, APT-A106–118), where the precise felling dates range from as early as AD 1706 to as late as AD 1716, with a possible repair in AD 1724. In most cases, however, the variation in the felling date

(where known precisely) is less, the timbers from the roof of the Library (N3.06, APT-A401–441), for example, being felled in AD 1737, AD 1738, and AD 1739, and several from the floor of rooms S2.02–04a (APT-A202–209) being felled in exactly the same year, AD 1621. This feature is, of course, seen more clearly in the later material because there are more complete sapwood samples of this date, but it is not clear if this might have been the case amongst the earlier timbers, particularly bearing in mind the extensive nature of the building works. This leads to some slight uncertainty as to whether some timbers are precisely or only broadly coeval that is, have they been felled at exactly the same time or as part of a longer, on-going, programme of works.

CONCLUSION

The multi-disciplinary research programme, including dendrochronology, undertaken has revealed the intricate and complicated nature of the development and refurbishment at Apethorpe Hall and its outbuildings, with dendrochronology providing firm dating evidence for various elements and areas within this large complex. Dendrochronology has confirmed the relationship between various phases of documented work with specific elements/areas and hence with various of the owners ranging from Sir Guy Wolston in the late-fifteenth century to the 9th Earl of Westmorland in the latter half of the eighteenth century. The value of an extensive, but nevertheless targeted, dendrochronology programme within such a complex site is demonstrated as is the importance of undertaking the dendrochronology programme concurrently with the documentary and survey investigation that allows the potential for questions to be addressed as they arise.

From a purely dendrochronological perspective the analysis has resulted in the production of two substantial site chronologies, one comprising 216 samples, being 348 rings long and spanning AD 1292–1639. The second site chronology contains 73 samples, is 176 rings long and spans AD 1574–1749. Both these chronologies will prove extremely useful in the dating of timbers from other buildings elsewhere in this region. In addition the 49 samples with bark edge have provided a useful insight into the characteristics of what are thought to be relatively local trees with respect to the variation in sapwood numbers and, hence, provide useful additional material for future investigation into regional and temporal variation in numbers of sapwood rings.

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FIGURES

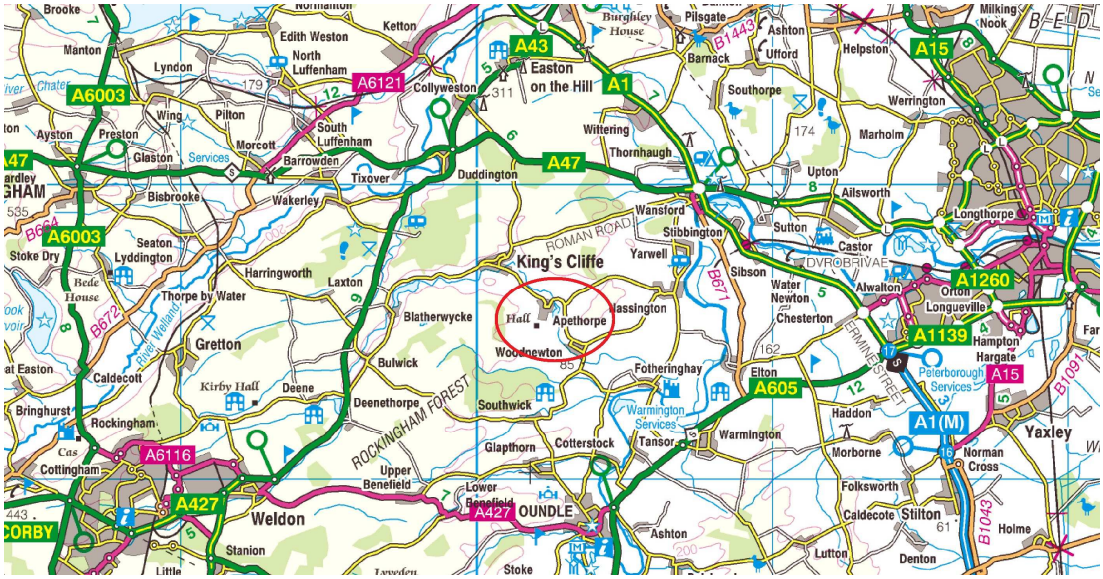


Figure 1: Location of Apethorpe, Northamptonshire. © Crown Copyright and database right 2016. All rights reserved. Ordnance Survey Licence number 100024900

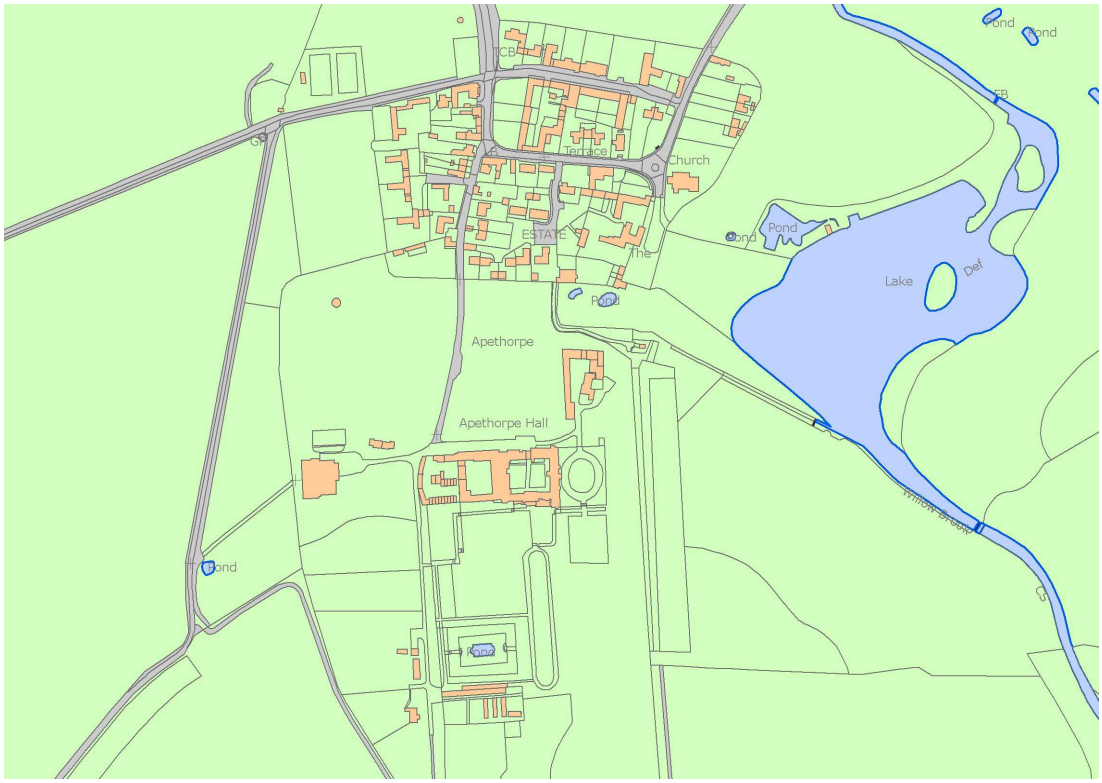


Figure 2: Location of Apethorpe Hall, Northamptonshire. © Crown Copyright and database right 2016. All rights reserved. Ordnance Survey Licence number 100024900

Figure 3: Plan of Apethorpe Hall, showing the layout of the main ranges

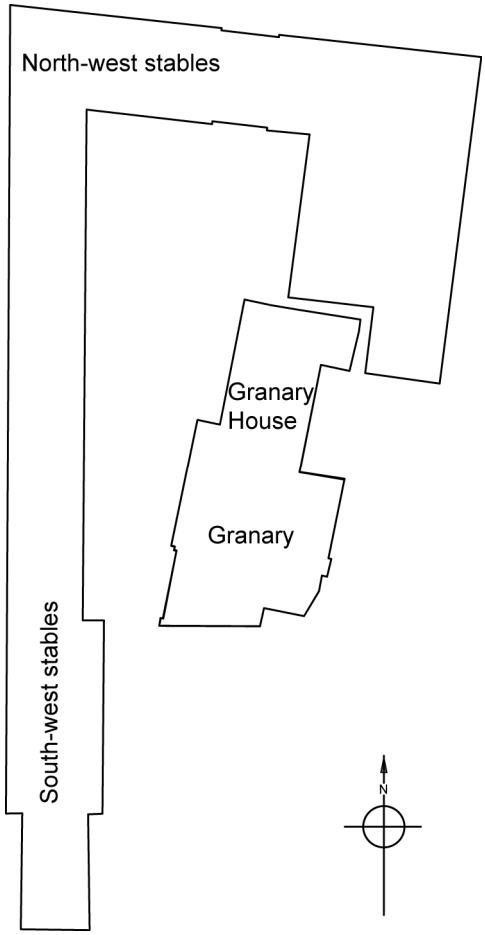


Figure 4: Plan showing the layout of the outbuildings immediately to the north-east of Apethorpe Hall

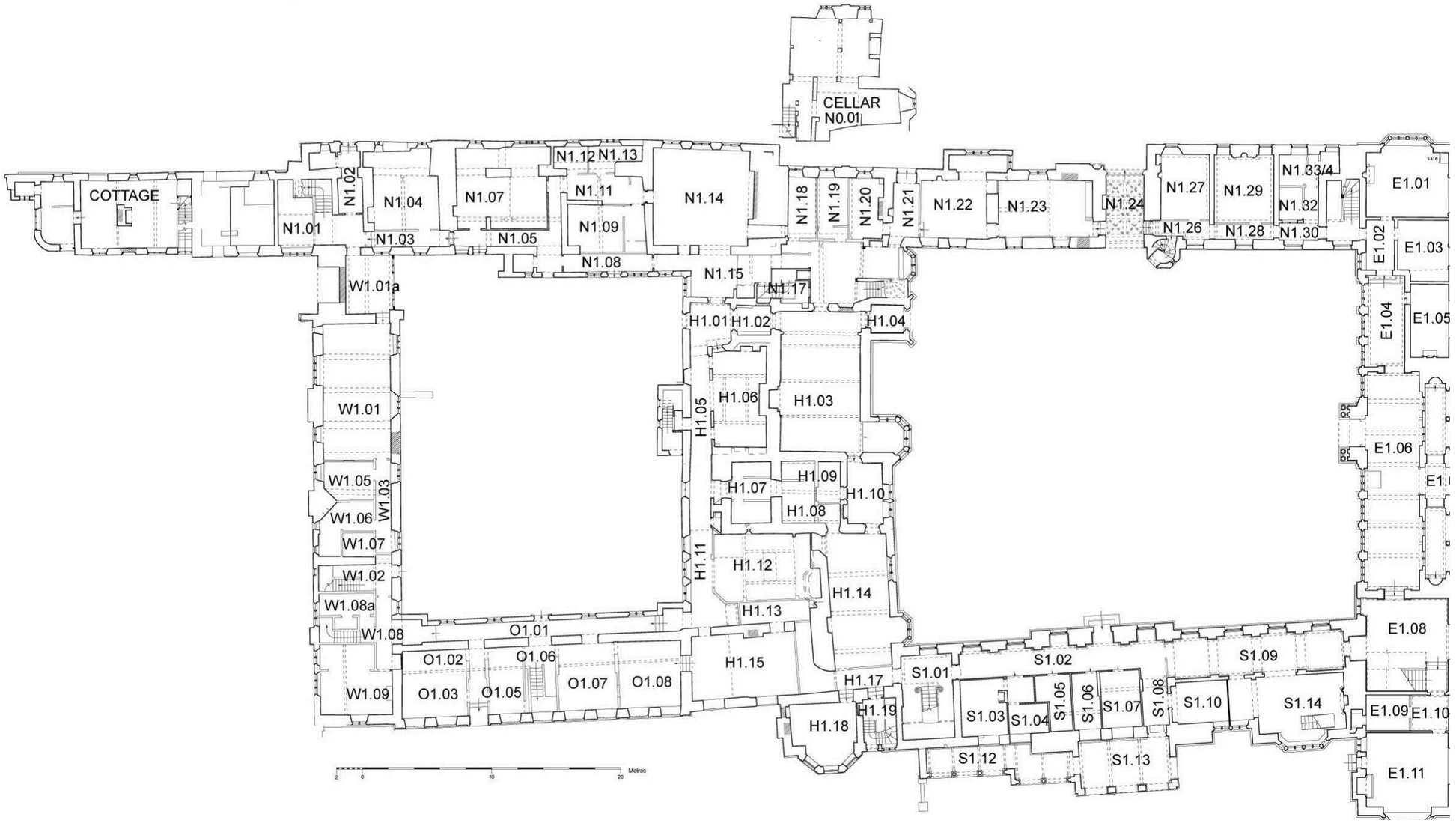


Figure 5: Ground floor of Apethorpe Hall, showing room numbers. E - east range; H - hall range; N - north range; O - Orangery; S - south range; W - west range

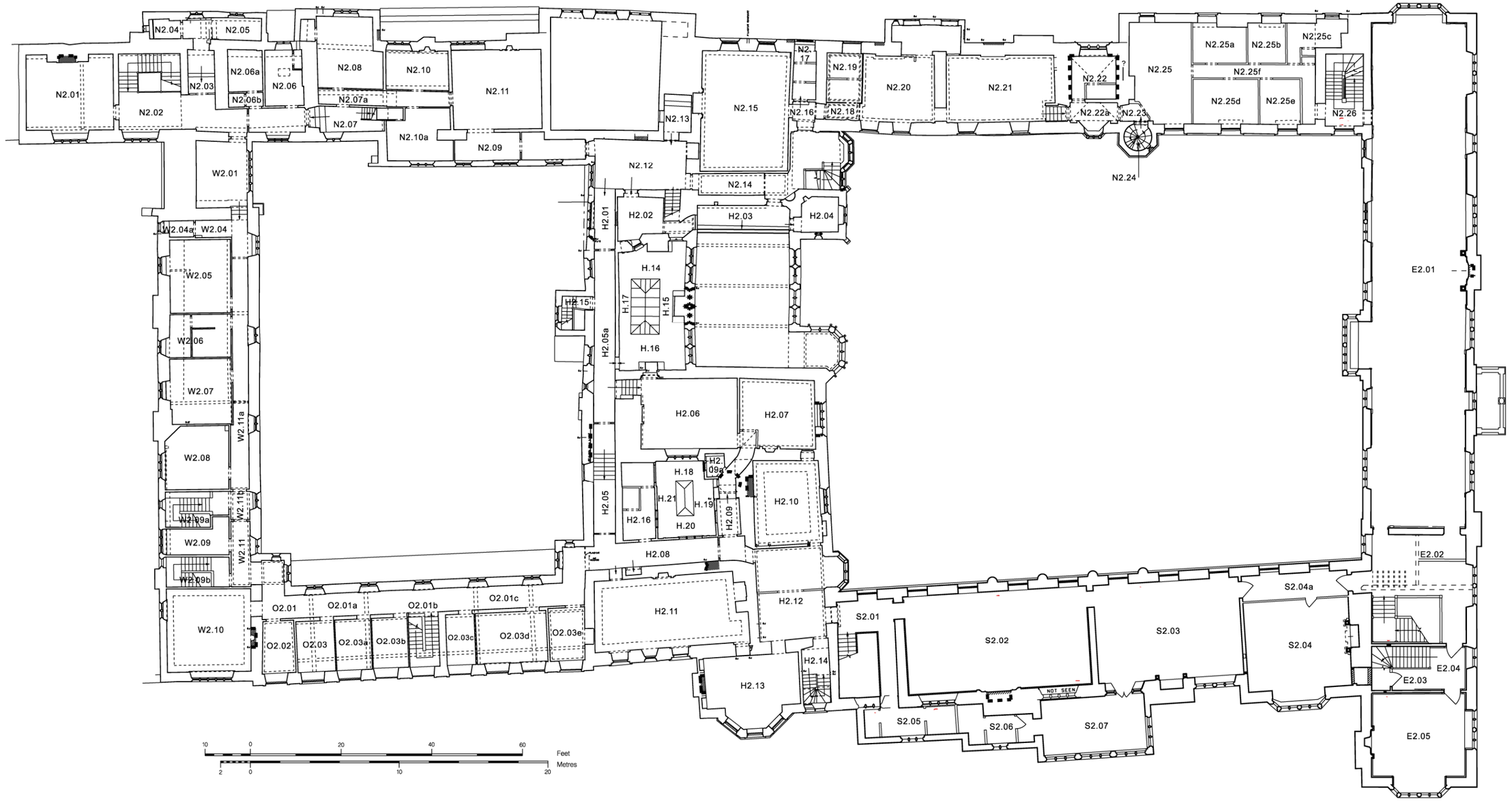


Figure 6: First floor of Apethorpe Hall, showing room numbers. E - east range; H - hall range; N - north range; O - Orangery; S - south range; W - west range

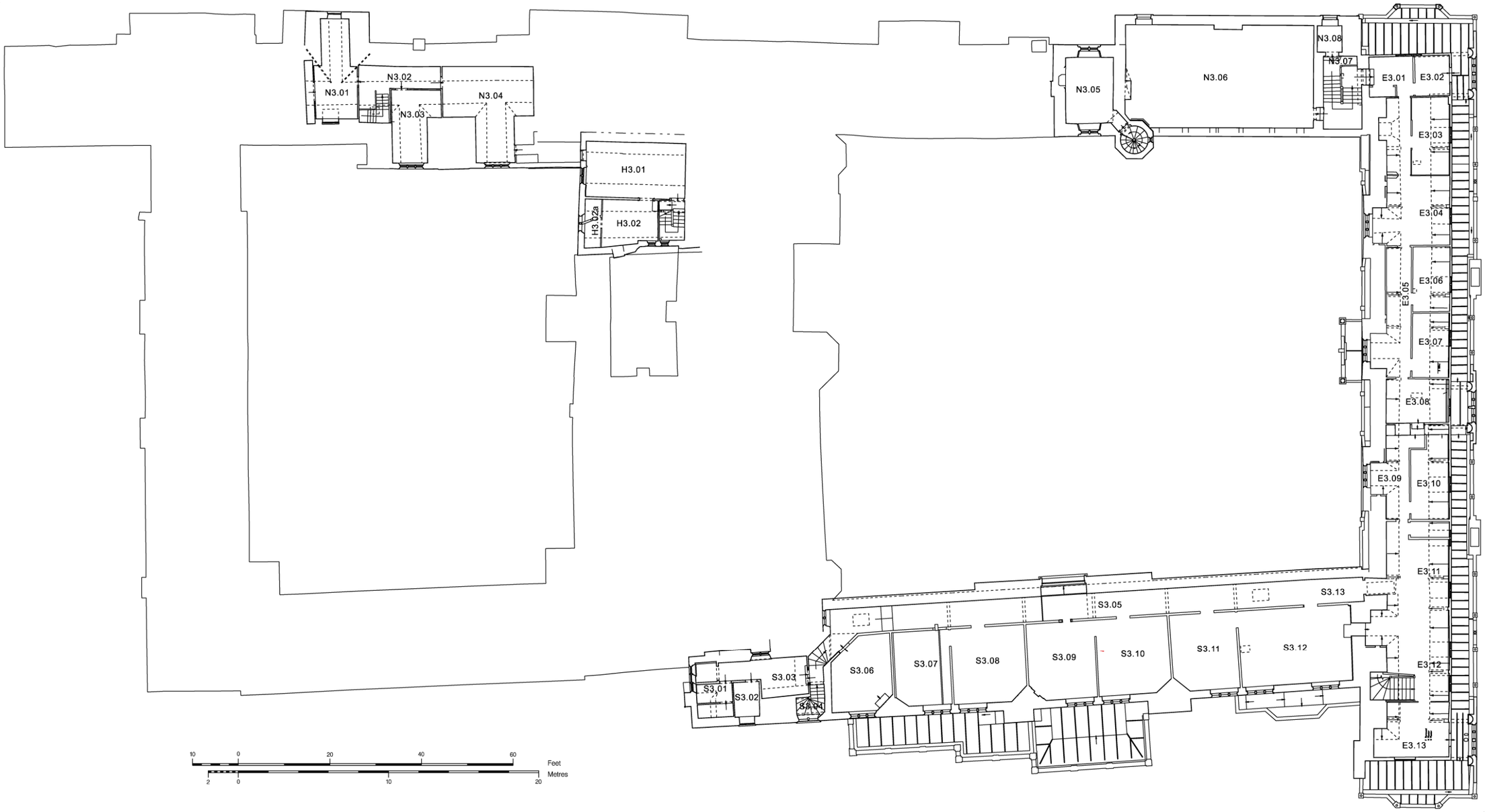
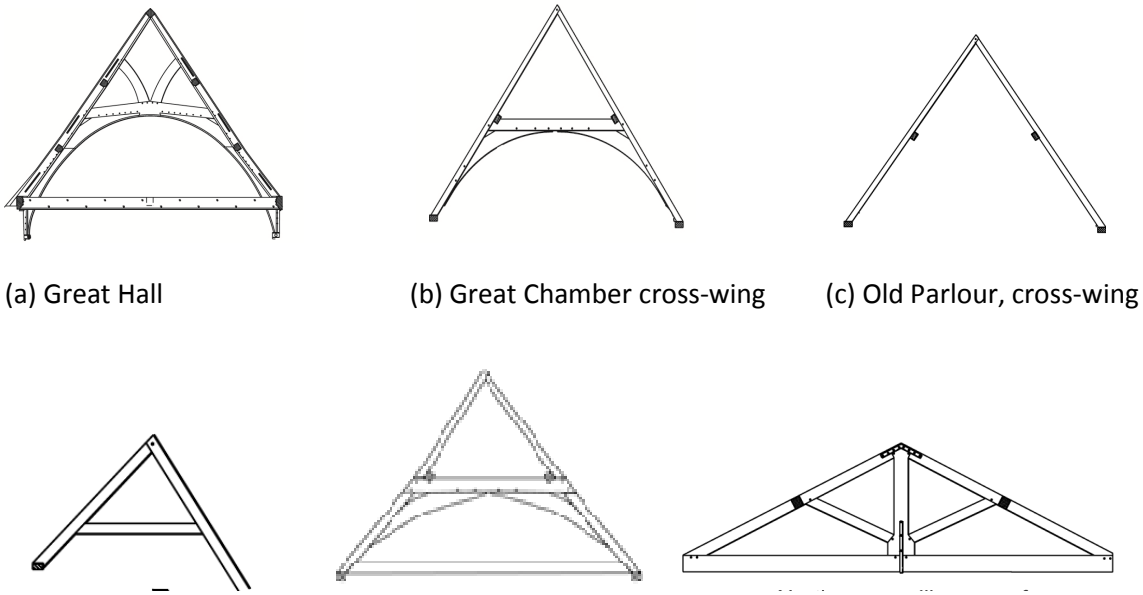


Figure 7: Second (attic) floor of Apethorpe Hall, showing room numbers. E - east range; H - hall range; N - north range; O - Orangery; S - south range; W - west range

Figure 8: First floor plan of the Stables and Granary complex, showing room numbers



(a) Great Hall (b) Great Chamber cross-wing (c) Old Parlour, cross-wing

(d) Matted Passage (e) North range middle section (f) Library

(g) Kitchen (h) east range -main roof looking north (i) West range

(j) Orangery (k) south-west Stables (l) Granary House

(m) Granary (n) north-west Cottage (o) Archway

Figure 9: Typical truss forms in the various roofs at Apethorpe. Not to scale

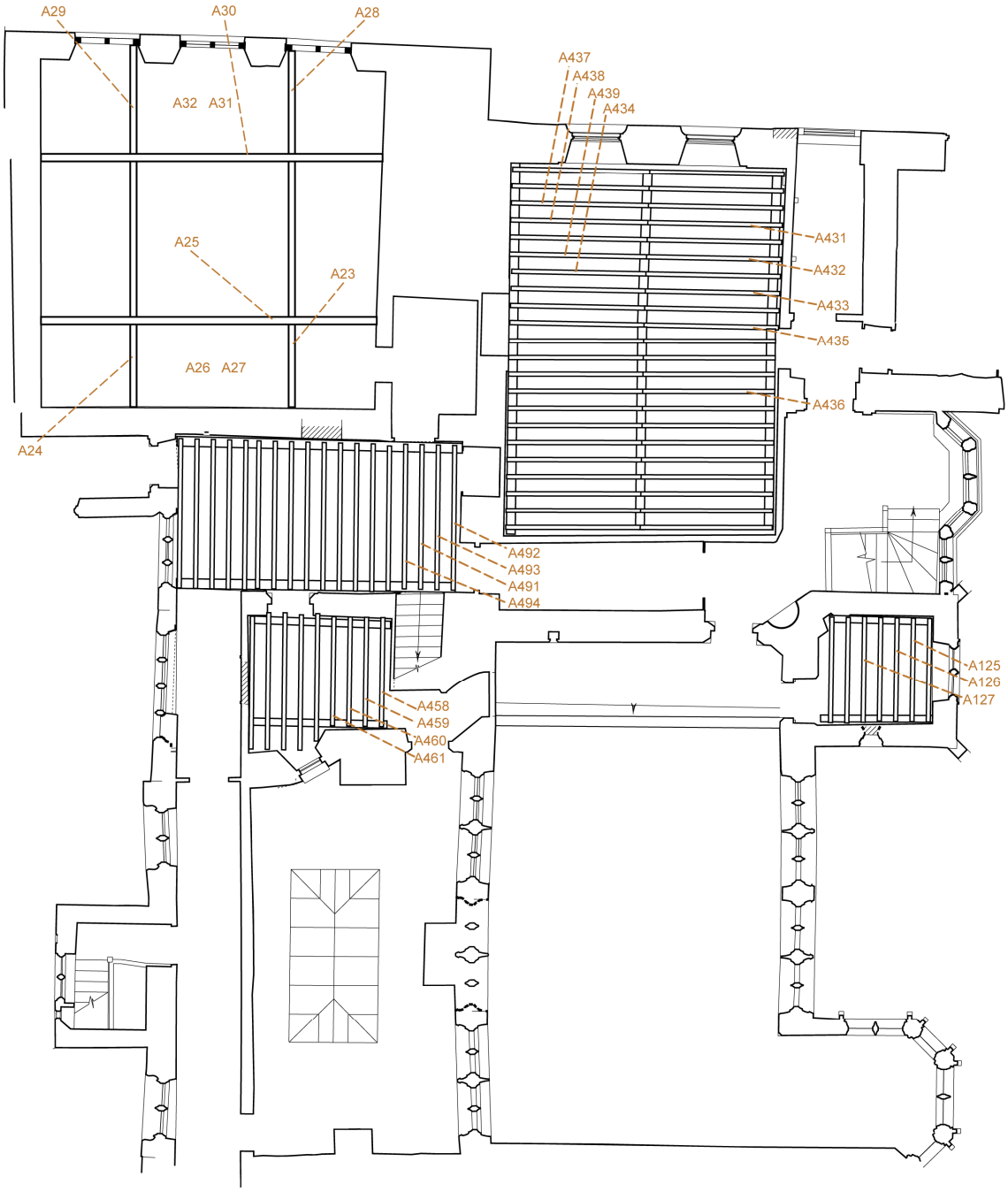


Figure 10: Floor timbers, second-floor rooms at the northern end of the Hall range, showing the locations of samples APT-A23–32, A125–7, A431–9, A458–61, and A491–4

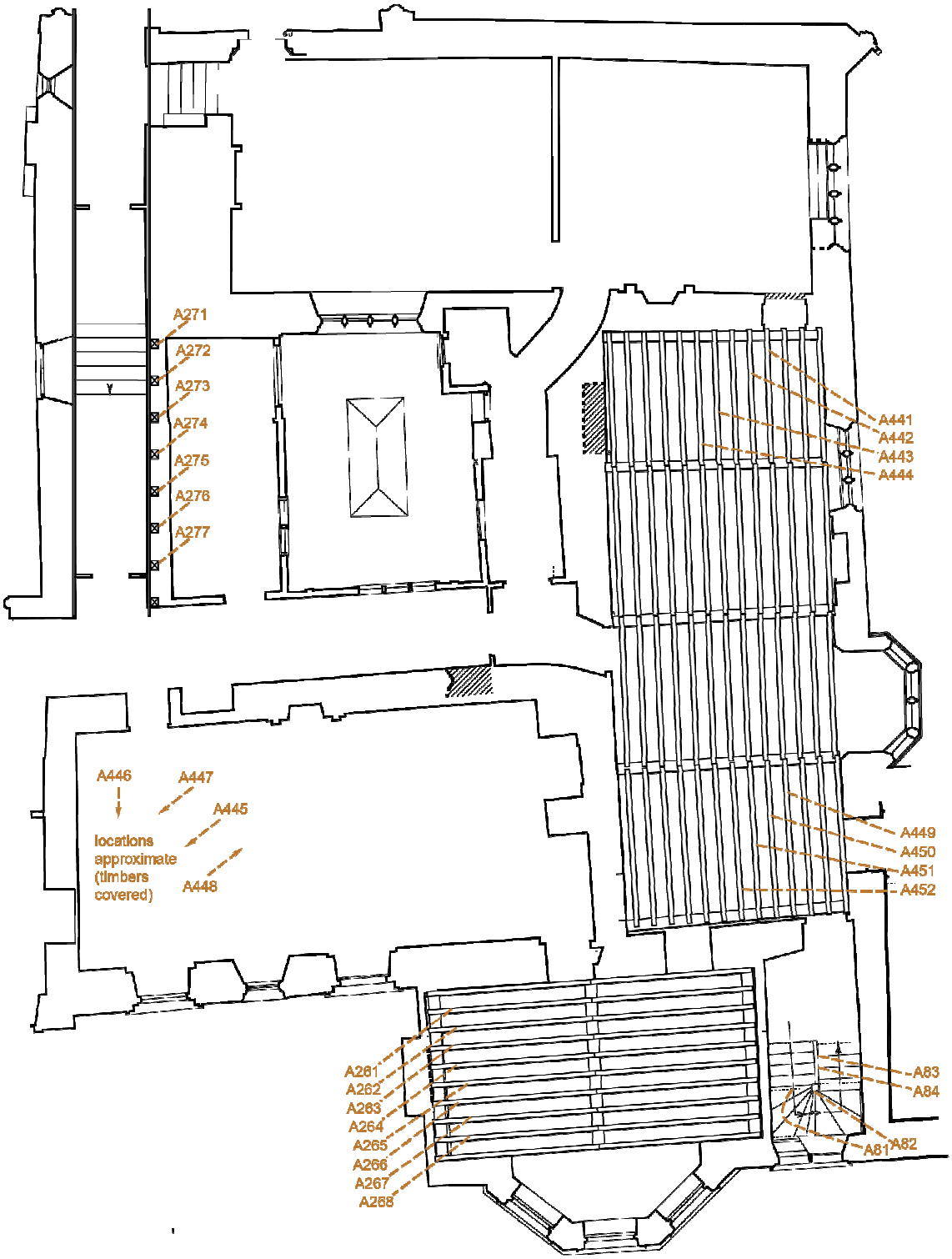
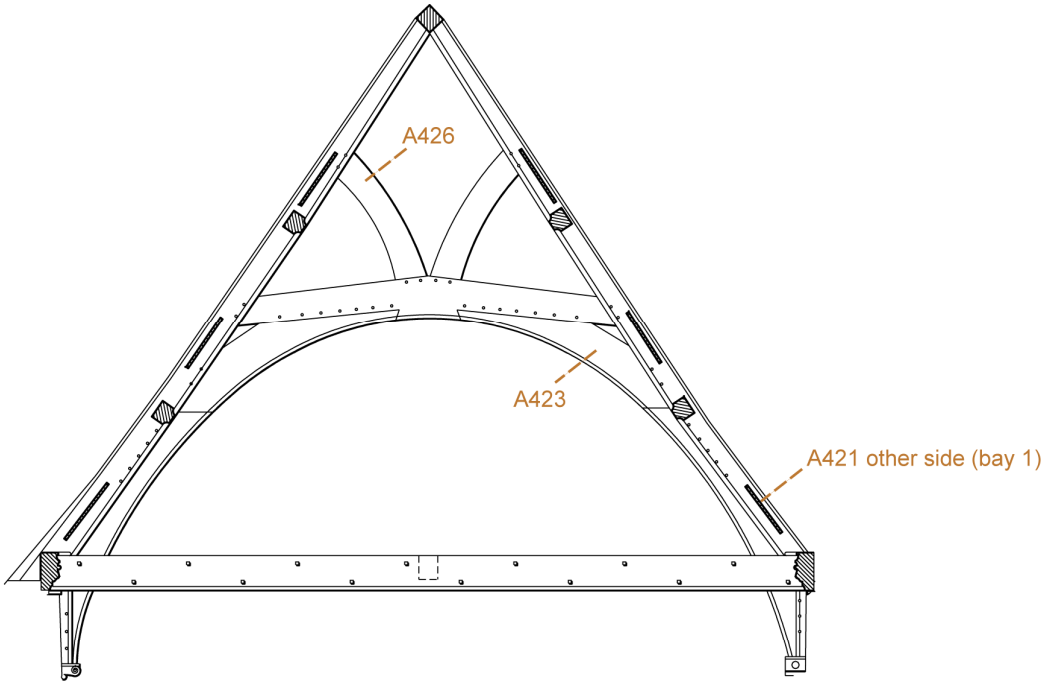
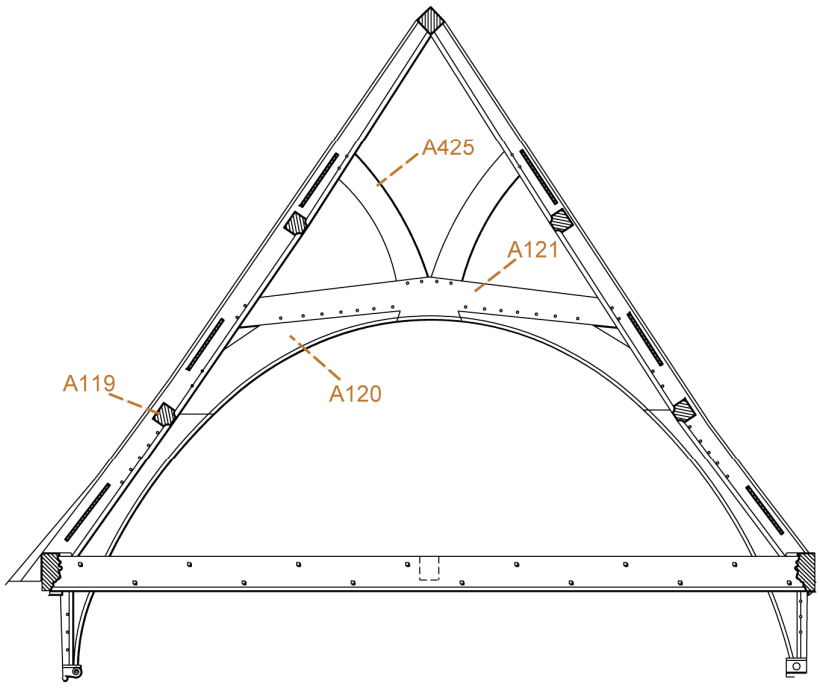


Figure 11: Floor timbers, second-floor rooms at the southern end of the Hall range, showing the locations of samples APT-A81–4, A261–8, A271–7, and A441–52

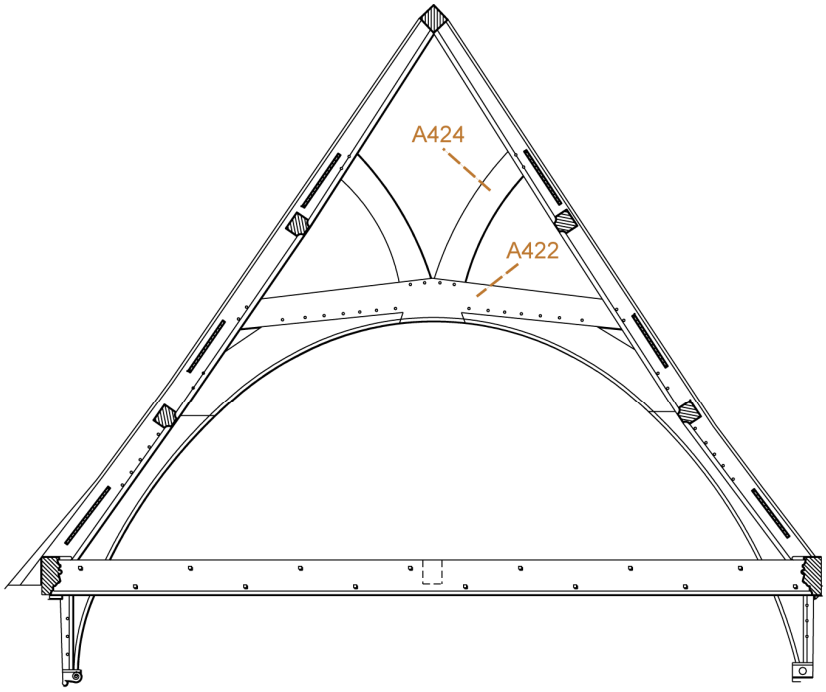


Truss 2 seen from south

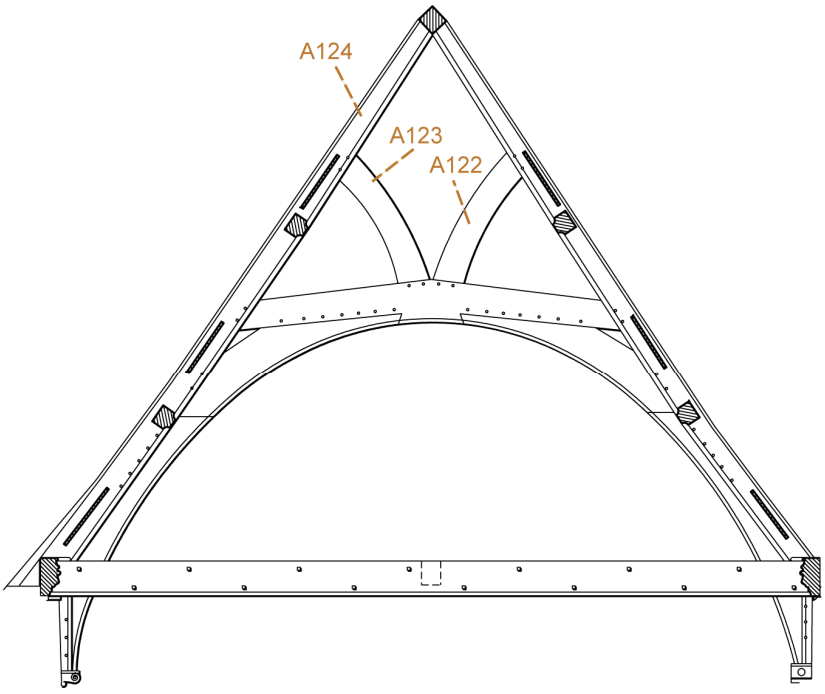


Truss 3 seen from south

Figure 12: Great Hall roof timbers, showing locations of samples APT-A119–21, A421, A423, and A425–6



Truss 4 seen from south



Truss 5 seen from south

Figure 13: Great Hall roof timbers, showing locations of samples APT-A122–4, A422, and A424

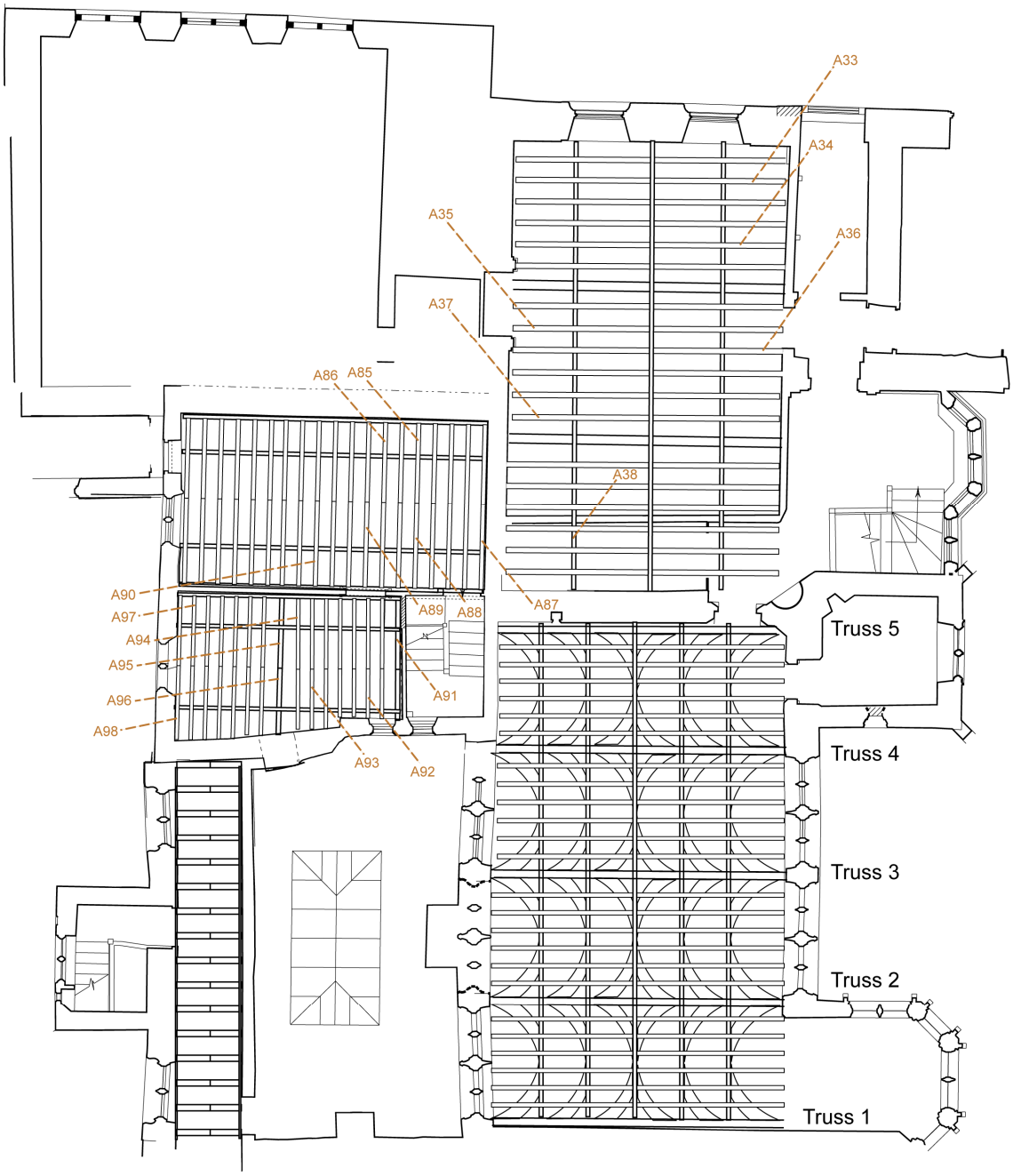


Figure 14: Roof timbers, first- and second-floor rooms at the northern end of the Hall range, showing the locations of samples APT-A33–8, A85–98

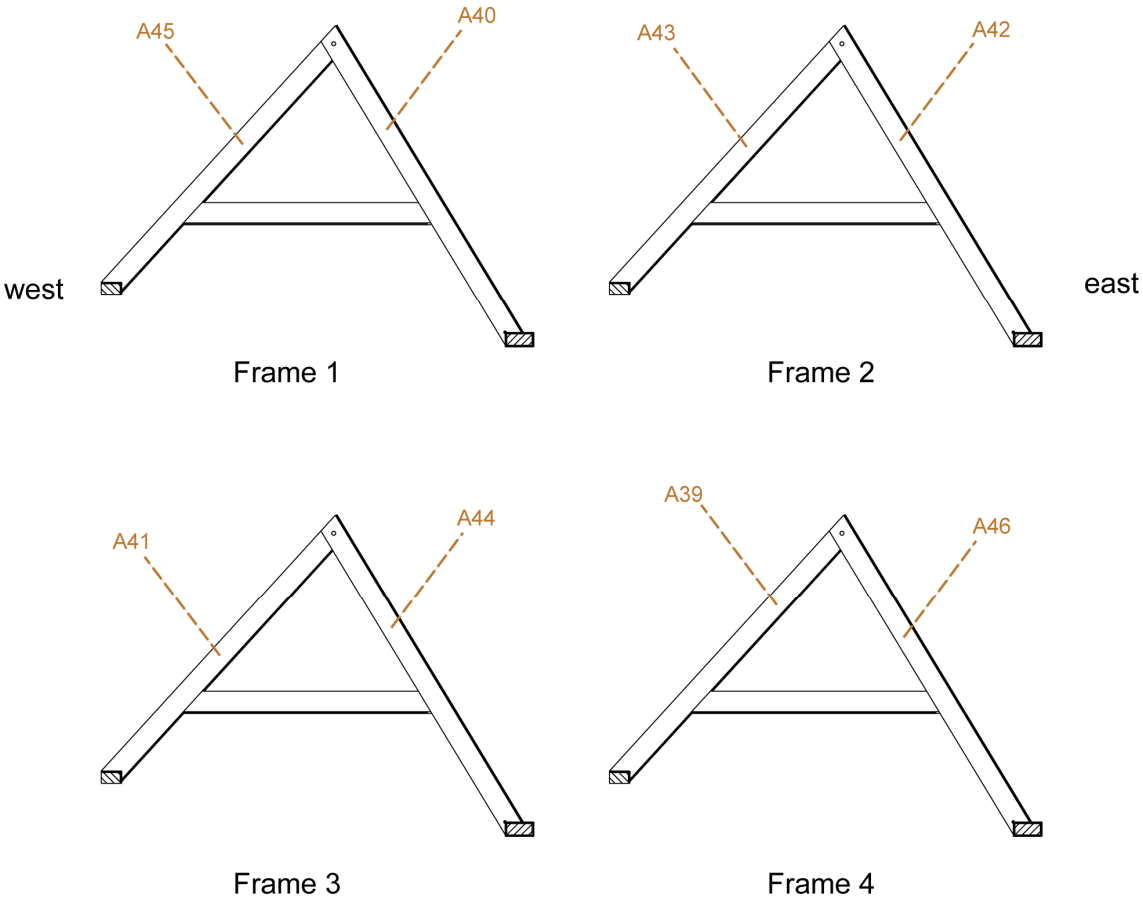


Figure 15: Matted passage trusses, showing the locations of sample APT-39–46

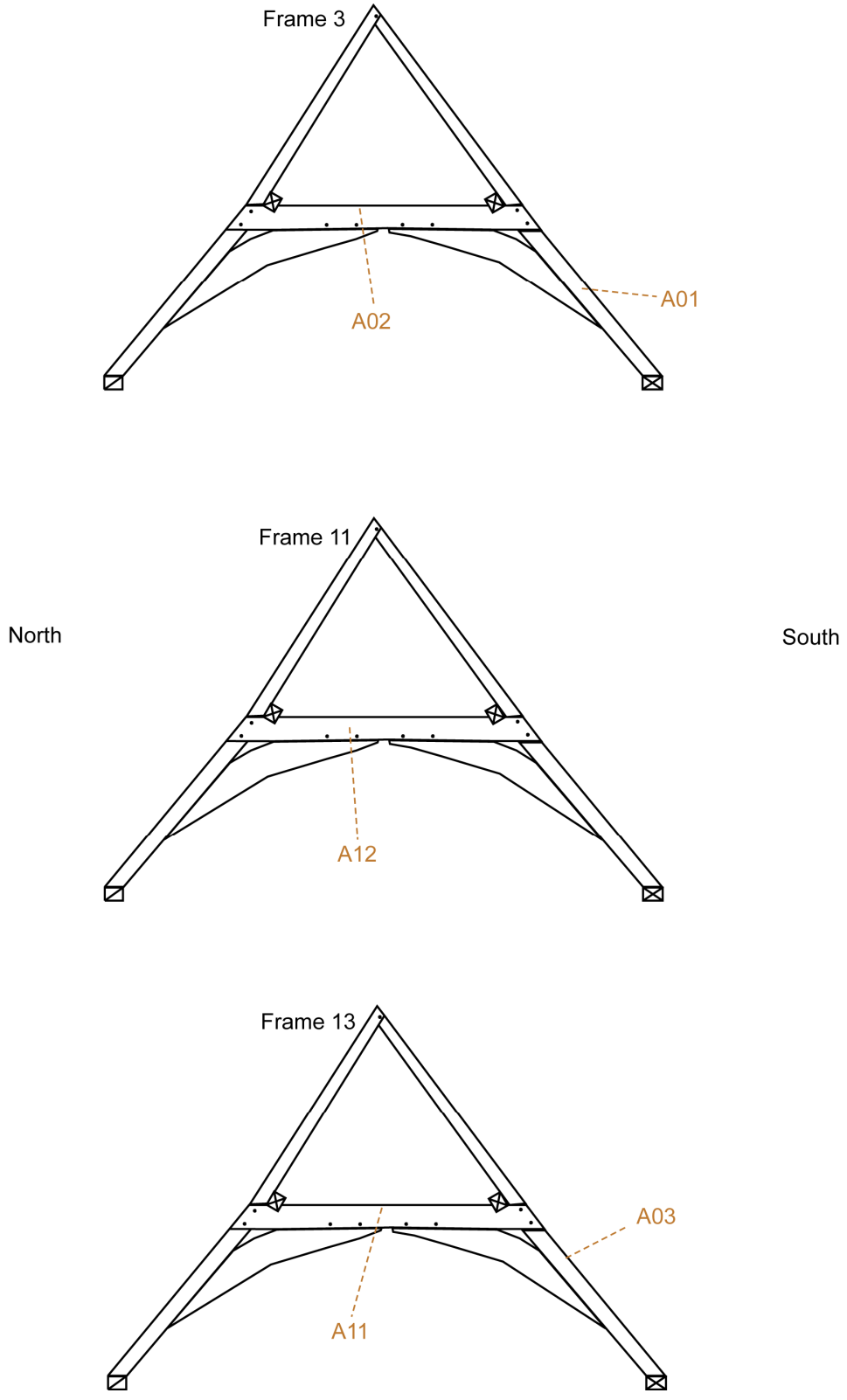


Figure 16: Great Chamber/cross-wing roof trusses, showing the locations of samples APT-A01–03 and A11–12

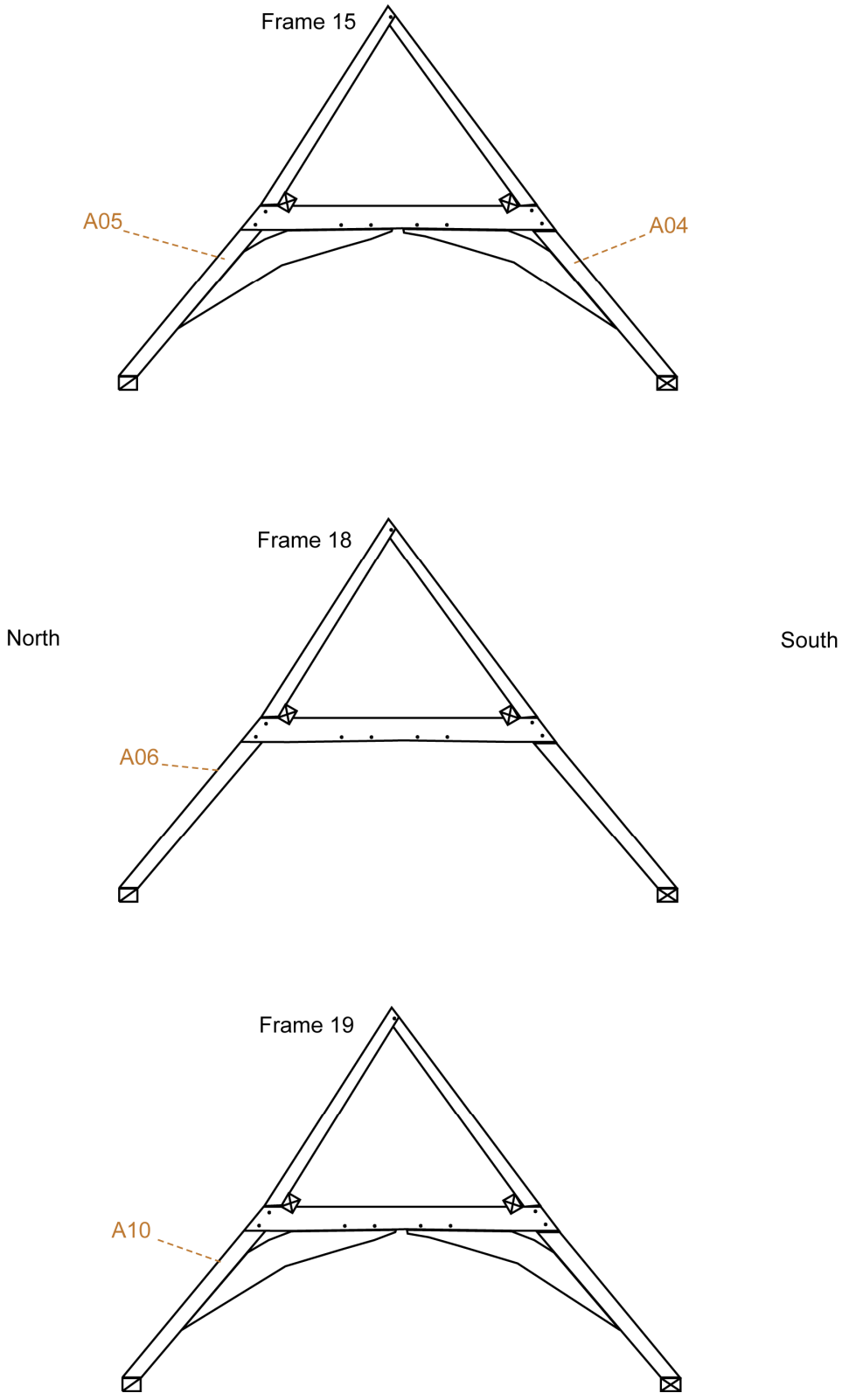


Figure 17: Great Chamber/cross-wing roof trusses, showing the locations of samples APT-A04–06 and A10

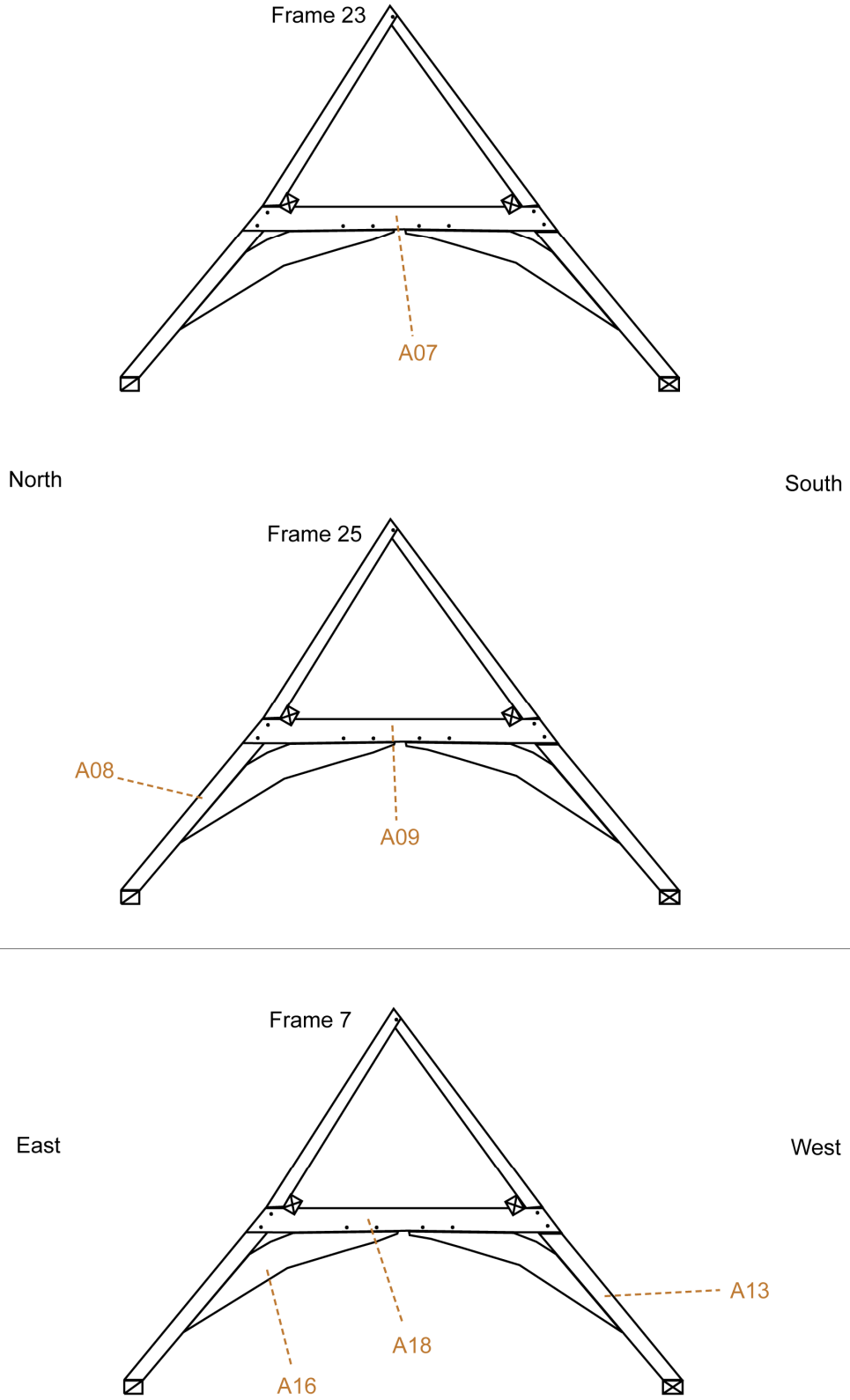


Figure 18: Great Chamber/cross-wing roof trusses, showing the locations of samples APT-A07–09 and Old Parlour/cross-wing roof trusses showing the locations of samples APT-A13, A16 and A18

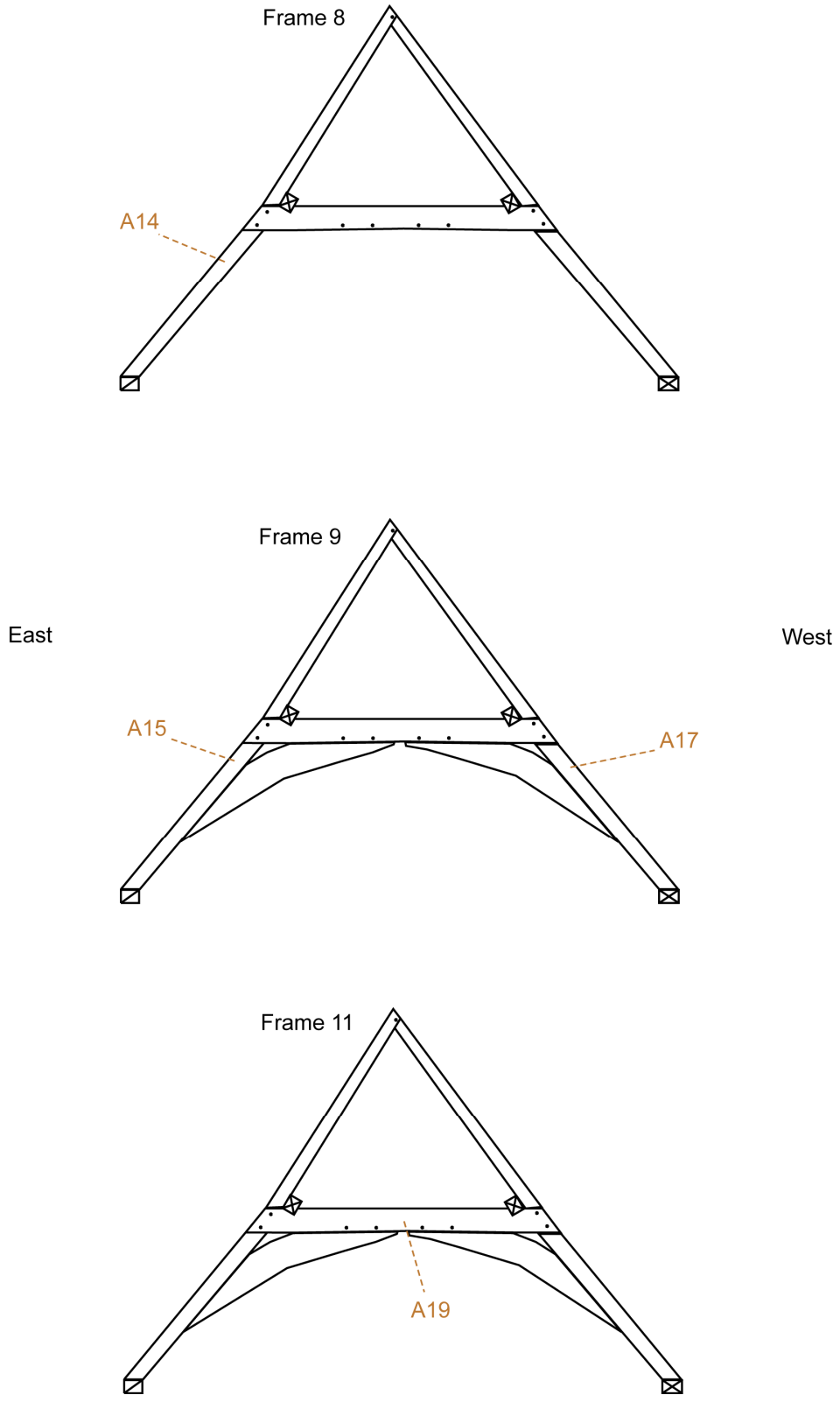


Figure 19: Old Parlour/cross-wing roof trusses showing the locations of samples APT-A14–15, A17, and A19

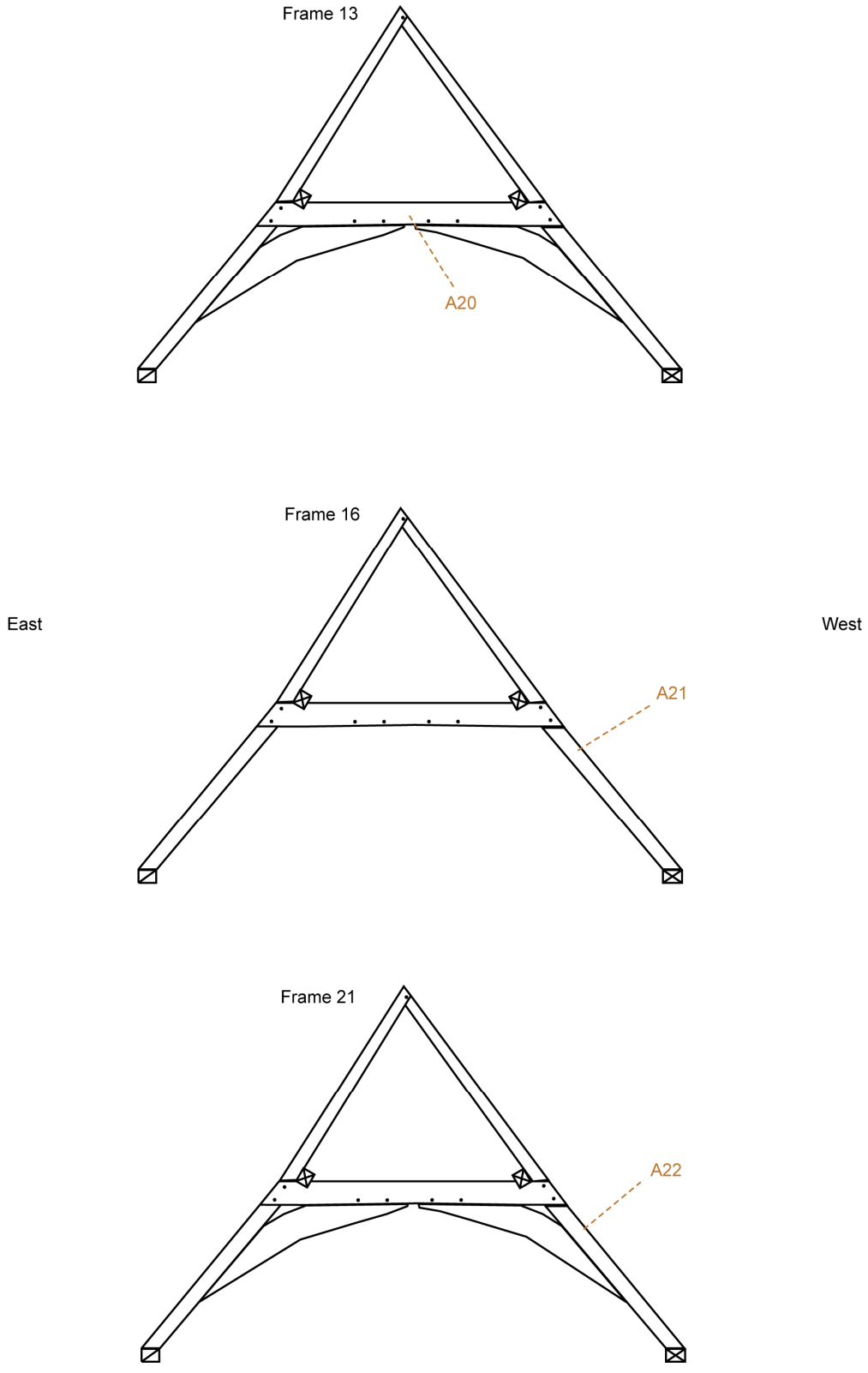


Figure 20: Old Parlour/cross-wing roof trusses showing the locations of samples APT-A20–2

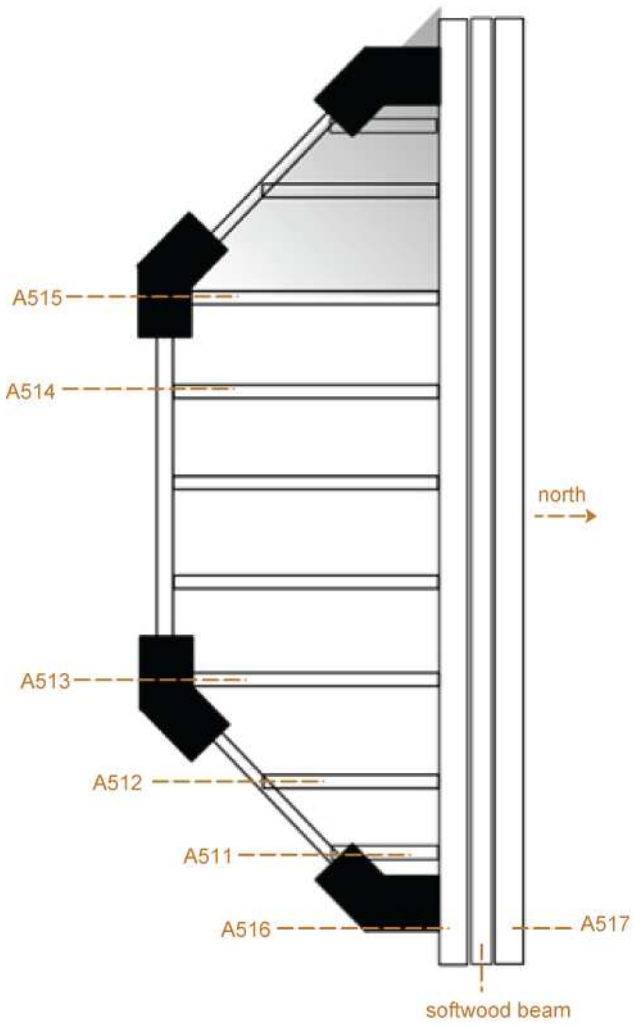


Figure 21: Ceiling joists to bay window of Lady Westmorland's room, showing locations of samples APT-A511–17

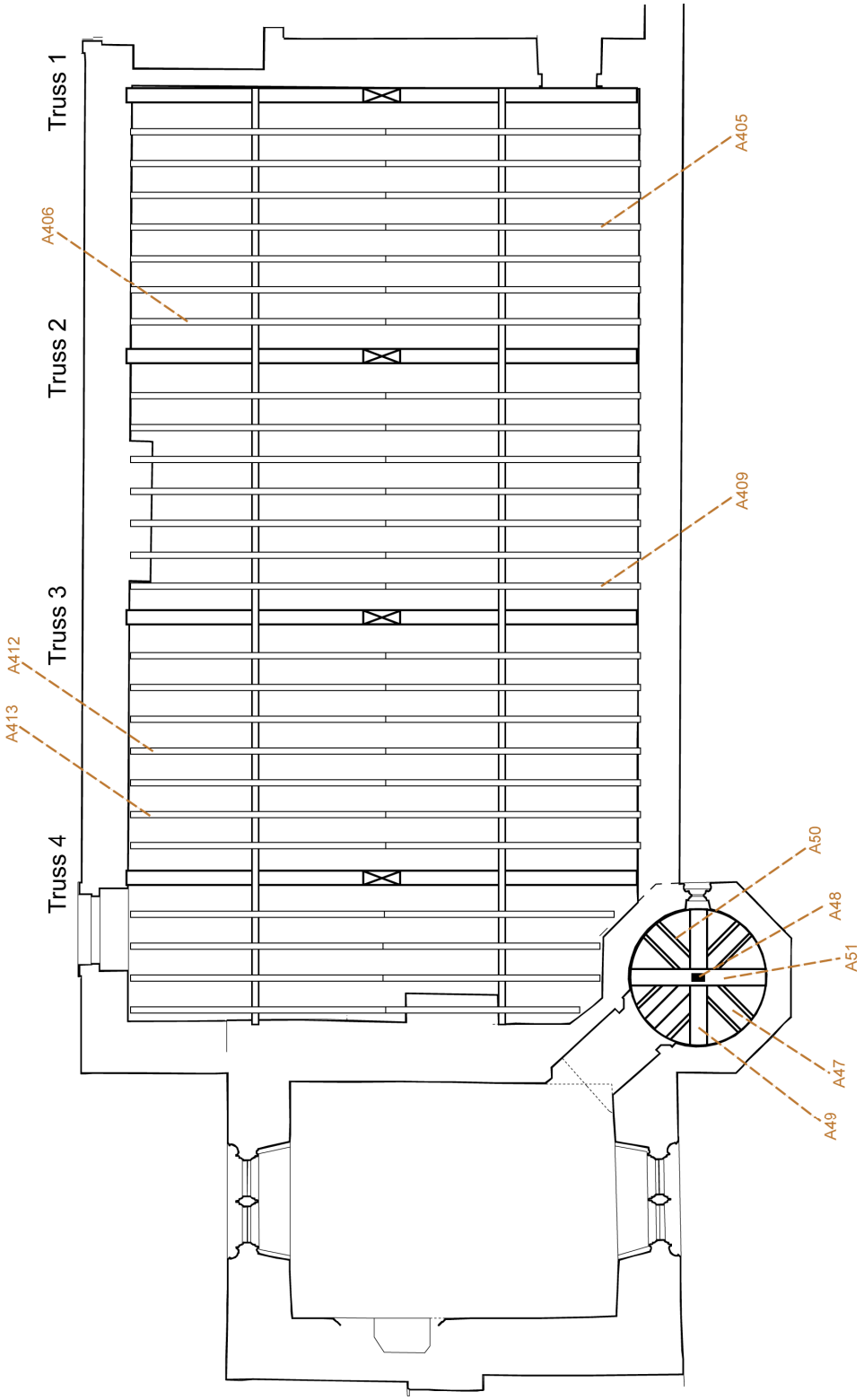


Figure 22: Roof timbers, first-floor rooms at the eastern end of the North range, showing the locations samples APT-A47–51, A405–6, A409, and A412–13

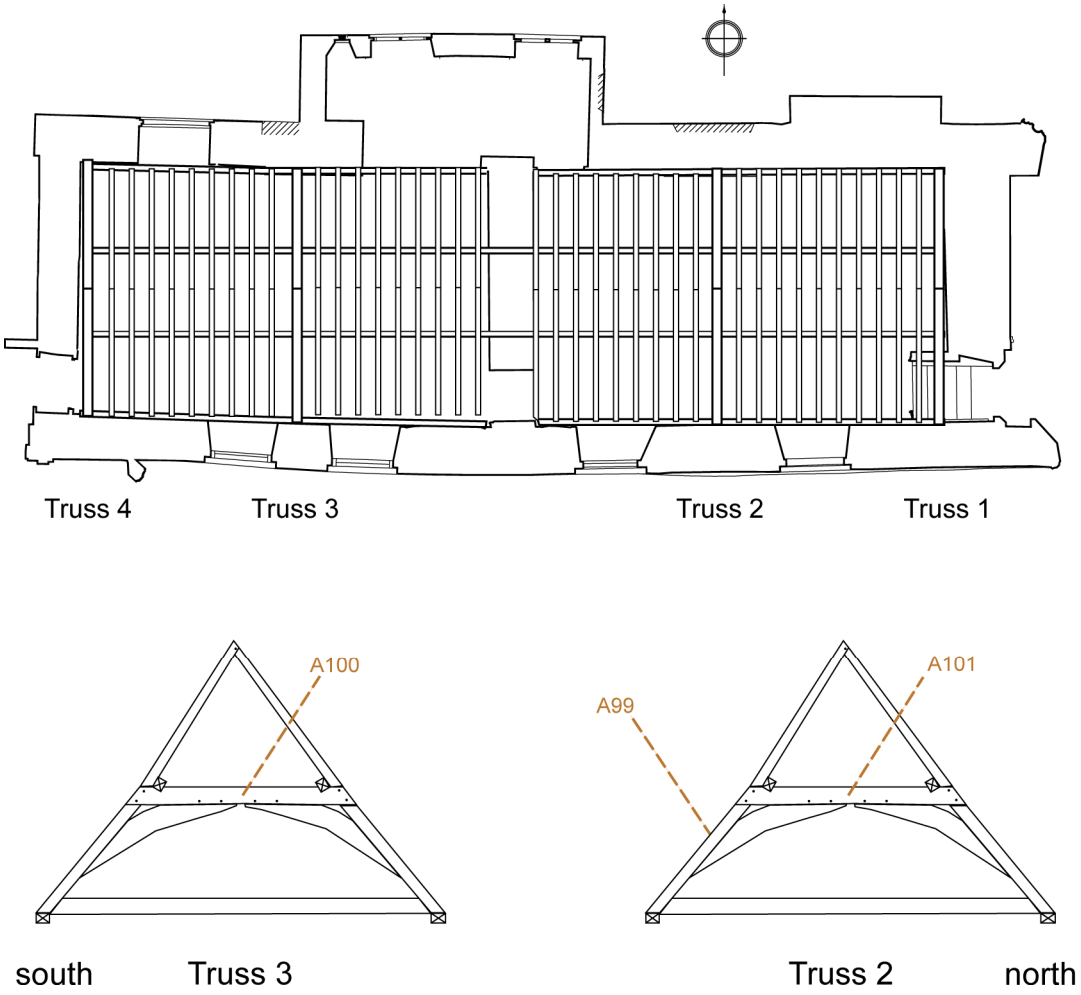


Figure 23: Roof timbers, rooms N2.16–21, showing the locations samples APT-A99–101

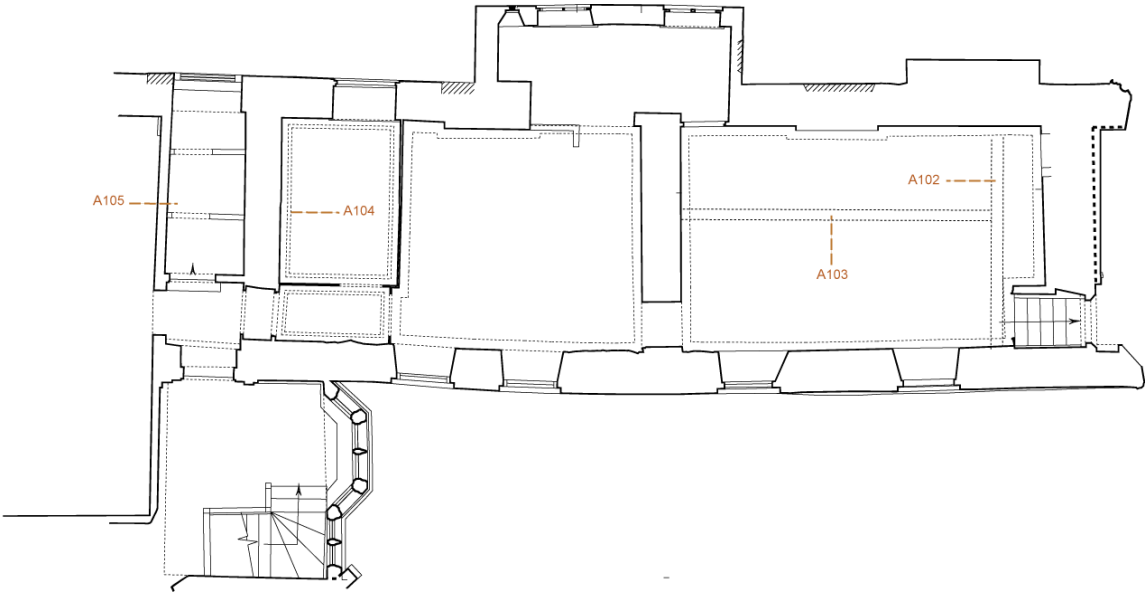


Figure 24: Floor N2.16–21, showing the locations samples APT-102–5

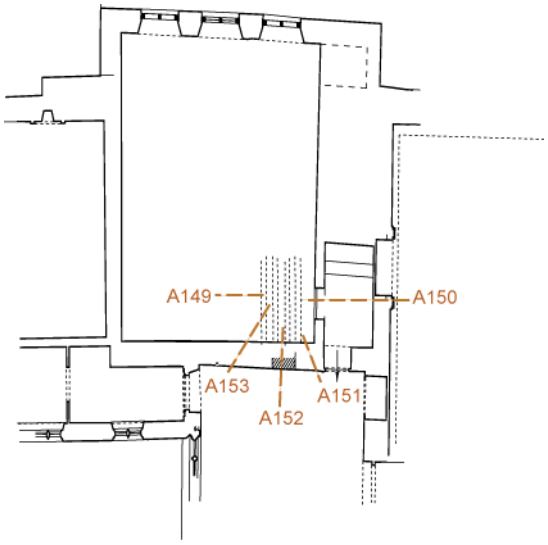


Figure 25: Kitchen ceiling N1.14, showing the approximate locations samples APT-149–53. Note that only approximately two square metres of ceiling frame had been exposed

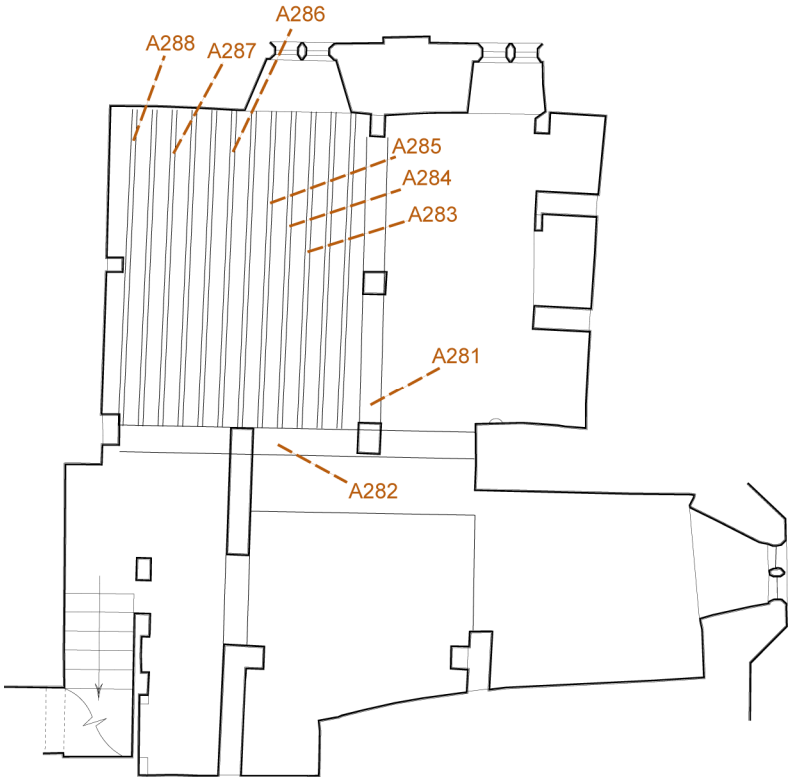


Figure 26: Cellar N0.01 showing locations of samples APT-A281–8

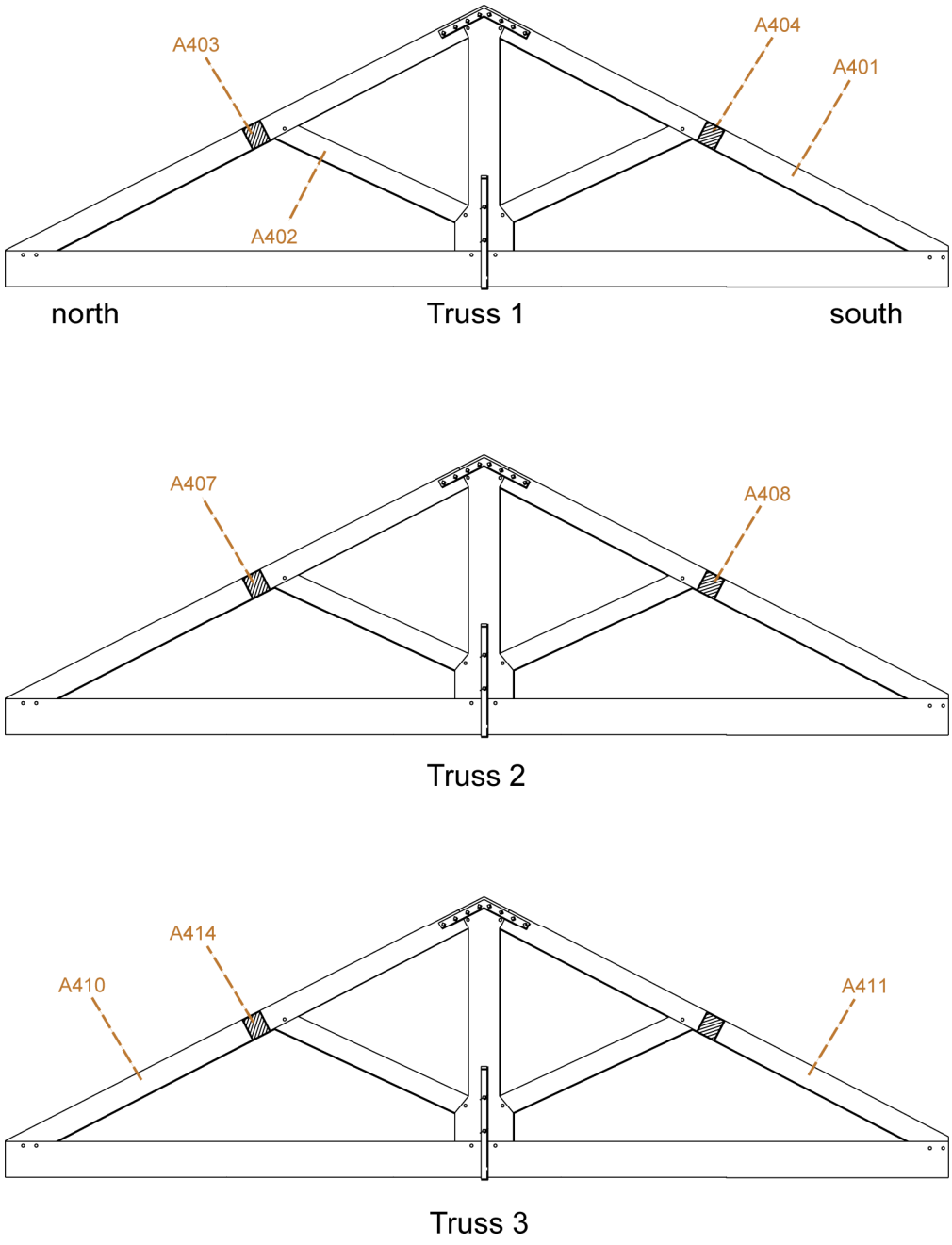


Figure 27: North range library trusses 1–3, showing locations of samples APT-A401–4, A407–8, A410–11, and A414

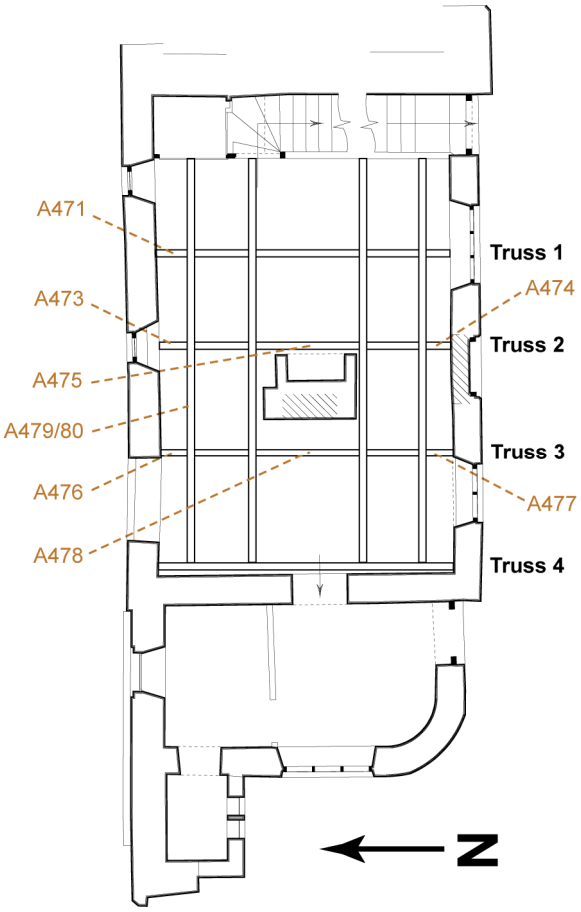


Figure 28: North range cottage roof, showing locations of samples APT-A471 and A473–80

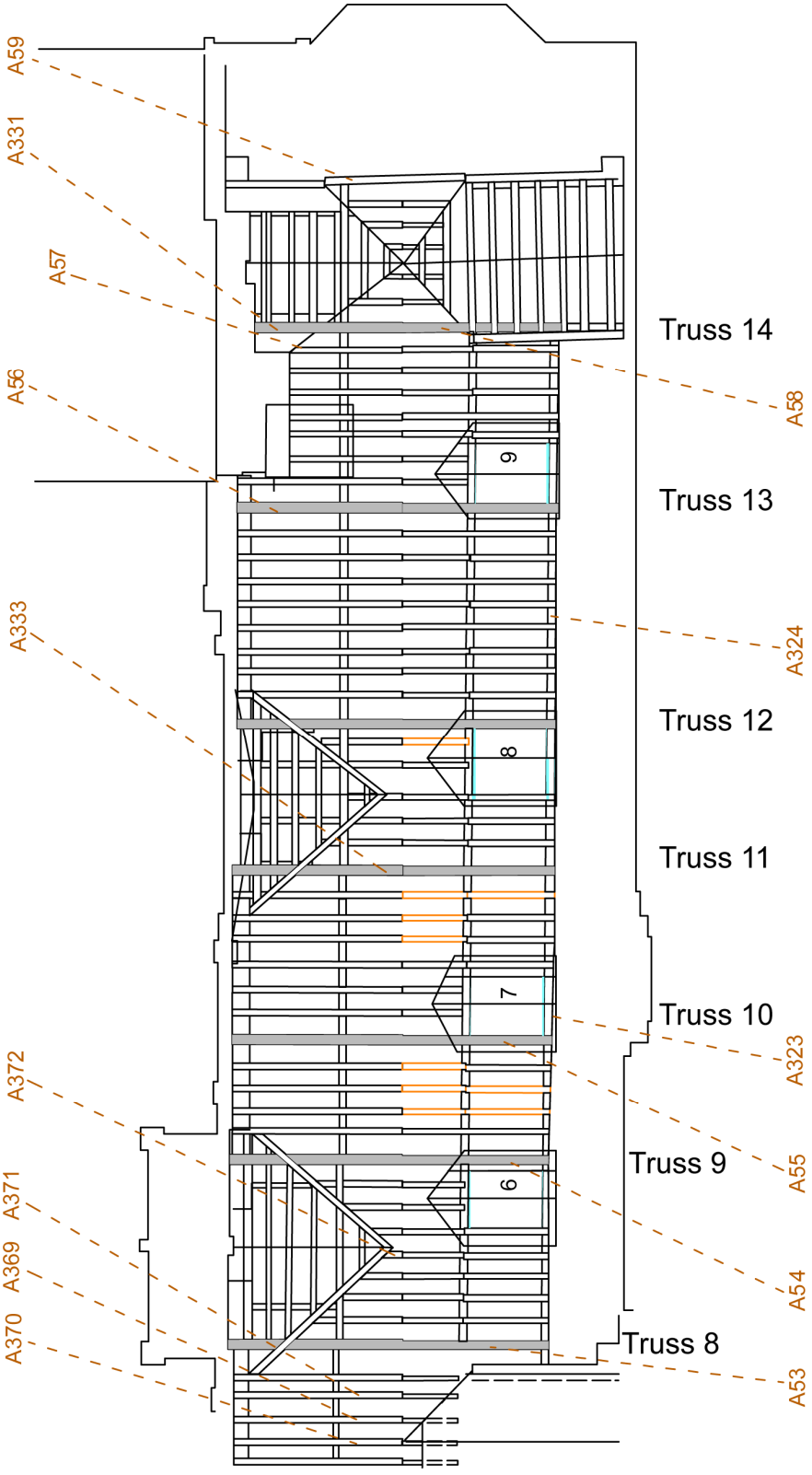


Figure 29: Roof plan of the East range, showing the locations of samples APT-A53–9, A323–4, A331, A333, and A369–72

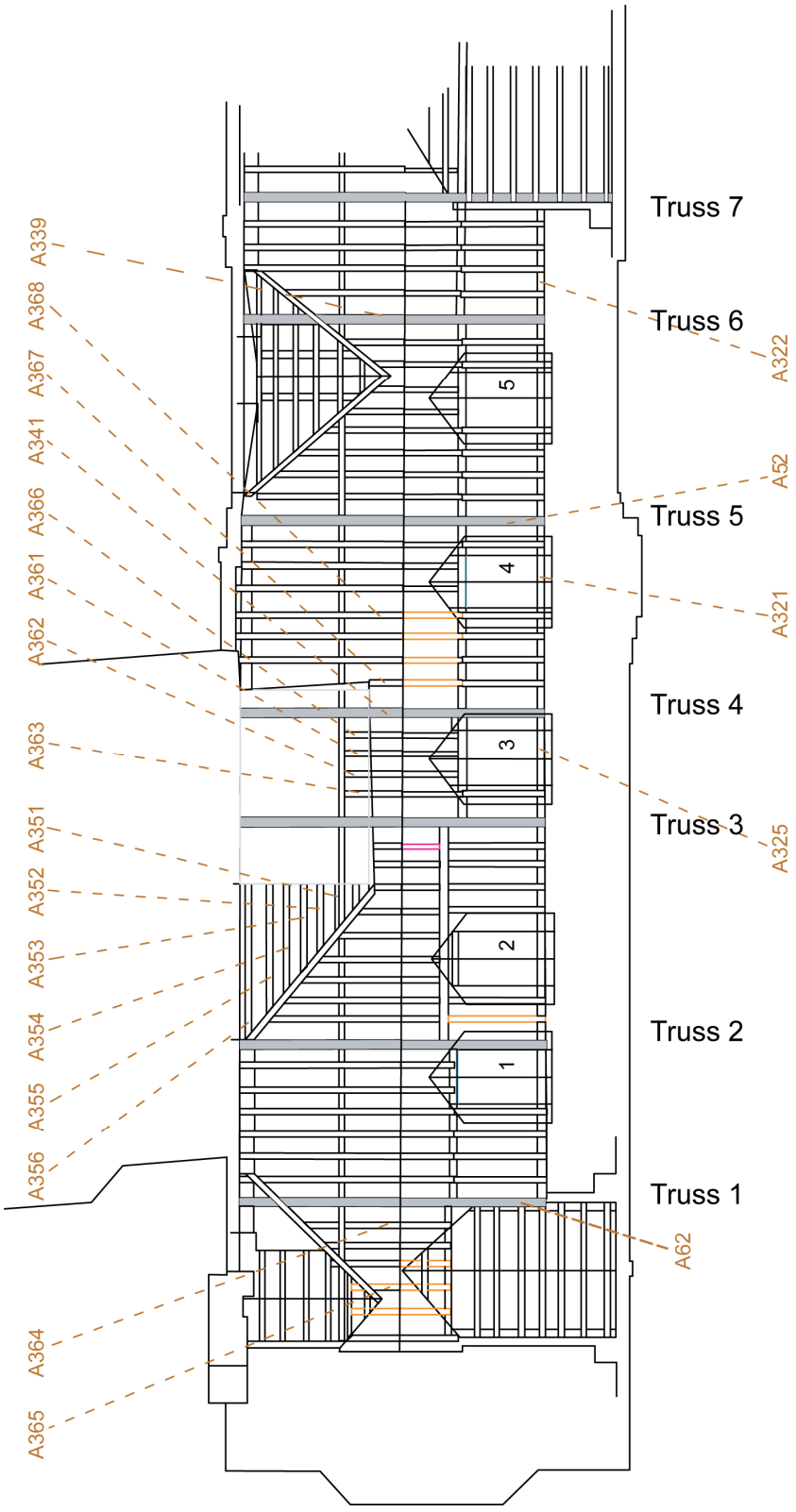


Figure 30: Roof plan of the East range, showing the locations of samples APT-A52, A62, A321–2, A325, A339, A341, A351–6, and A361–8

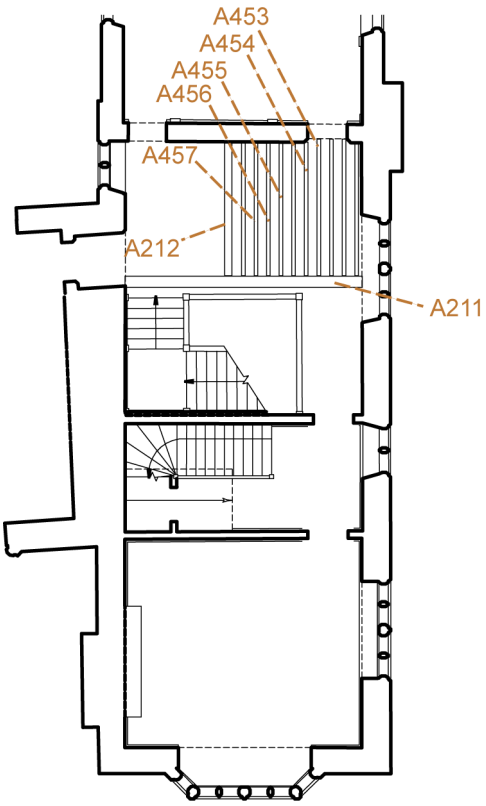


Figure 31: First-floor plan of the southern end of the East range, showing the locations of samples APT-A211–12 and A453–7

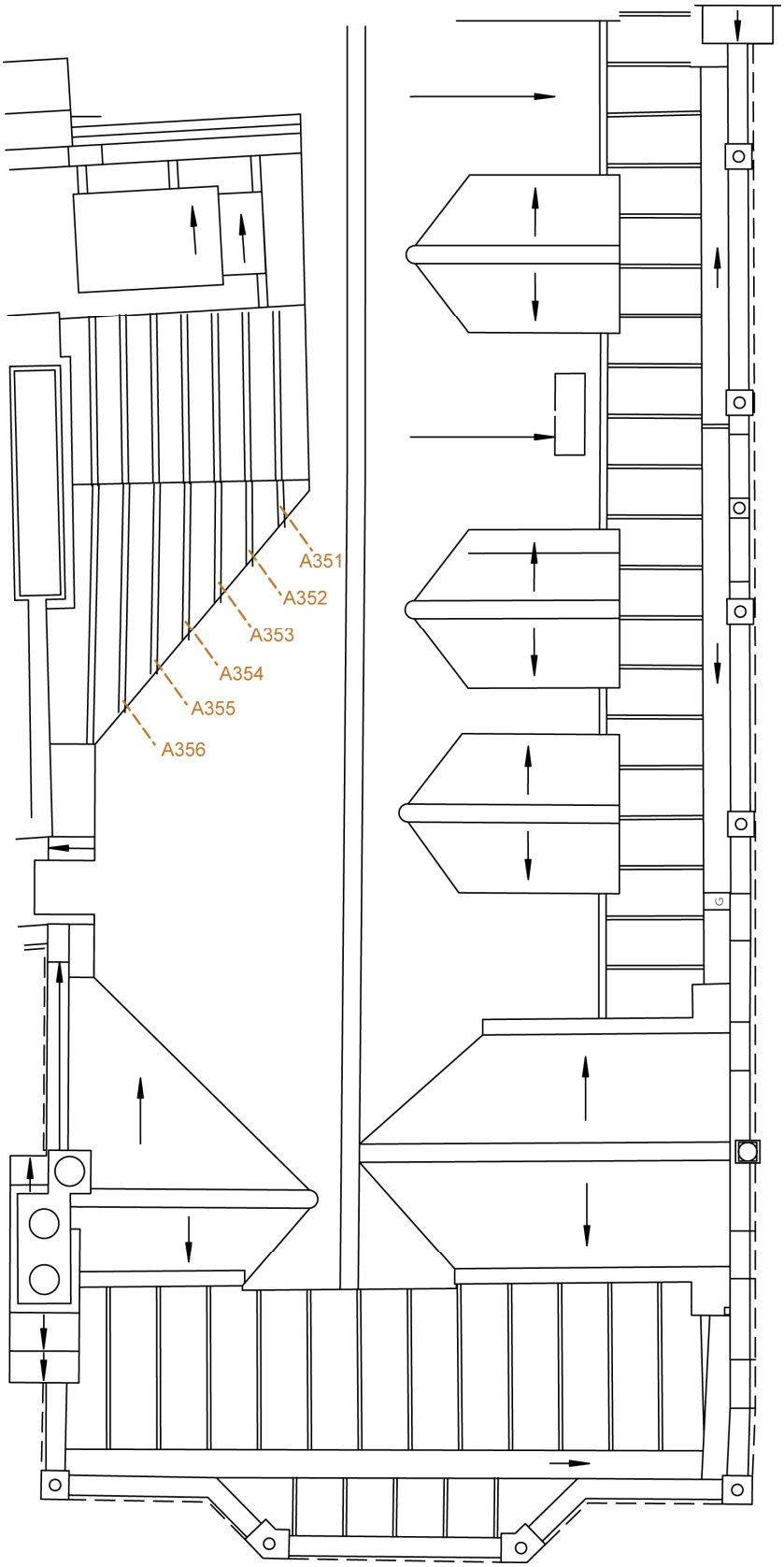


Figure 32: West roof of the East range, showing the locations of samples APT-A351–6

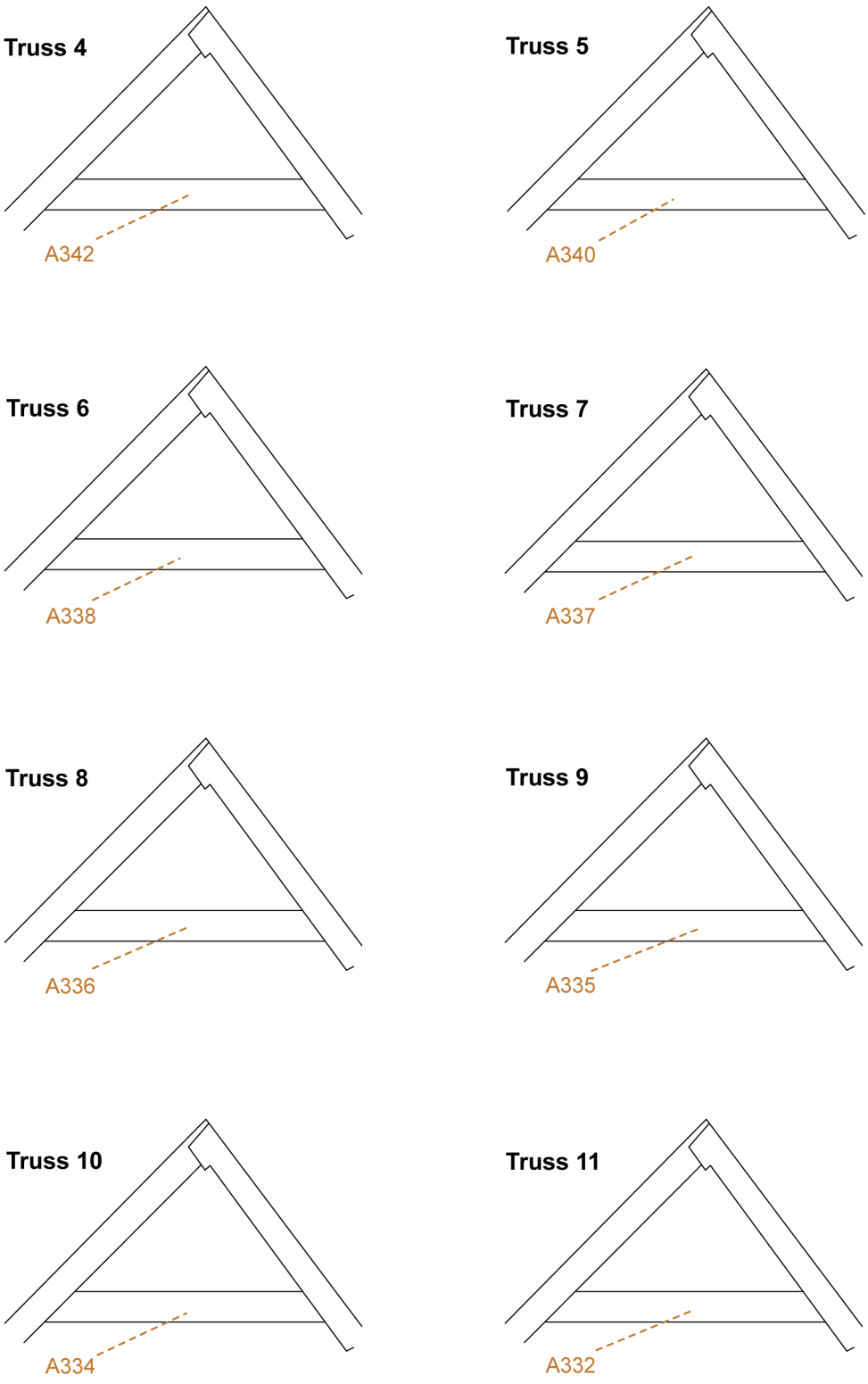


Figure 33: East range roof collars, showing the locations of samples APT-A332, A334–8, A340 and A342

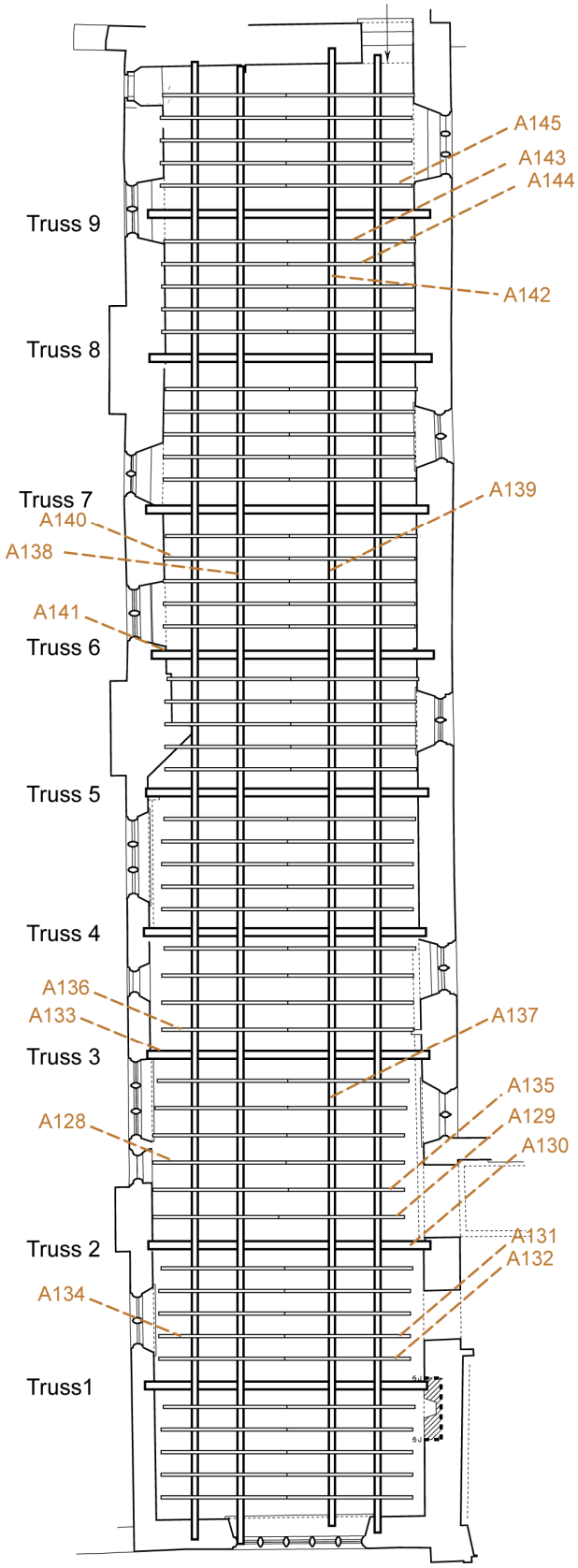


Figure 34: West range roof timbers, showing locations of samples APT-A128–45

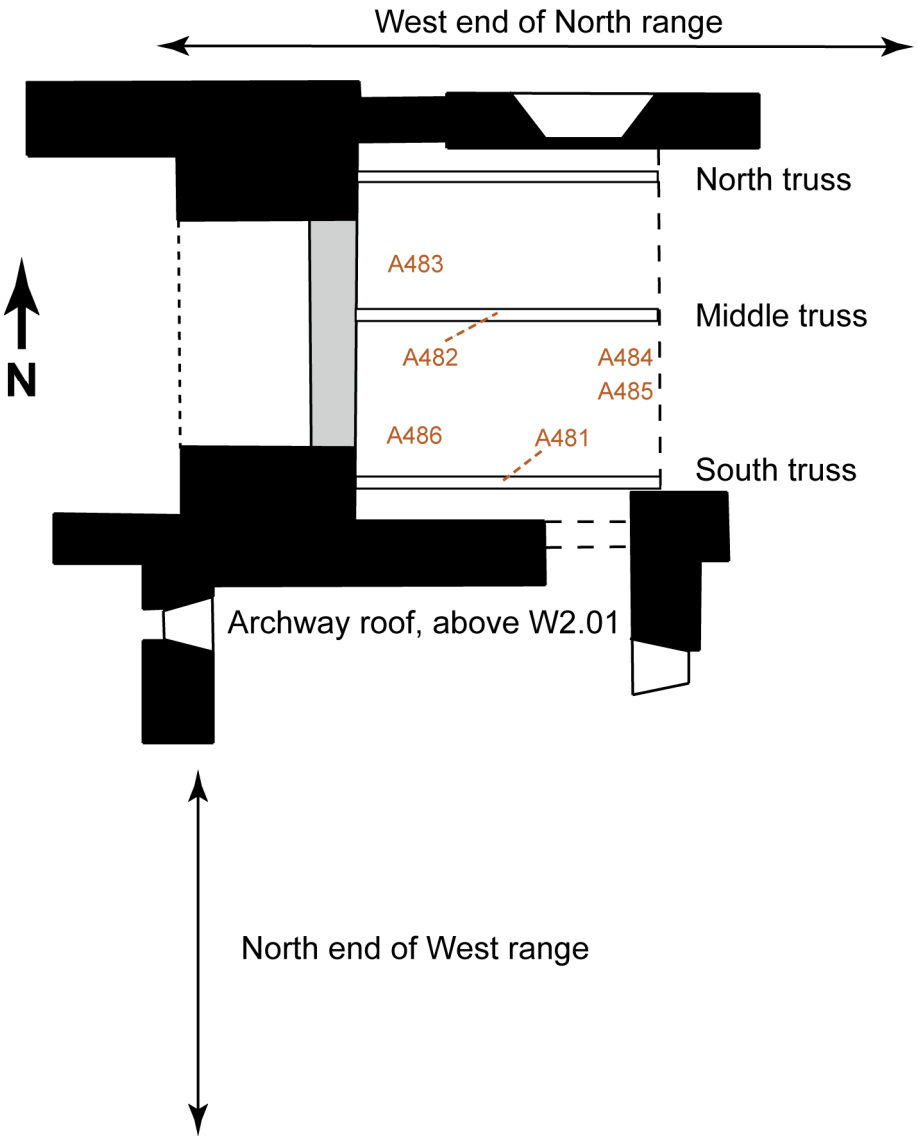


Figure 35: Archway roof above W2.01, showing the locations of samples APT-A481–6

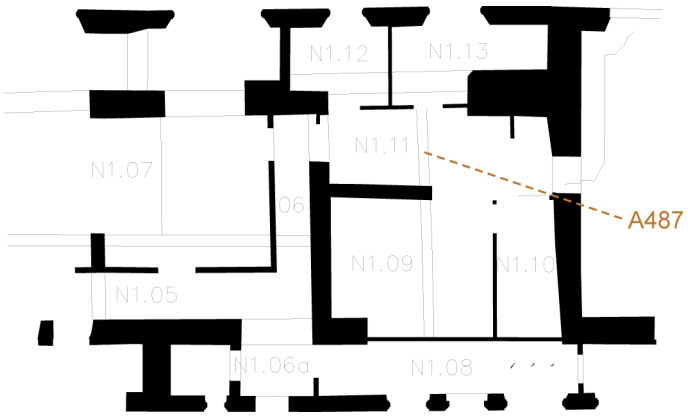


Figure 36: North range N1.11 and Archway roof W2.01, showing location of sample APT-A487

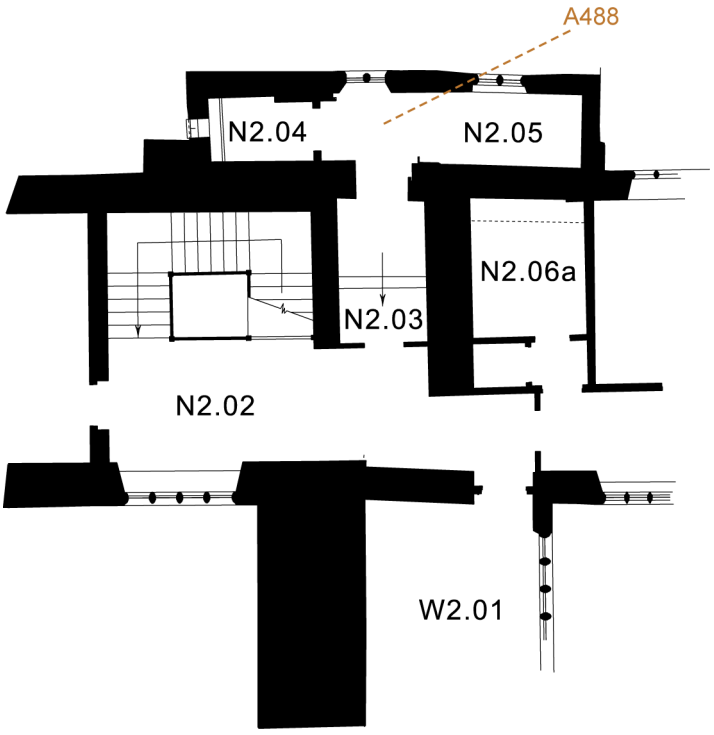


Figure 37: North range N2.04–05 and Archway roof W2.01, showing the location of sample APT-A488

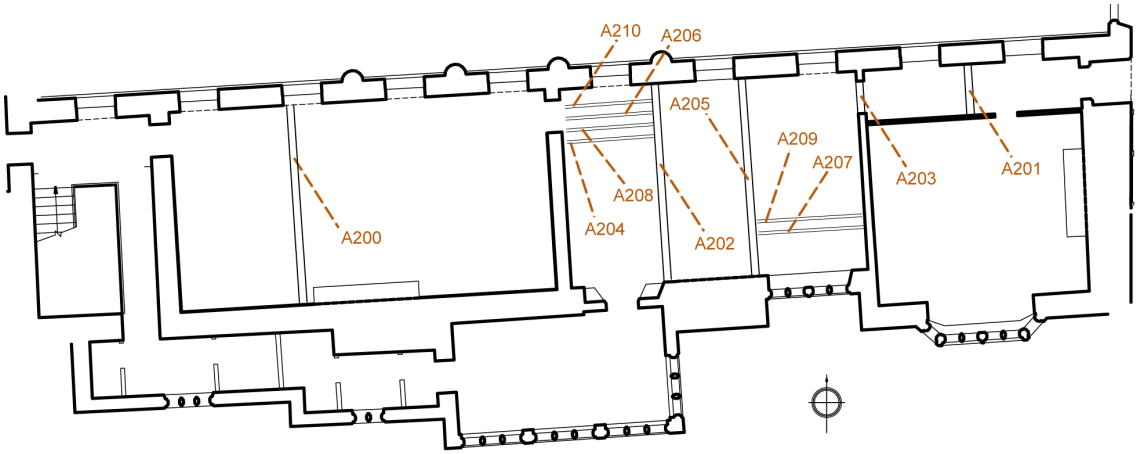


Figure 38: First-floor plan of the South range, showing the locations of samples APT-A200–10

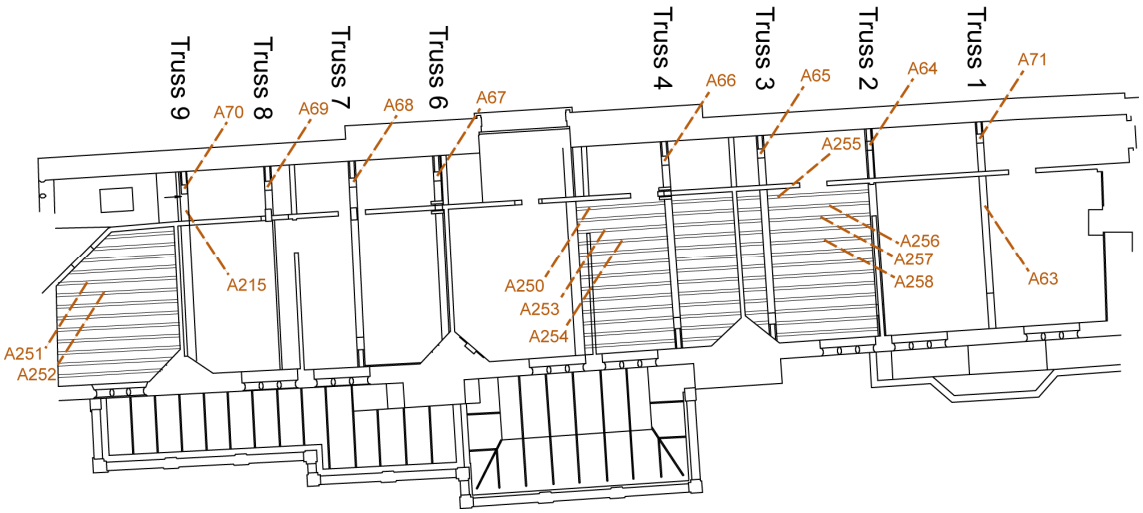


Figure 39: Attic plan of the South range, showing the locations of samples APT-A63–71, A215, A250–8

Figure 40: South range attic, showing location of samples APT-A72–80

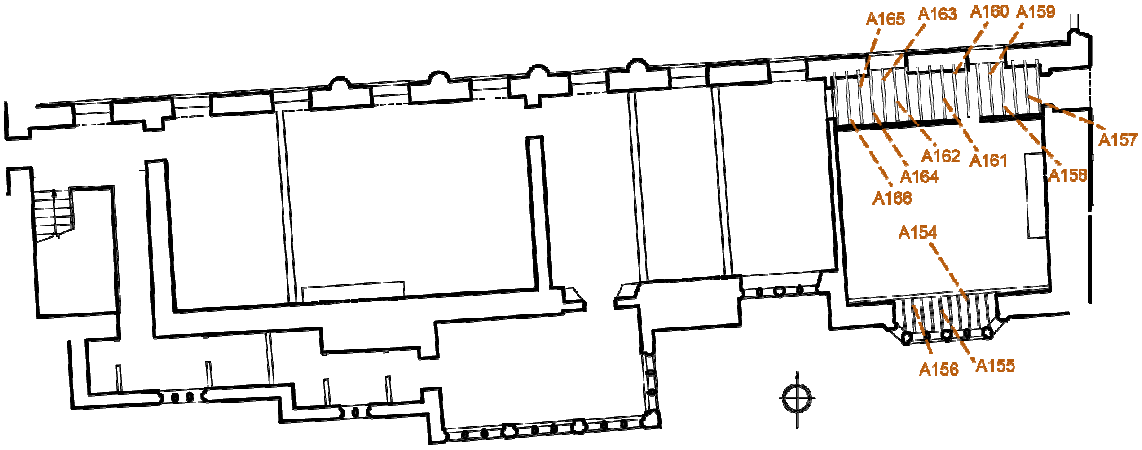


Figure 41: First-floor ceiling of the South range, showing locations of samples APT-A154–66

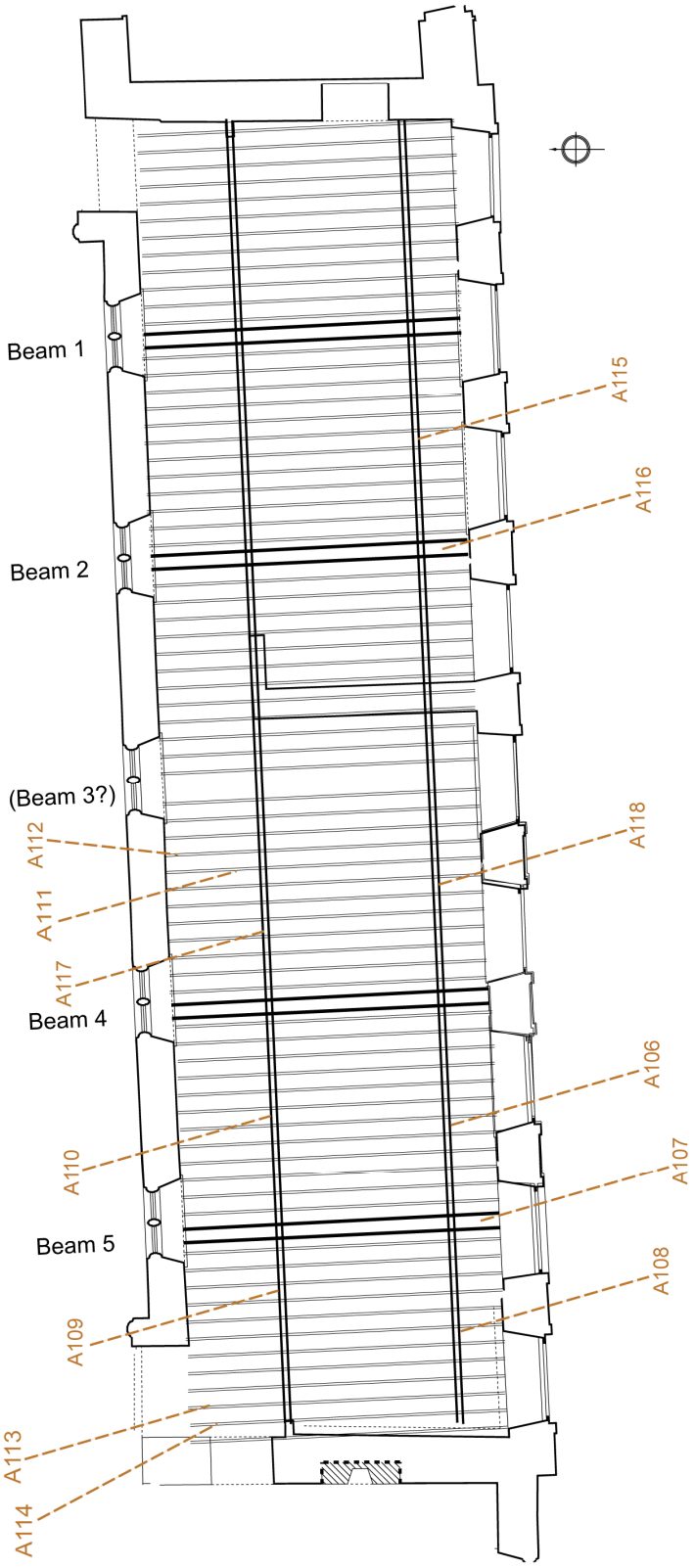


Figure 42: Orangery roof timbers, showing locations of samples APT-A106–18. Note APT-A111 is a joist at the same level as the main cross beams added to this roof plan

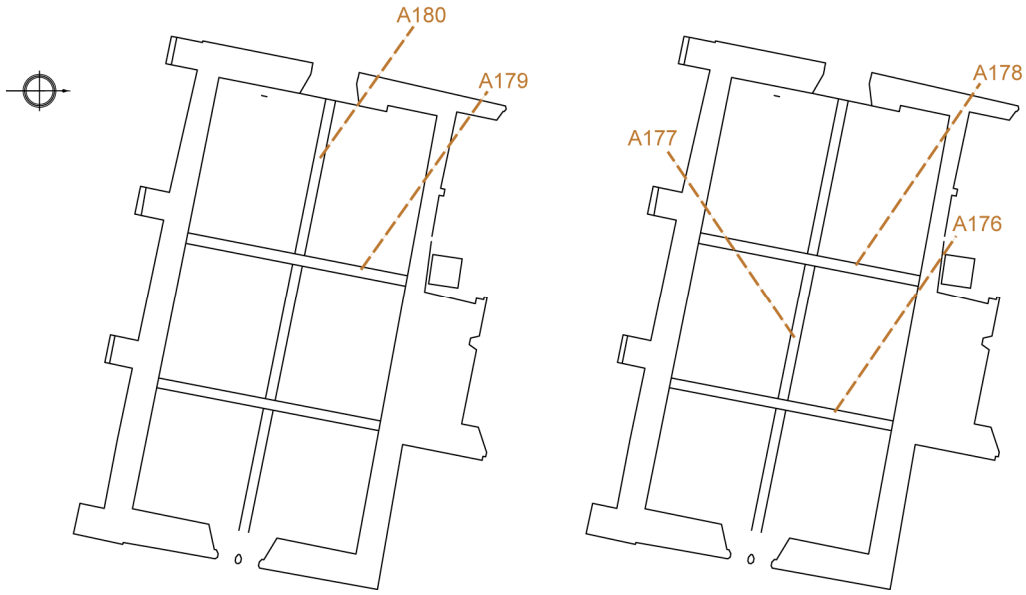


Figure 43: Granary, showing the locations of samples APT-A179–80 from the ground-floor ceiling and samples APT-A176–8 from the first-floor ceiling

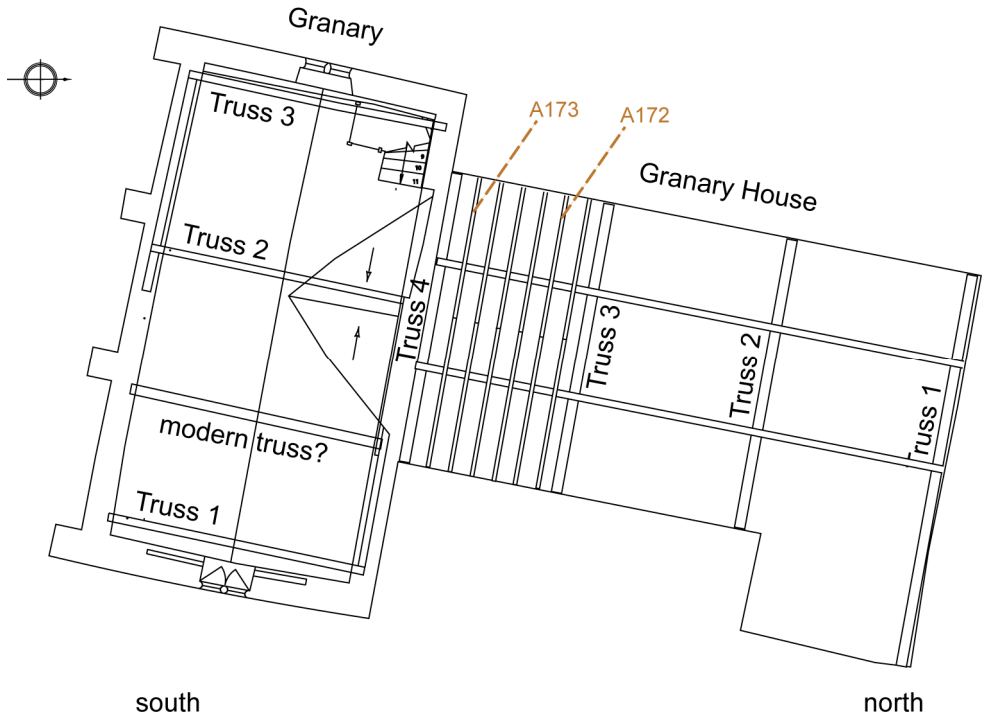


Figure 44: Roof plan, Granary and Granary House, showing the locations of samples APT-A172–3

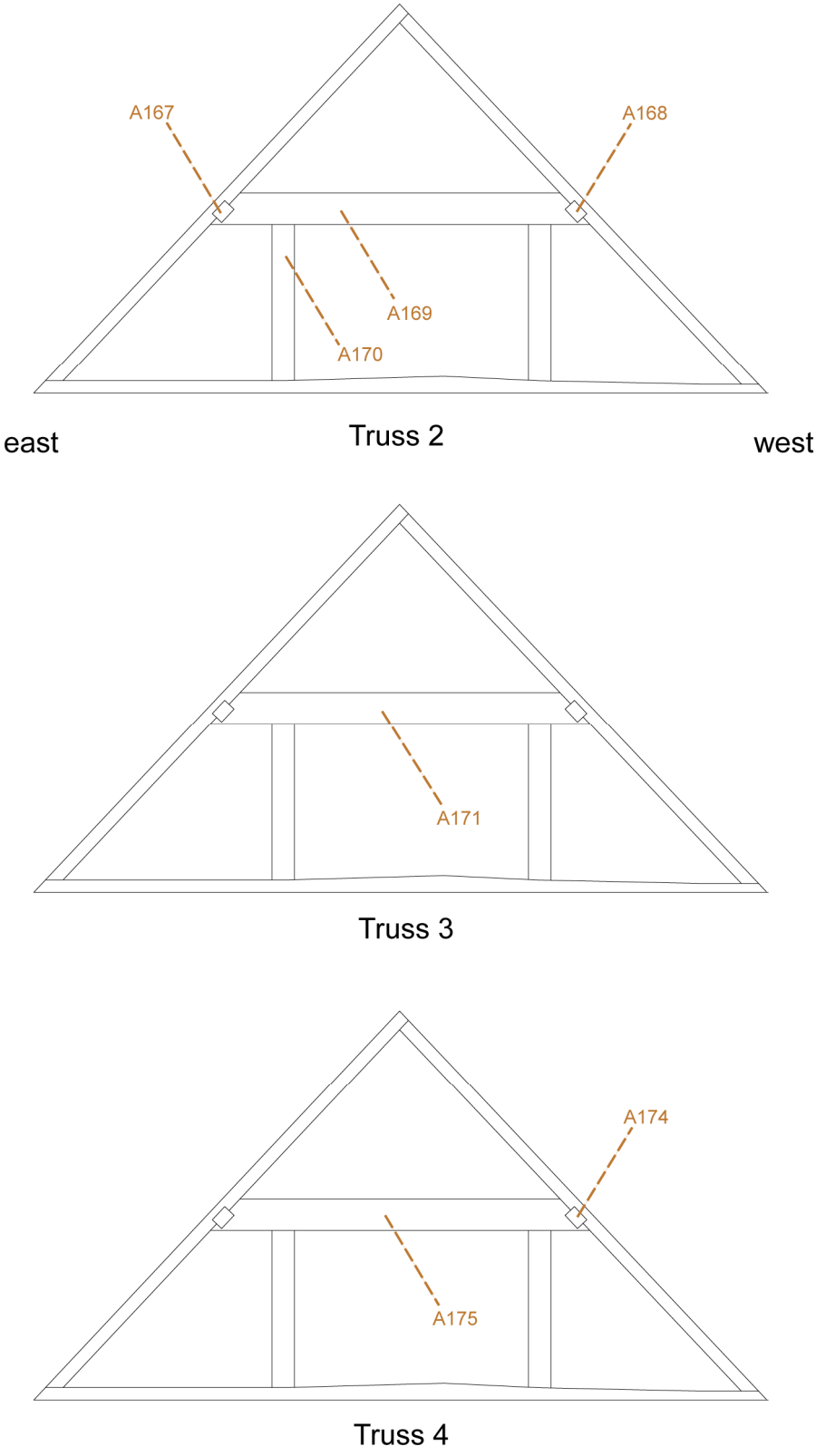


Figure 45: Granary House roof trusses 2–4, seen from the north, showing the location of samples APT-A167–71, and APT-A174–5

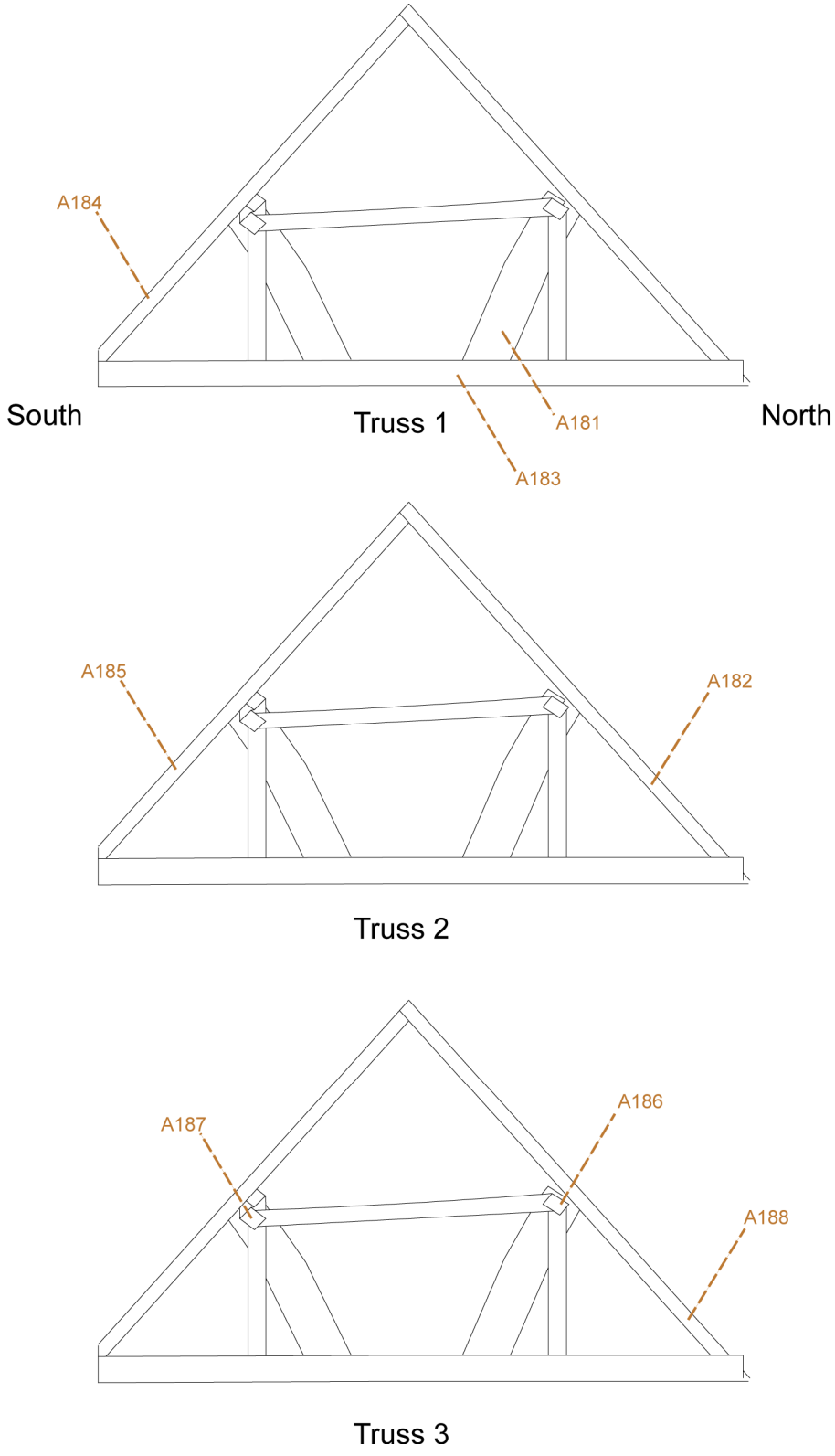


Figure 46: Granary roof trusses 1–3, seen from the west, showing the location of samples APT-A181–8

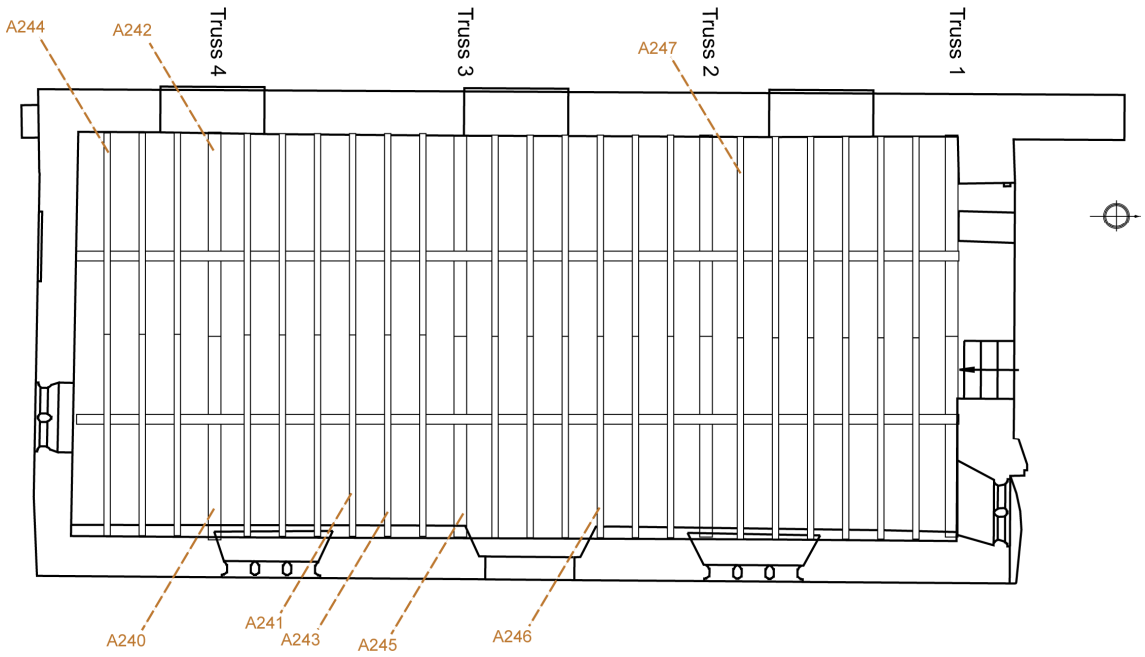


Figure 47: Roof plan, south-west stable, showing the locations of samples APT-A240–7

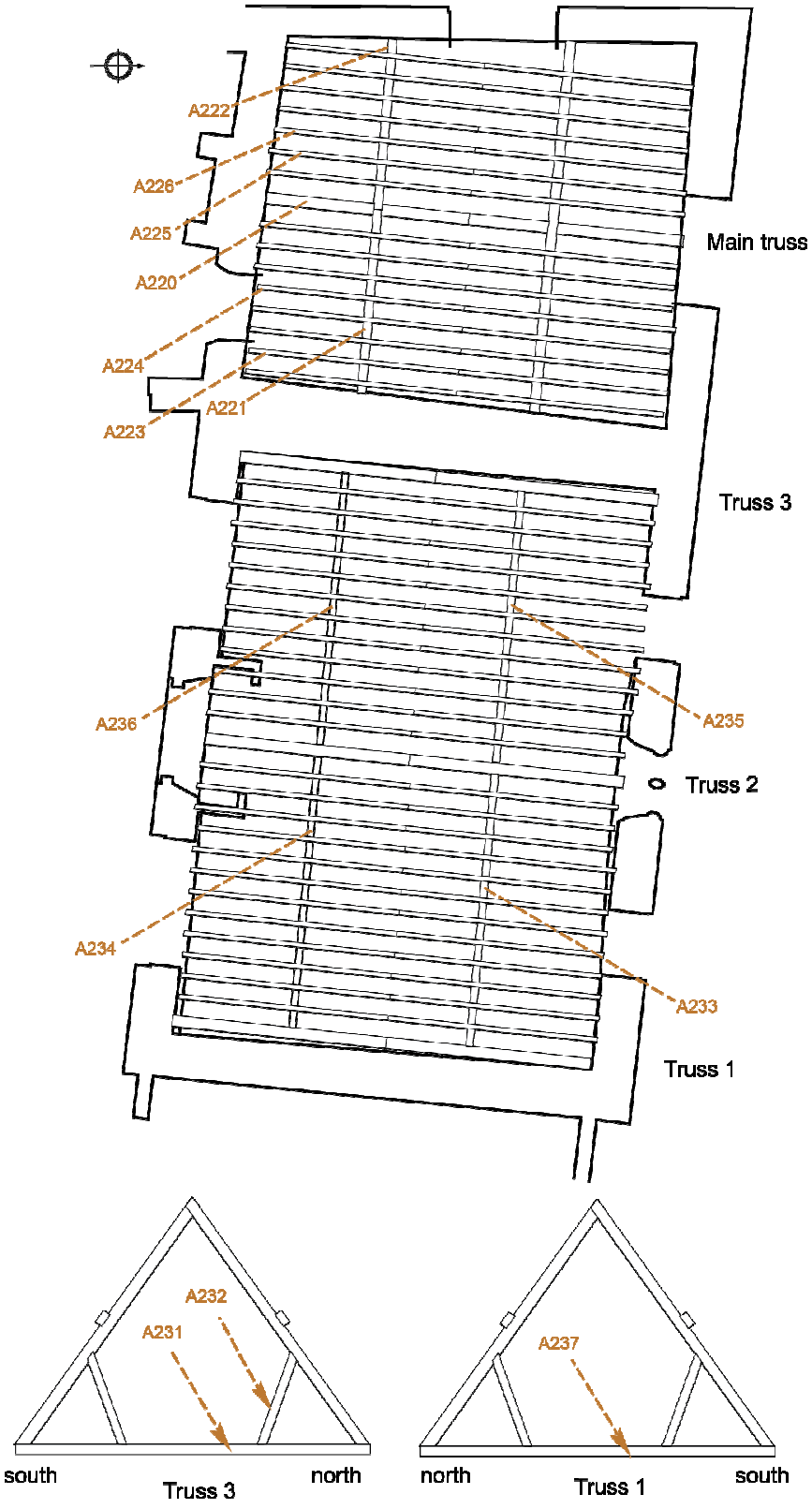


Figure 48: Roof structures in the north-west corner of the stables, showing the locations of samples APT-A220–6 and A231–7

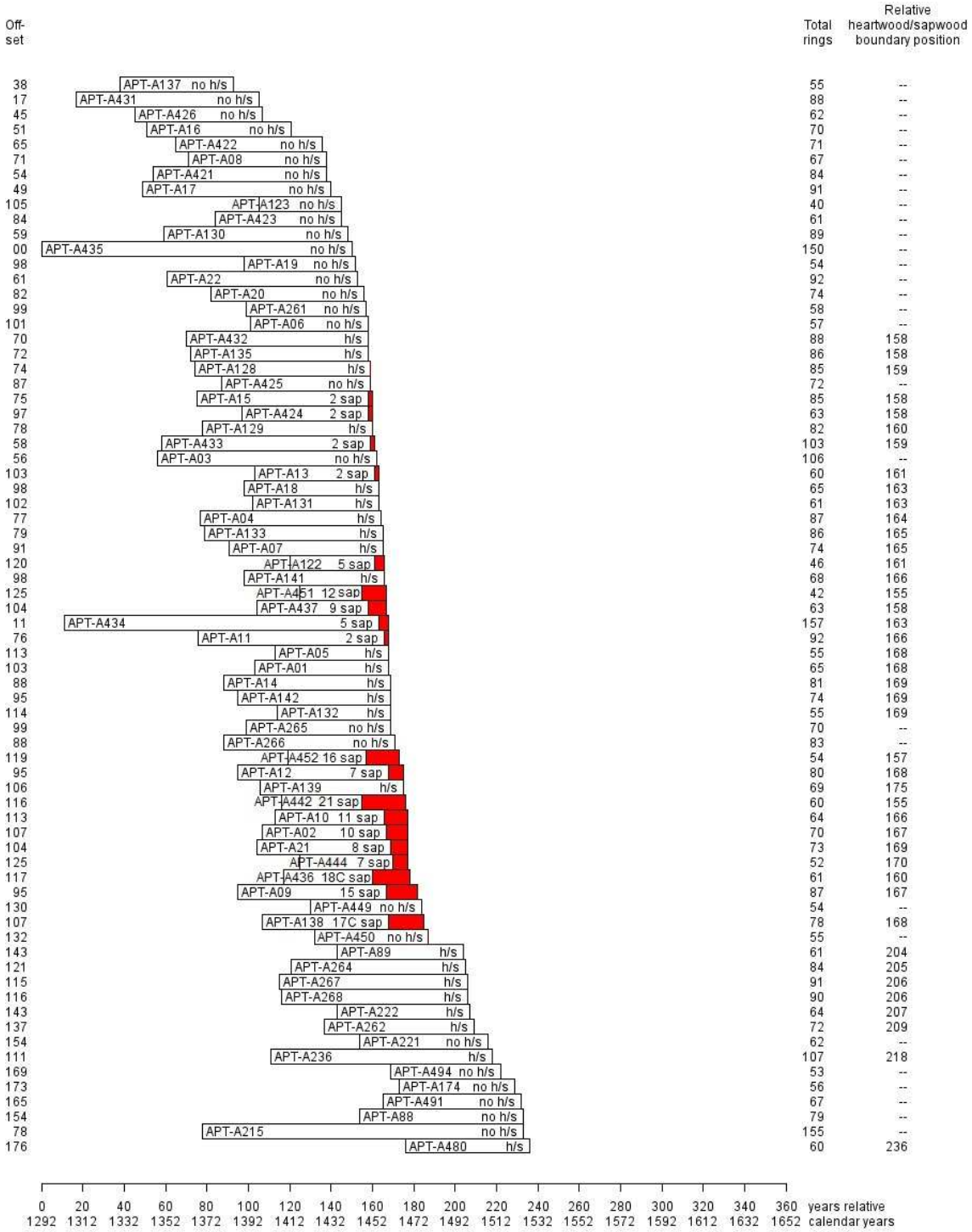


Figure 49: Bar diagram showing the relative positions of the 'early' samples in site chronology APTASQ01

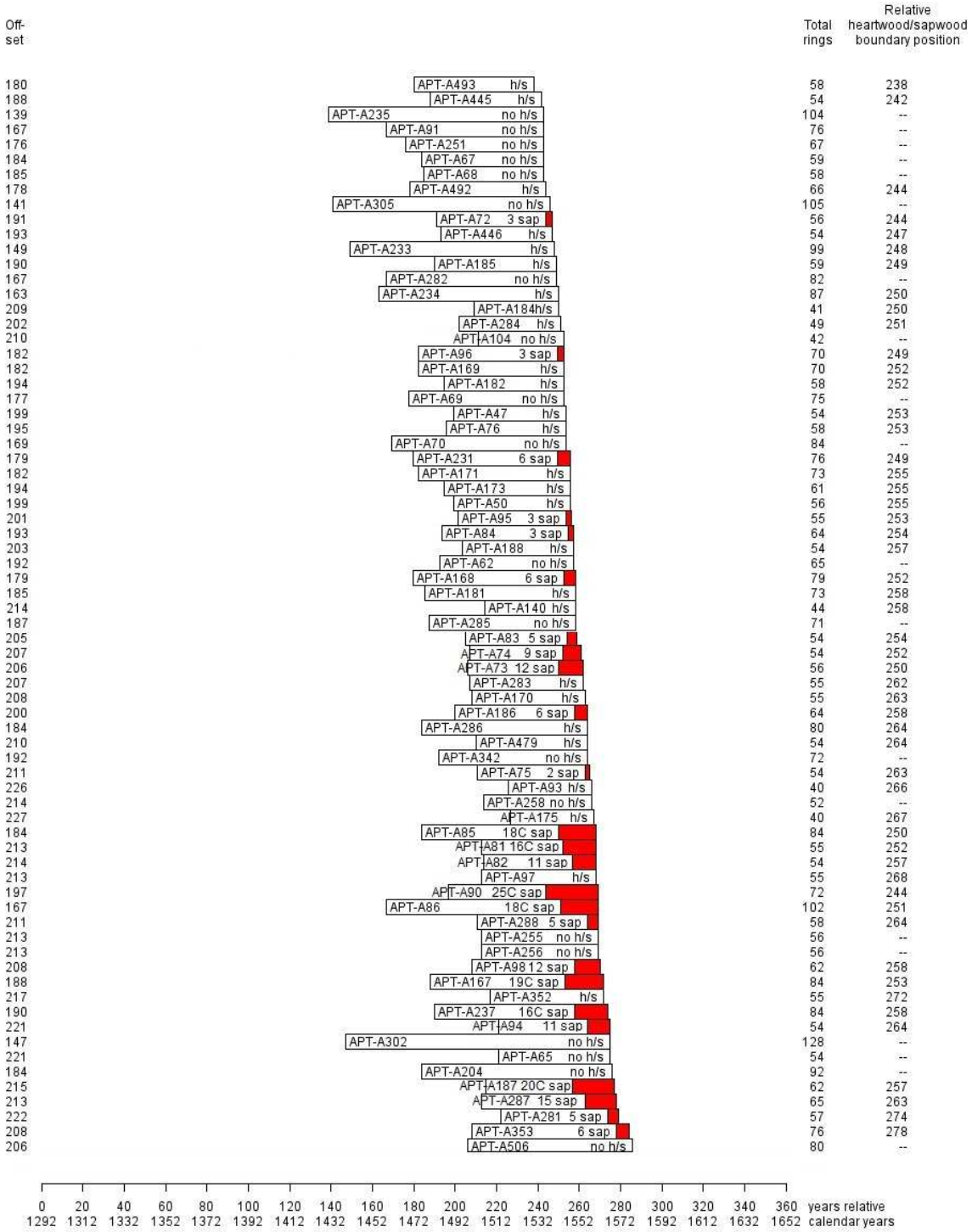


Figure 50: Bar diagram showing the relative positions of the 'middle' samples in site chronology APTASQ01

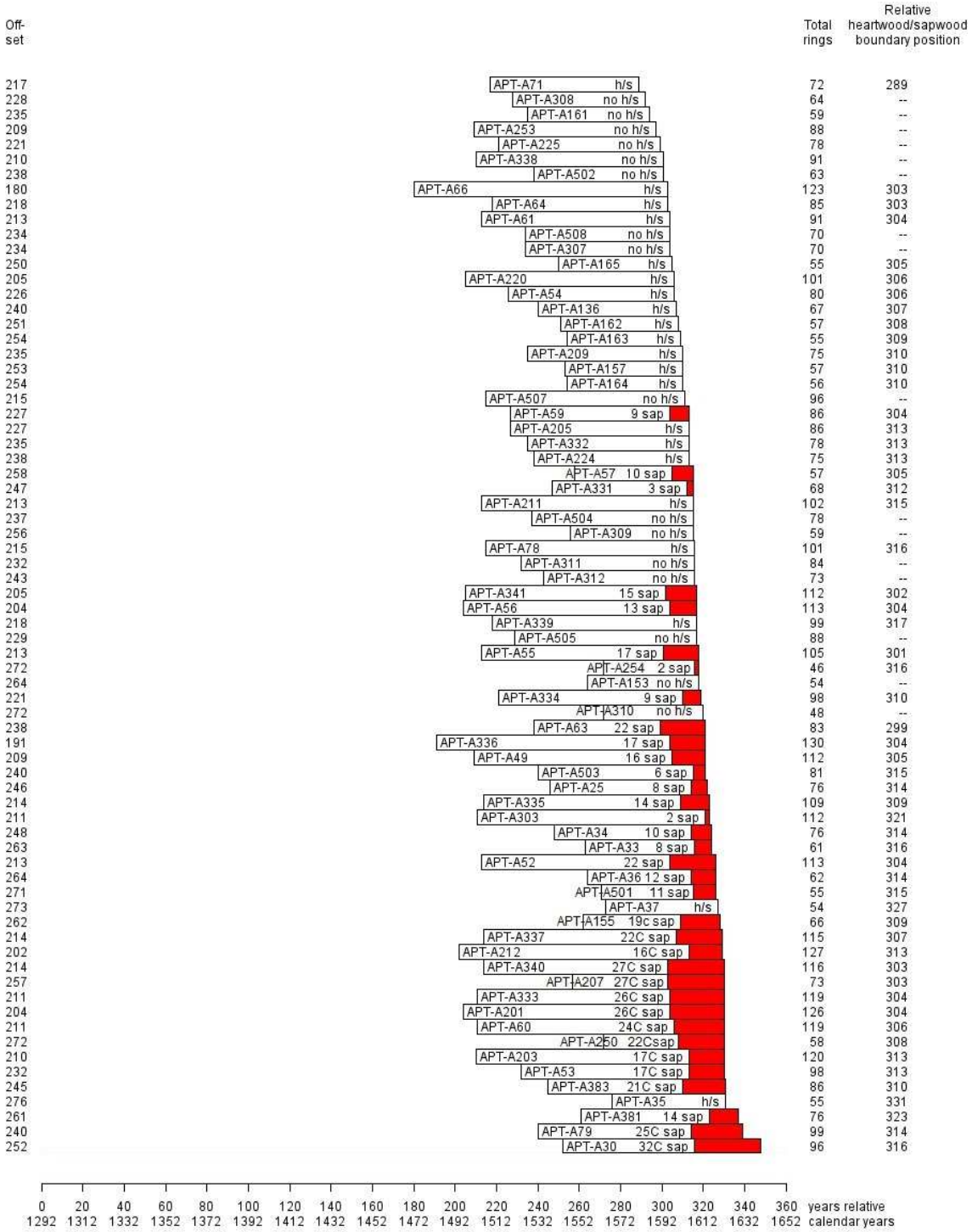


Figure 51: Bar diagram showing the relative positions of the 'late' samples in site chronology APTASQ01

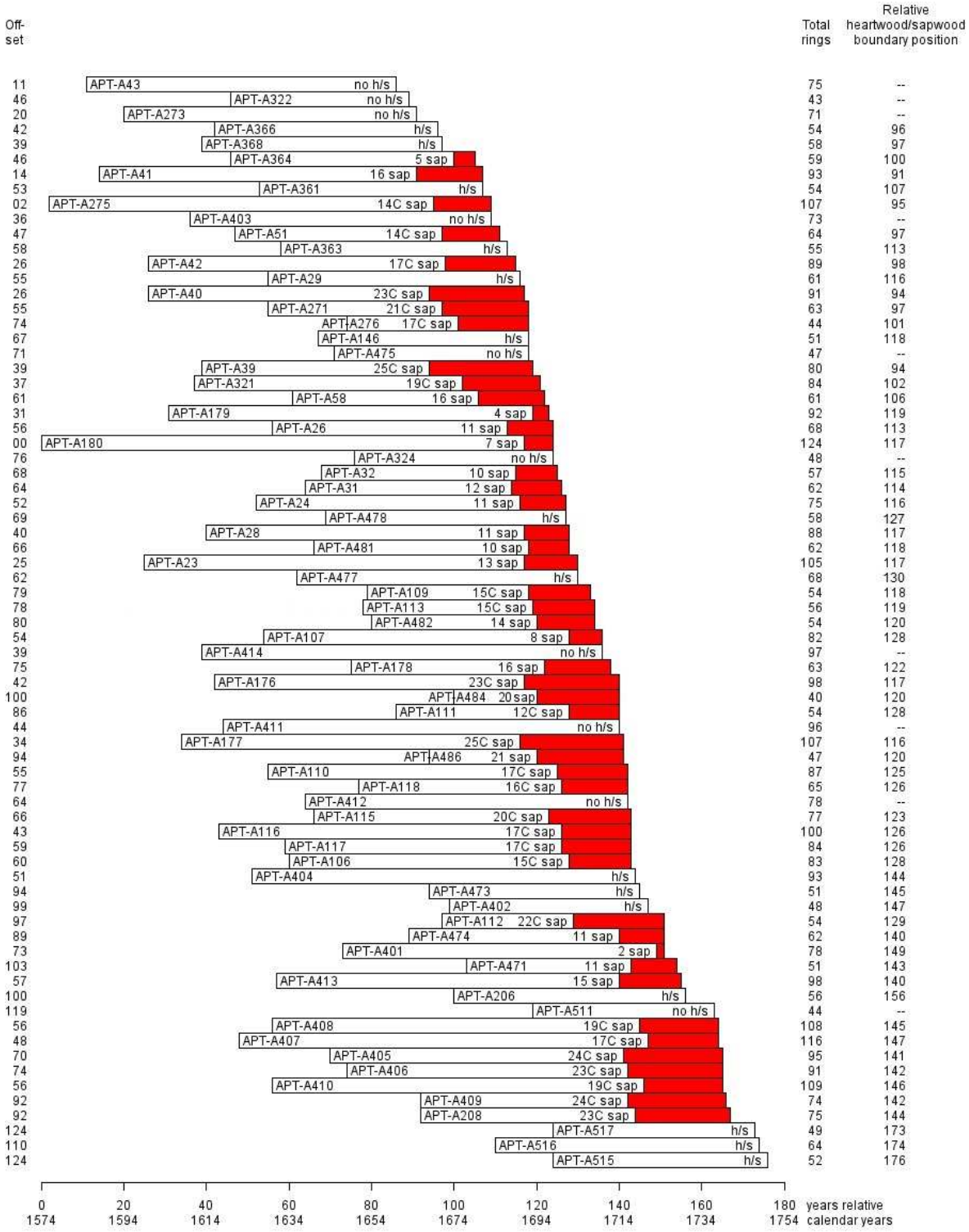


Figure 52: Bar diagram showing the relative positions of the samples in site chronology APTASQ02

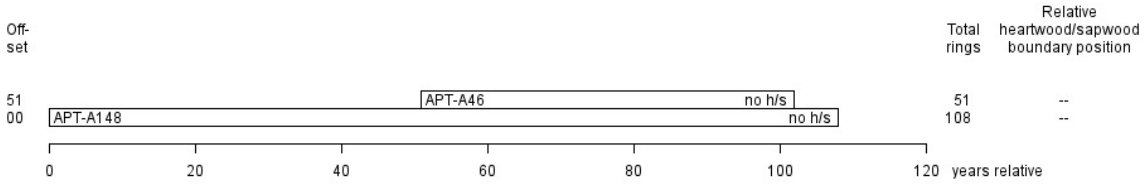


Figure 53: Bar diagram showing the relative positions of the samples in site chronology APTASQ03

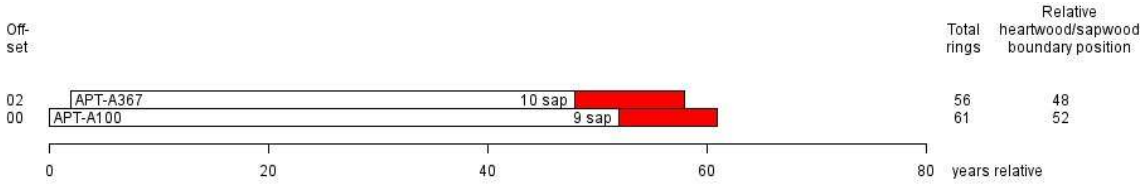


Figure 54: Bar diagram showing the relative positions of the samples in site chronology APTASQ04

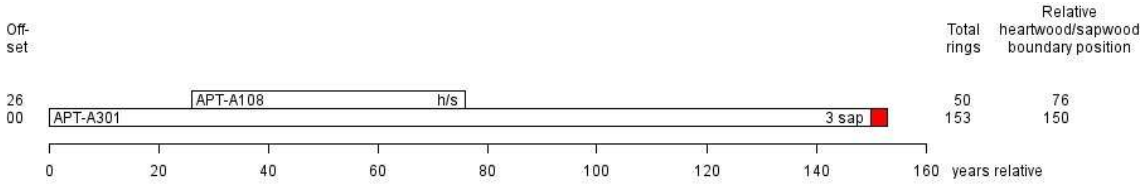


Figure 55: Bar diagram showing the relative positions of the samples in site chronology APTASQ05

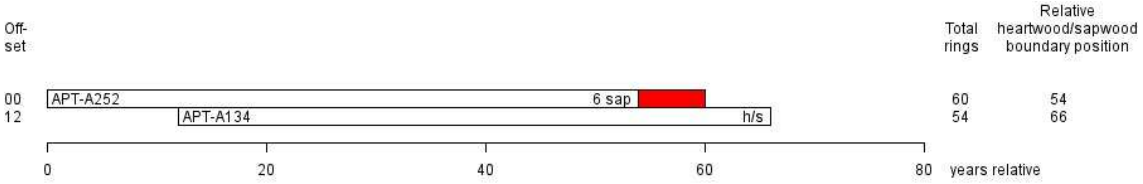


Figure 56: Bar diagram showing the relative positions of the samples in site chronology APTASQ06

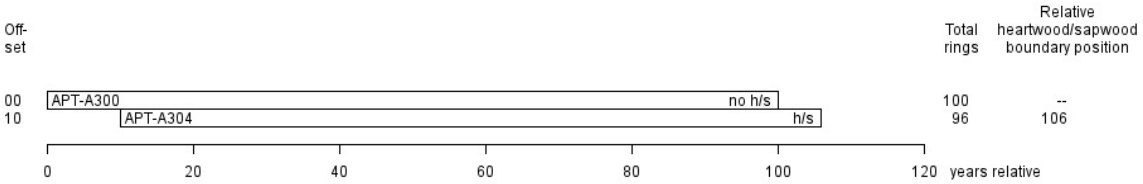


Figure 57: Bar diagram showing the relative positions of the samples in site chronology APTASQ07

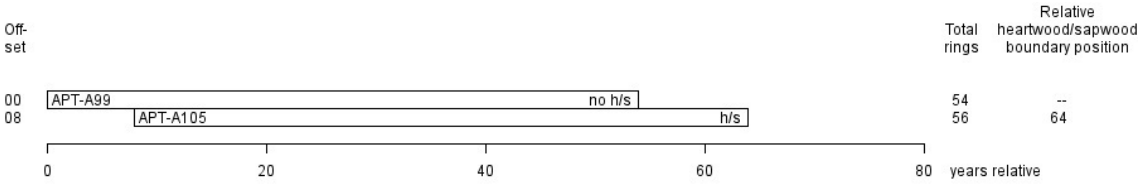


Figure 58: Bar diagram showing the relative positions of the samples in site chronology APTASQ08

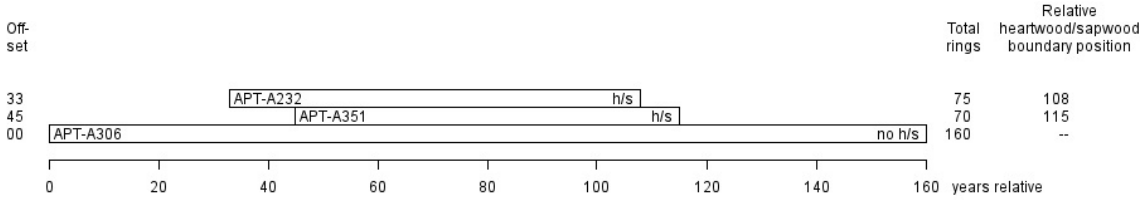


Figure 59: Bar diagram showing the relative positions of the samples in site chronology APTASQ09

Key to figures 49–59

White bars = heartwood rings
Red bars = sapwood rings
nn sap = number of sapwood rings retained on the sample
C = complete sapwood is retained on the sample
c= there is complete sapwood on timber, but part has been lost in sampling
h/s = heartwood/sapwood boundary

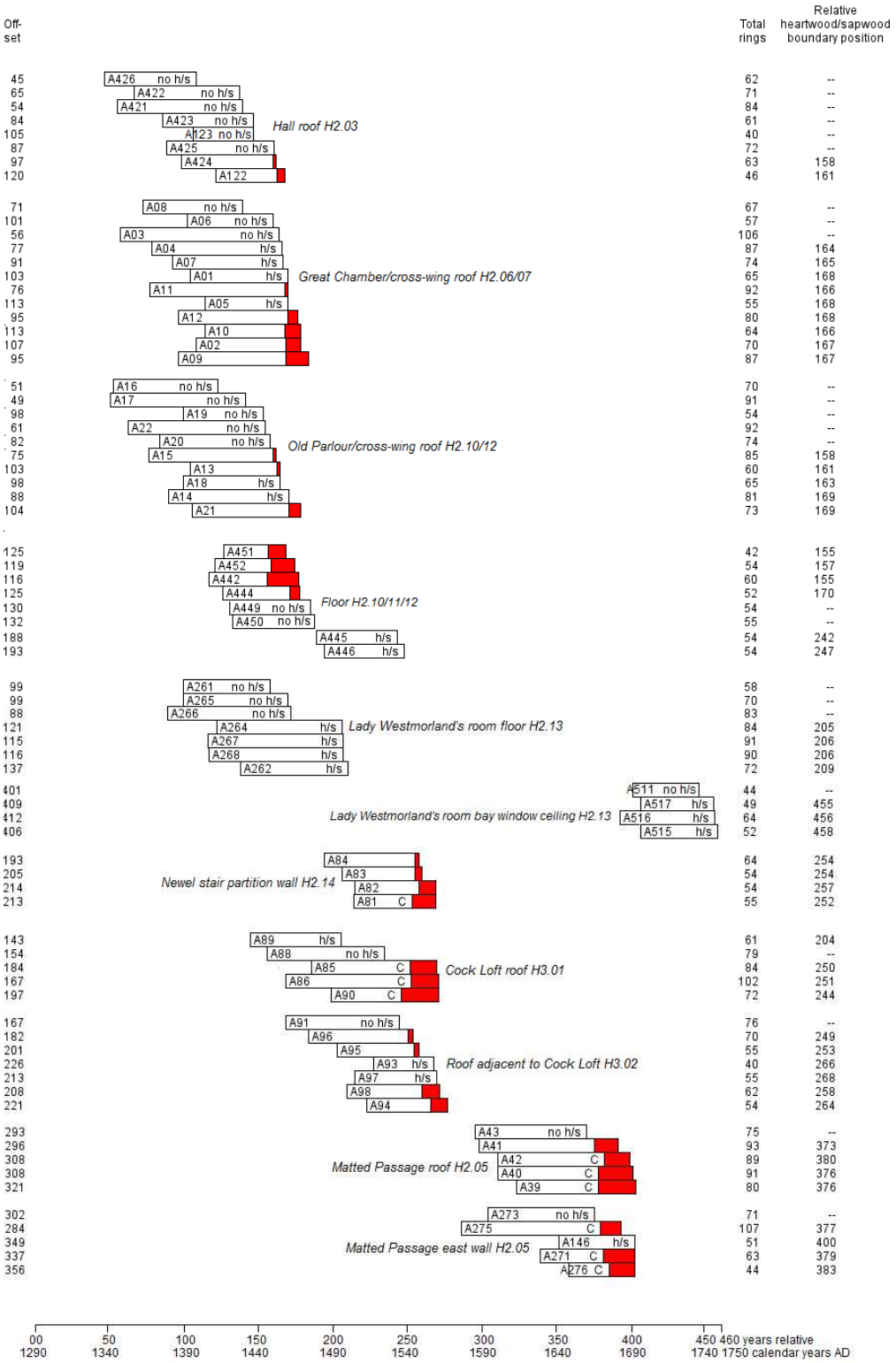


Figure 60: Bar diagram showing the relative positions of the dated samples from the Hall range grouped by area

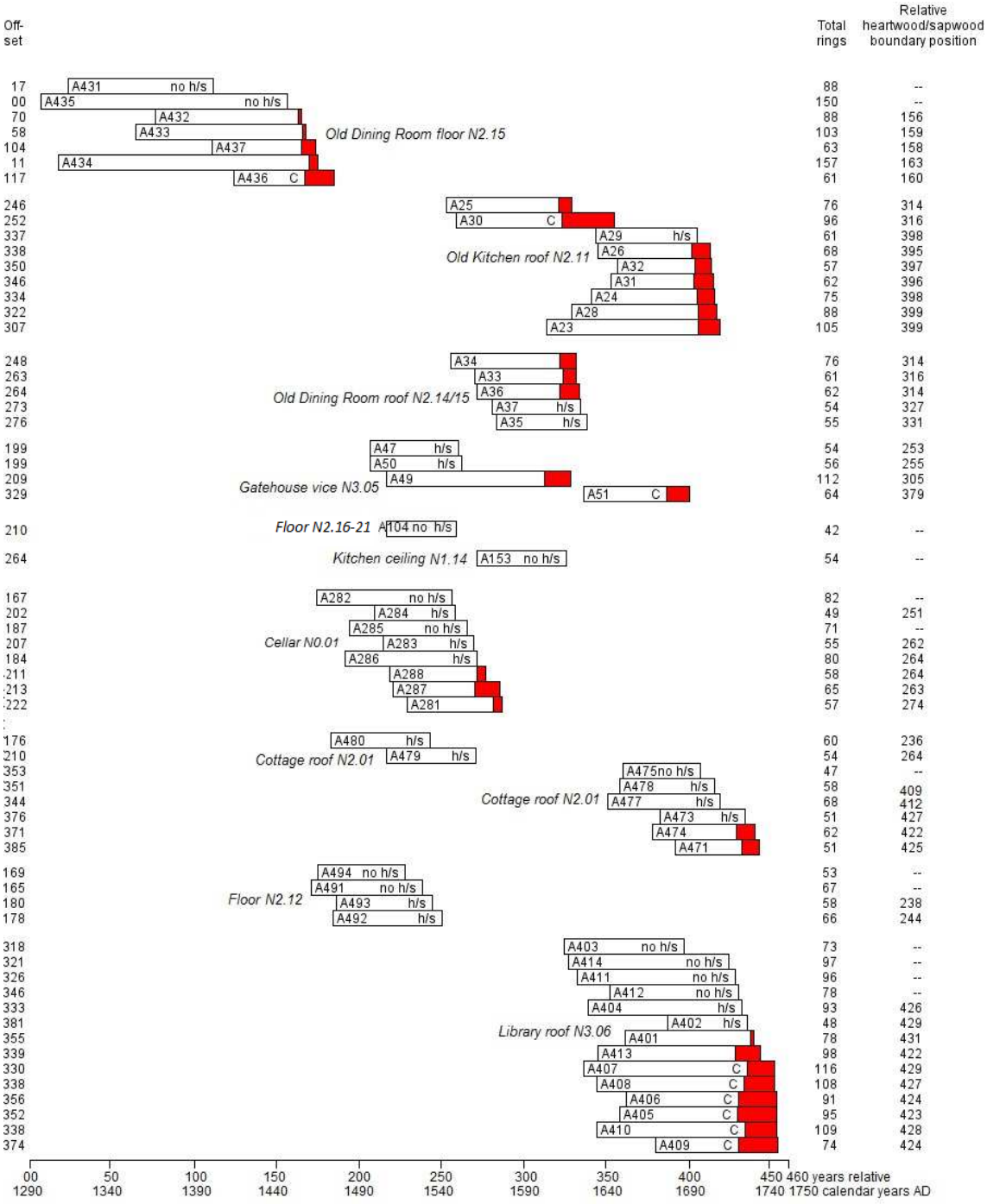


Figure 61: Bar diagram showing the relative positions of the dated samples from the North range grouped by area

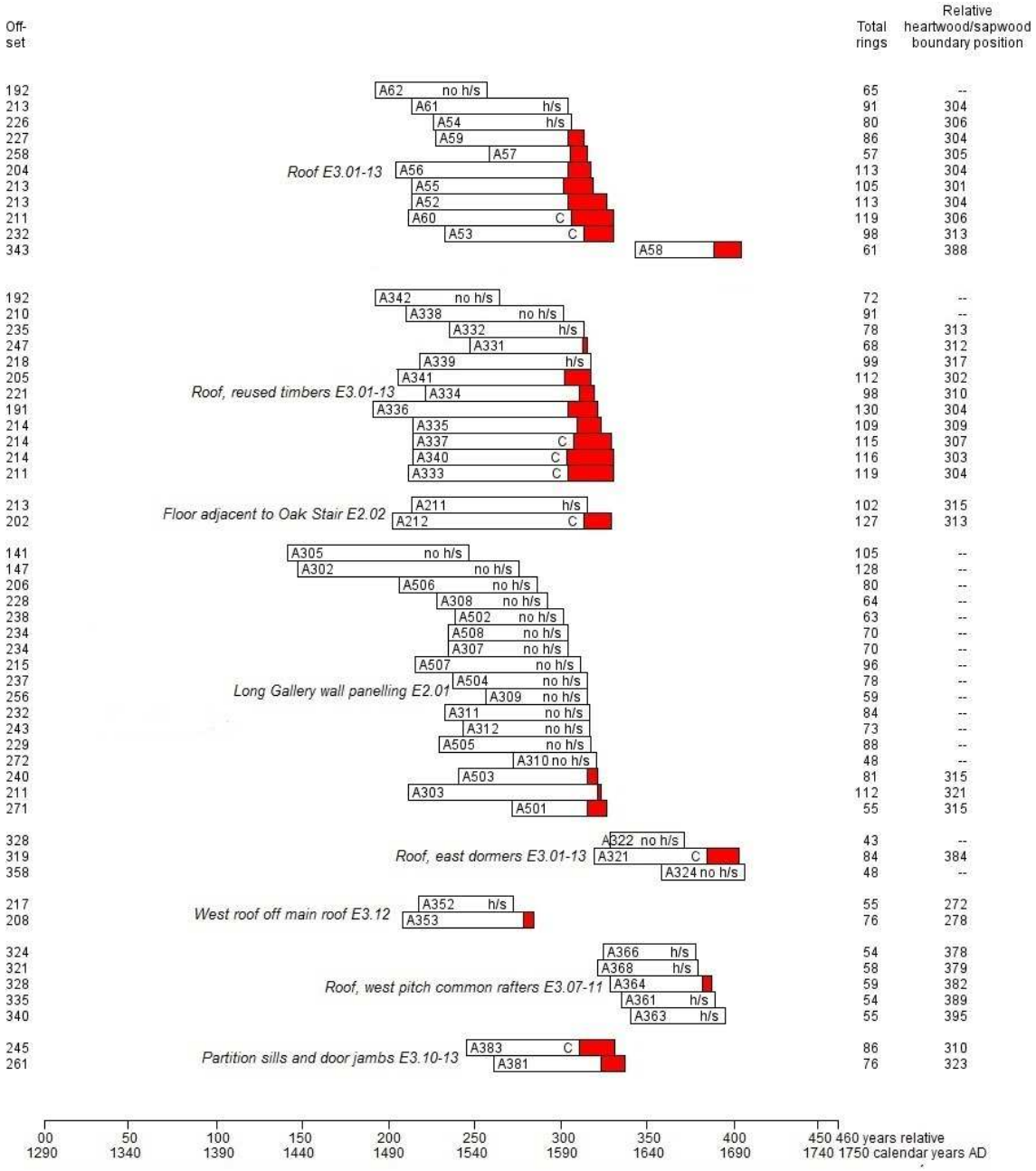


Figure 62: Bar diagram showing the relative positions of the dated samples from the East range grouped by area

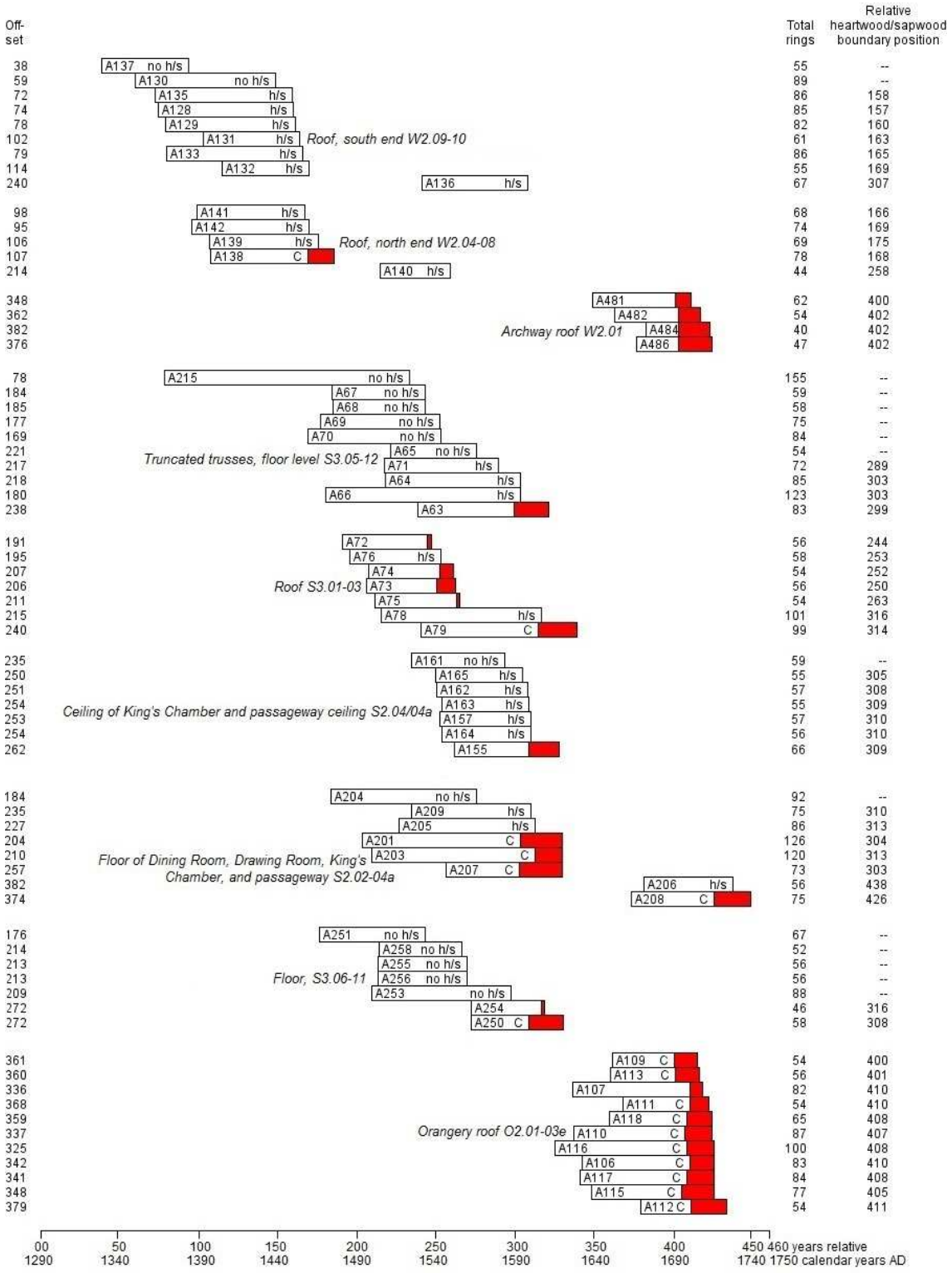


Figure 63: Bar diagram showing the relative positions of the dated samples from the West range, South range, and Orangery grouped by area

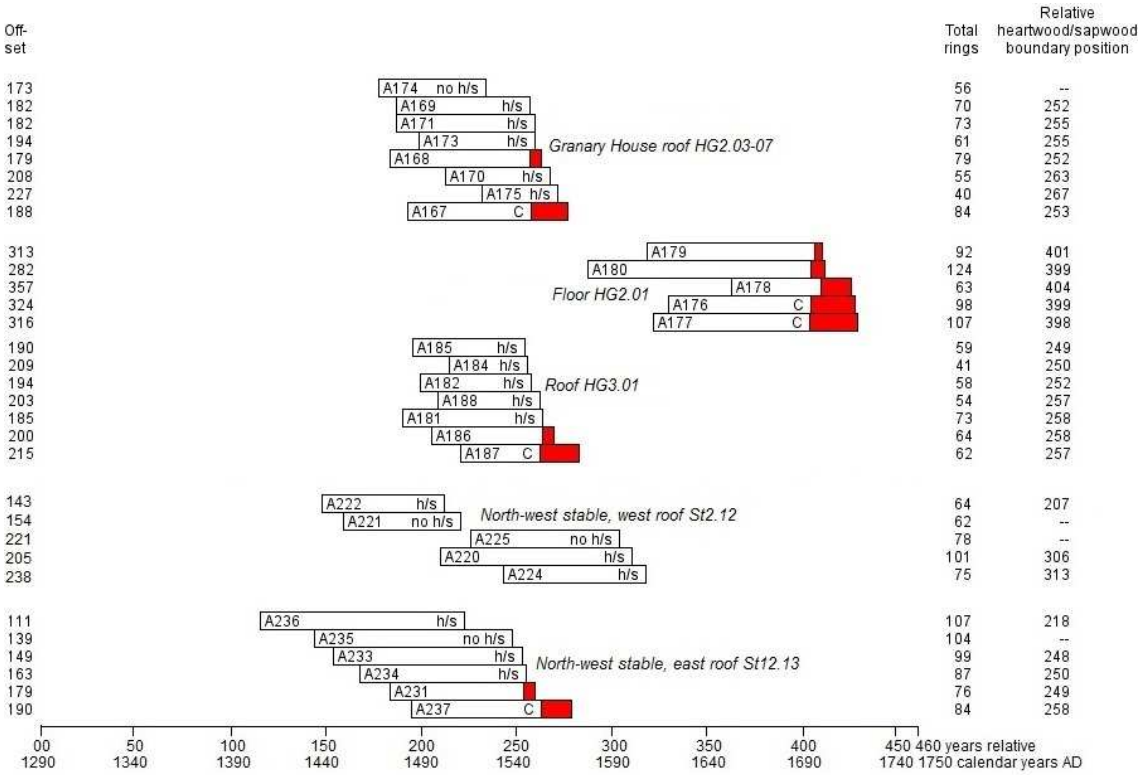
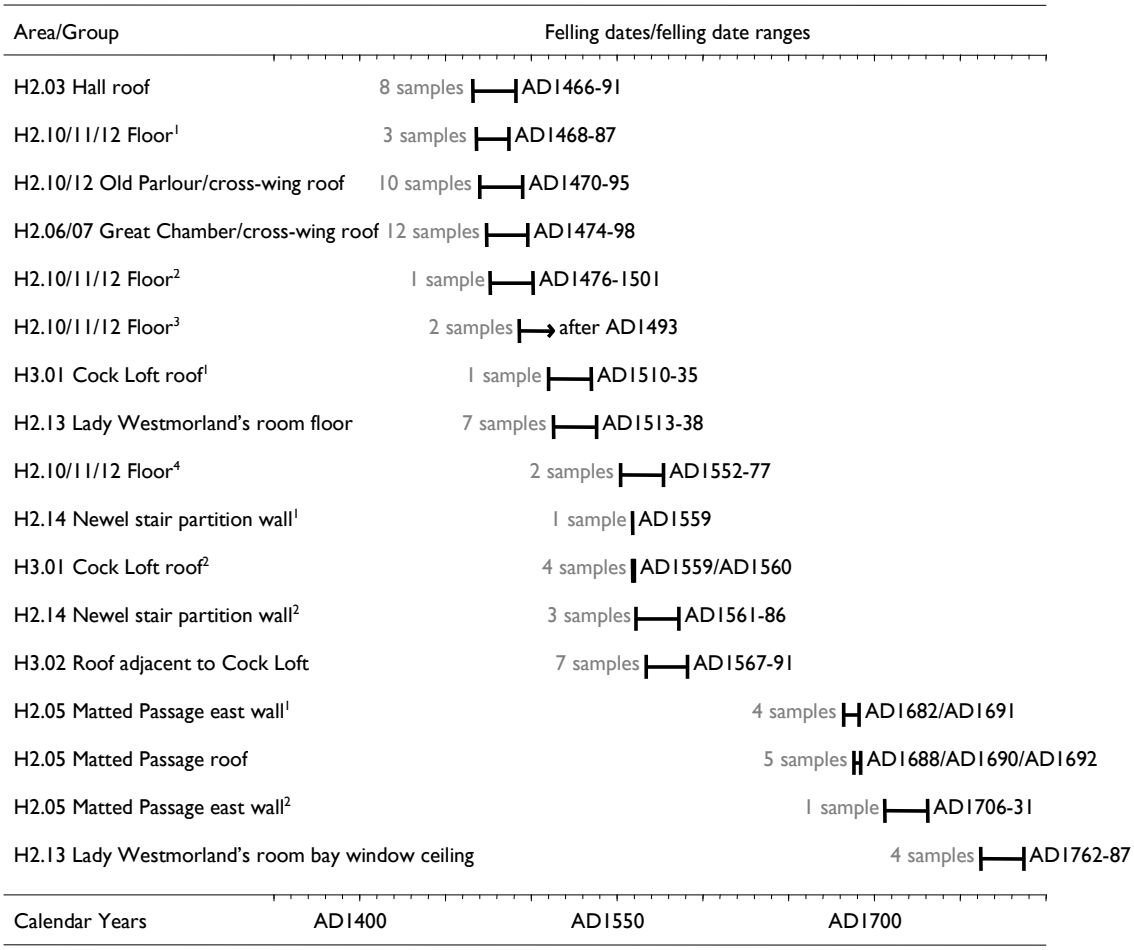


Figure 64: Bar diagram showing the relative positions of the dated samples from the Granary complex and Stables grouped by area

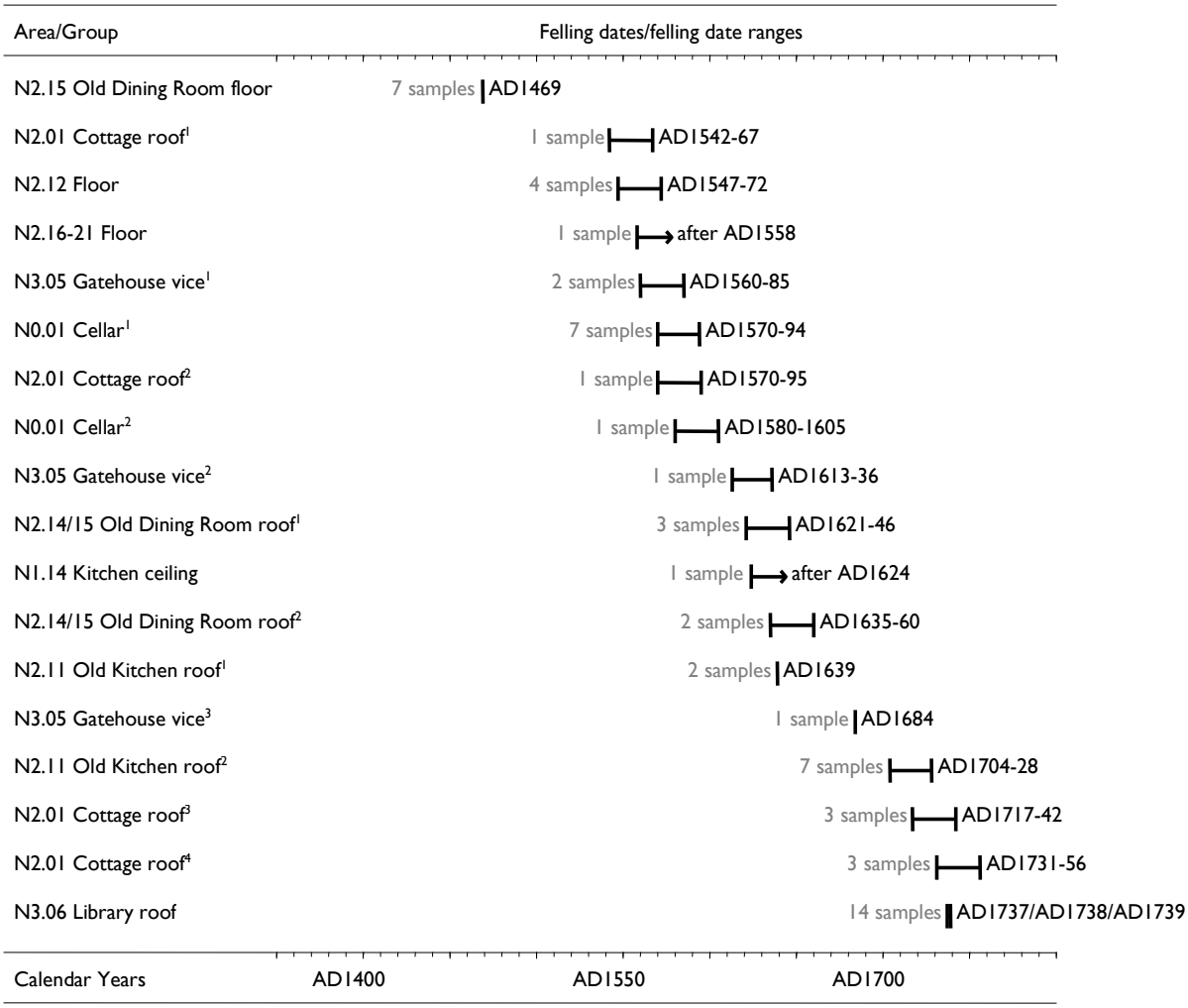
Key to figures 60–4

White bars = heartwood rings
Red bars = sapwood rings
C = complete sapwood is retained on the sample
c= there is complete sapwood on timber, but part has been lost in sampling
h/s = heartwood/sapwood boundary



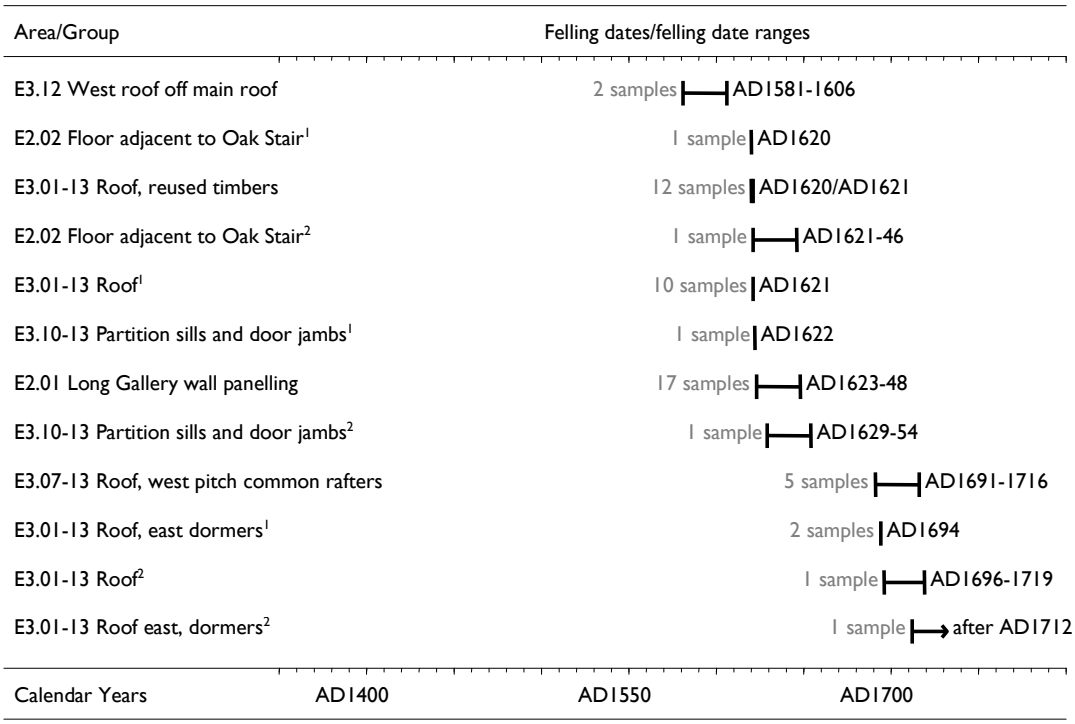
NB Area/Group labels followed by a number in superscript indicate that there is more than one group of timbers dated from that single Area and that those Groups have different felling dates

Figure 65: Summary of the felling dates obtained for the associated groups of timbers from the Hall range



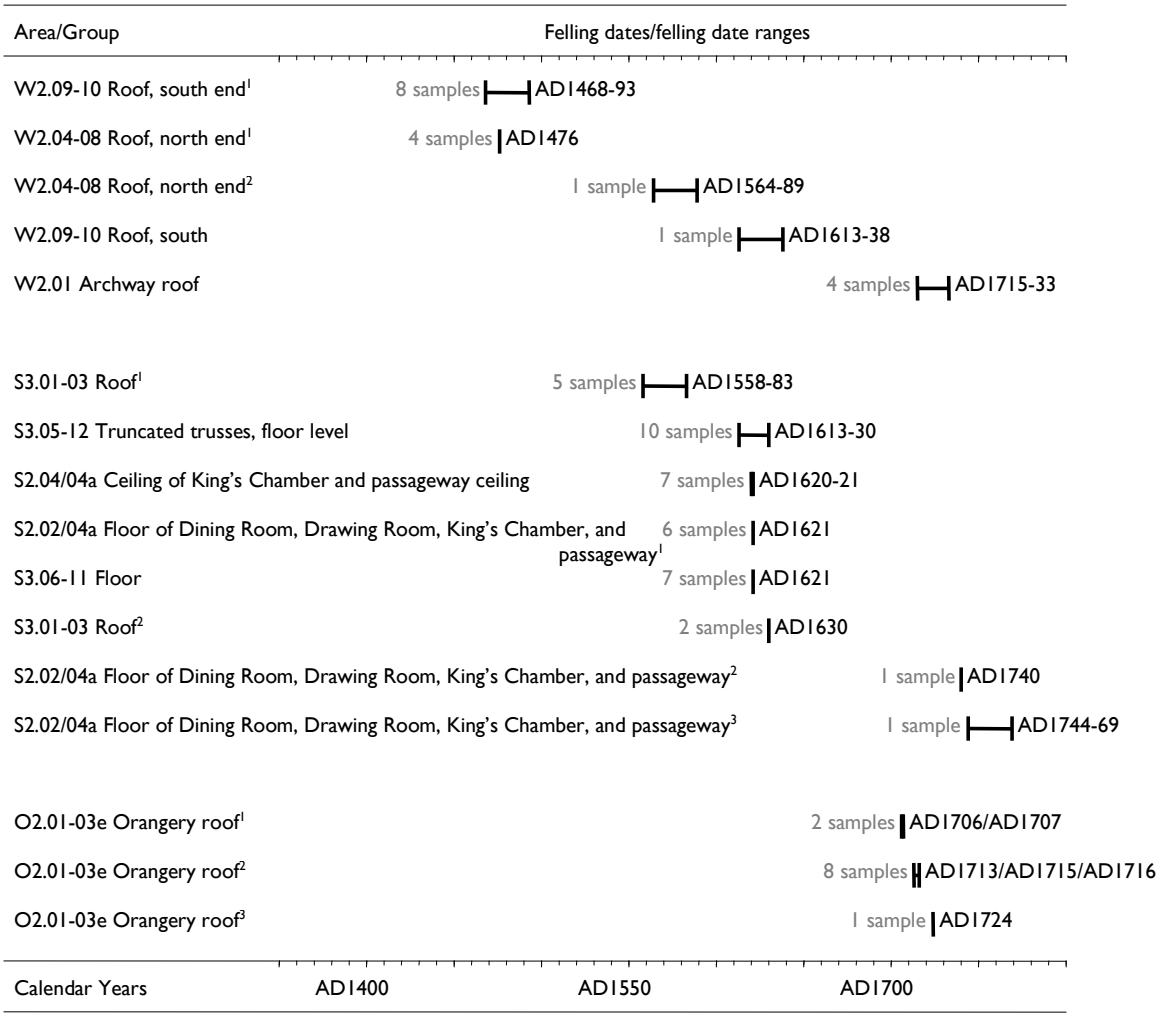
NB Area/Group labels followed by a number in superscript indicate that there is more than one group of timbers dated from that single Area and that those Groups have different felling dates

Figure 66: Summary of the felling dates obtained for the associated groups of timbers from the North range



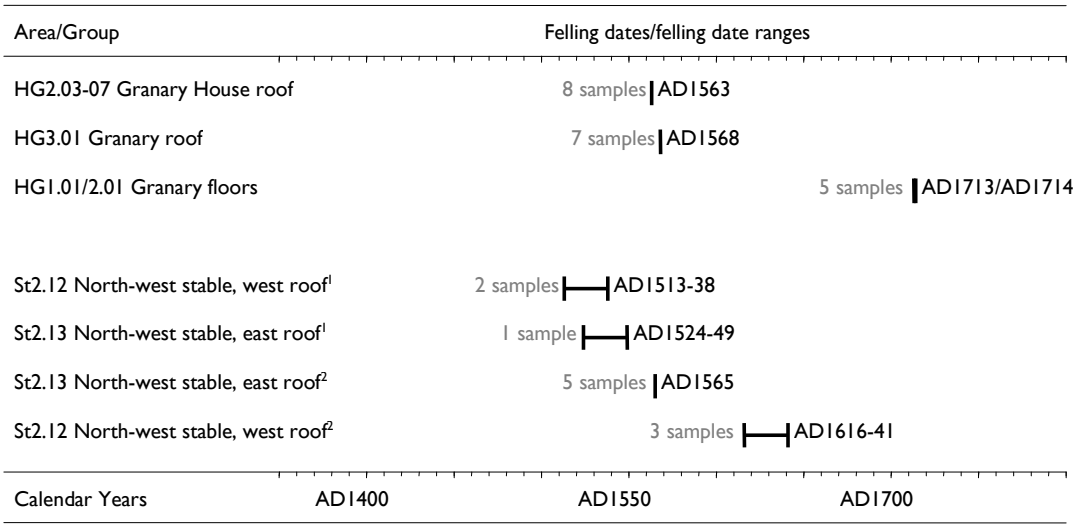
NB Area/Group labels followed by a number in superscript indicate that there is more than one group of timbers dated from that single Area and that those Groups have different felling dates

Figure 67: Summary of the felling dates obtained for the associated groups of timbers from the East range



NB Area/Group labels followed by a number in superscript indicate that there is more than one group of timbers dated from that single Area and that those Groups have different felling dates

Figure 68: Summary of the felling dates obtained for the associated groups of timbers from the West range, South range, and Orangery



NB Area/Group labels followed by a number in superscript indicate that there is more than one group of timbers dated from that single Area and that those Groups have different felling dates

Figure 69: Summary of the felling dates obtained for the associated groups of timbers from the Granary and Stables

NB Area/Group labels followed by a number in superscript indicate that there is more than one group of timbers dated from that single Area and that those Groups have different felling dates

Figure 70: Summary of the felling dates obtained for the associated groups of timbers from all ranges arranged in date order

TABLES

Table 1: Areas of Apethorpe Hall sampled for tree-ring dating

Rooms	Description	Samples	Figure
Hall Range			
H2.02	Floor	458–61	10
H2.03	Hall roof	119–24, 421–6	12 & 13
H2.04	Hall porch floor	125–7	10
H2.05	Matted Passage roof	39–46	15
H2.05	Matted Passage east wall	146–8*, 271–7	11
H2.06/07	Great Chamber/cross-wing roof	1–12	16–18
H2.10/11/12	Floors	441–52	11
H2.10/12	Old Parlour/cross-wing roof	13–22	18–20
H2.13	Lady Westmorland's room floor	261–8	11
H2.13	Lady Westmorland's room bay window ceiling	511–17	21
H2.14	Newel stair partition wall	81–4	11
H3.01	Cock Loft roof	85–90	14
H3.02	Roof adjacent to Cock Loft	91–8	14
North range			
N0.01	Cellar	281–8	26
N1.14	Kitchen ceiling	149–53	25
N2.01	Cottage roof	471, 472*, 473–80	28
N2.11	Old Kitchen roof	23–32	10
N2.12	Floor	491–4	10
N2.14/15	Old Dining Room roof	33–8	14
N2.15	Old Dining Room floor	431–9	10
N2.16–21	Floor	102–5	24
N2.16–21	Roof	99–101	23
N3.05	Gatehouse vice	47–51	22
N3.06	Library roof	401–14	22 & 27
East range			
E2.01	Long Gallery wall panelling	300–12, 501–8	*
E2.02	Floor adjacent to Oak Stair	211–12, 453–7	31
E3.01–13	Roof	52–59, 60–1*, 62	29 & 30
E3.01–13	Roof, east dormers	321–5	29 & 30
E3.01–13	Roof, reused timbers	331–42	29–30 & 33
E3.12	West roof off main roof	351–6	30 & 32
E3.07–11	Roof, west pitch common rafters	361–72	29 & 30
E3.10-13	Partition sills and door jambs	381–5	*
West range			
W2.01	Archway roof	481–8	35–37
W2.04–08	Roof, north end	138–45	34
W2.09–10	Roof, south end	128–37	34

South range			
S2.02-04a	Floor of Dining Room, Drawing Room, King's Chamber, and passageway	200–10	38
S2.04/04a	Ceiling of King's Chamber and passageway ceiling	154–66	41
S3.01–03	Roof	72–80	40
S3.05–12	Truncated trusses, floor level	63–71, 215	39
S3.06–11	Floor	250–8	39
Orangery			
O2.01–03e	Orangery roof	106–18	42
Granary			
HG1.01/2.01	Granary floors	176–80	43
HG3.01	Granary roof	181–88	46
HG2.03–07	Granary House roof	167–75	44 & 45
Stables			
St2.06–10	West stable range roof	240–7	47
St2.12	North-west stable, west roof	220–6	48
St2.13	North-west stable, east roof	231–7	48

* not shown

Table 2: Details of samples from Apethorpe Hall, Apethorpe, Northamptonshire

Sample number	Sample location	Total rings	Sapwood rings	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
	Great Chamber/cross-wing roof: H2.06/07					
APT-A01	South rafter, frame 3	65	h/s	1395	1459	1459
APT-A02	Collar, frame 3	70	10	1399	1458	1468
APT-A03	South rafter, frame 13	106	no h/s	1348	------	1453
APT-A04	South rafter, frame 15	87	h/s	1369	1455	1455
APT-A05	North rafter, frame 15	55	h/s	1405	1459	1459
APT-A06	North rafter, frame 18	57	no h/s	1393	------	1449
APT-A07	Collar, frame 23	74	h/s	1383	1456	1456
APT-A08	North rafter, frame 25	67	no h/s	1363	------	1429
APT-A09	Collar, frame 25	87	15	1387	1458	1473
APT-A10	North rafter, frame 19	64	11	1405	1457	1468
APT-A11	Collar, frame 13	92	2	1368	1457	1459
APT-A12	Collar, frame 11	80	7	1387	1459	1466
	Old Parlour/cross–wing roof: H2.10/12					
APT-A13	West rafter, frame 7	60	2	1395	1452	1454
APT-A14	East rafter, frame 8	81	h/s	1380	1460	1460
APT-A15	East rafter, frame 9	85	2	1367	1449	1451
APT-A16	East brace, frame 7	70	no h/s	1343	------	1412
APT-A17	West rafter, frame 9	91	no h/s	1341	------	1431
APT-A18	Collar, frame 7	65	h/s	1390	1454	1454
APT-A19	Collar, frame 11	54	no h/s	1390	------	1443
APT-A20	Collar, frame 13	74	no h/s	1374	------	1447
APT-A21	West rafter, frame 16	73	8	1396	1460	1468
APT-A22	West rafter, frame 21	92	no h/s	1353	------	1444
	Old Kitchen roof: N2.11					
APT-A23	South principal rafter, truss 1	105	13	1599	1690	1703
APT-A24	South principal rafter, truss 2	75	11	1626	1689	1700
APT-A25	South purlin truss 1–2, bay 2	76	8	1538	1605	1613
APT-A26	South common rafter 6, bay 2	68	11	1630	1686	1697
APT-A27	South common rafter 5, bay 2	43	h/s	------	------	------
APT-A28	North principal rafter, truss 1	88	11	1614	1690	1701
APT-A29	North principal rafter, truss 2	61	h/s	1629	1689	1689
APT-A30	North purlin, truss 1–2, bay 2	96	32C	1544	1607	1639
APT-A31	North common rafter 2, bay 2	62	12	1638	1687	1699
APT-A32	North common rafter 4, bay 2	57	10	1642	1689	1698
	Old Dining Room roof: N2.14/15					
APT-A33	East common rafter 2, bay 1	61	8	1555	1607	1615
APT-A34	East common rafter 5, bay 1	76	10	1540	1605	1615
APT-A35	West common rafter 2, bay 2	55	h/s	1568	1622	1622
APT-A36	East common rafter 3, bay 2	62	12	1556	1605	1617
APT-A37	West common rafter 6, bay 2	54	h/s	1565	1618	1618
APT-A38	West purlin, south gable to truss 1	54	4	------	------	------

	Matted Passage roof: H2.05					
APT-A39	West rafter, frame 4	80	25C	1613	1667	1692
APT-A40	East rafter, frame 1	91	23C	1600	1665	1690
APT-A41	West rafter, frame 3	93	16	1588	1664	1680
APT-A42	East rafter, frame 2	89	17C	1600	1671	1688
APT-A43	West rafter, frame 2	75	no h/s	1585	------	1659
APT-A44	East rafter, frame 3	nm	---	------	------	------
APT-A45	West rafter, frame 1	nm	---	------	------	------
APT-A46	East rafter, frame 4	51	no h/s	------	------	------
	Gatehouse vice: N3.05					
APT-A47	West south-west joist	54	h/s	1491	1544	1544
APT-A48	King post	nm	---	------	------	------
APT-A49	Main east–west base beam	112	16	1501	1596	1612
APT-A50	East north–east joist	56	h/s	1491	1546	1546
APT-A51	South cross-beam	64	14C	1621	1670	1684
	Roof: E3.01–13					
APT-A52	East principal rafter, truss 5	113	22	1505	1595	1617
APT-A53	East principal rafter, truss 8	98	17C	1524	1604	1621
APT-A54	East principal rafter, truss 9	80	h/s	1518	1597	1597
APT-A55	East principal rafter, truss 10	105	17	1505	1592	1609
APT-A56	West principal rafter, truss 13	113	13	1496	1595	1608
APT-A57	West common rafter, frame 99	57	10	1550	1596	1606
APT-A58	East principal rafter, truss 14	61	16	1635	1679	1695
APT-A59	West principal rafter, truss 15	86	9	1519	1595	1604
APT-A60	Main attic floor beam, truss 4–5	119	24C	1503	1597	1621
APT-A61	Main attic floor beam, truss 12	91	h/s	1505	1595	1595
APT-A62	East principal rafter, truss 1	65	no h/s	1484	------	1548
	Truncated trusses, floor level: S3.05–12					
APT-A63	Collar, truss 1	83	22	1530	1590	1612
APT-A64	North principal rafter, truss 2	85	h/s	1510	1594	1594
APT-A65	North principal rafter, truss 3	54	no h/s	1513	------	1566
APT-A66	North principal rafter, truss 4	123	h/s	1472	1594	1594
APT-A67	North principal rafter, truss 6	59	no h/s	1476	------	1534
APT-A68	North principal rafter, truss 7	58	no h/s	1477	------	1534
APT-A69	North principal rafter, truss 8	75	no h/s	1469	------	1543
APT-A70	North principal rafter, truss 9	84	no h/s	1461	------	1544
APT-A71	North principal rafter, truss 1	72	h/s	1509	1580	1580
	Roof: S3.01–03					
APT-A72	South principal rafter, half-truss	56	3	1483	1535	1538
APT-A73	North common rafter, frame 11	56	12	1498	1541	1553
APT-A74	South common rafter, frame 14	54	9	1499	1543	1552
APT-A75	South common rafter, frame 17	54	2	1503	1554	1556
APT-A76	South common rafter, frame 18	58	h/s	1487	1544	1544
APT-A77	West common rafter, frame 3	nm	---	------	------	------
APT-A78	West common rafter, frame 6	101	h/s	1507	1607	1607
APT-A79	West common rafter, frame 9	99	25C	1532	1605	1630
APT-A80	Purlin to south side	58	10	------	------	------
	Newel stair partition wall: H2.14					
APT-A81	Lower rail, south wall	55	16C	1505	1543	1559
APT-A82	Newel post	54	11	1506	1548	1559
APT-A83	Lower rail, west wall	54	5	1497	1545	1550
APT-A84	Top rail, west wall	64	3	1485	1545	1548

	Cock Loft roof: H3.01					
APT-A85	North common rafter, frame 5	84	18C	1476	1541	1559
APT-A86	North common rafter, frame 7	102	18C	1459	1542	1560
APT-A87	South common rafter, frame 1	nm	---	------	------	------
APT-A88	South common rafter, frame 5	79	no h/s	1446	------	1524
APT-A89	South common rafter, frame 8	61	h/s	1435	1495	1495
APT-A90	South common rafter, frame 11	72	25C	1489	1535	1560
	Roof adjacent to Cock Loft: H3.02					
APT-A91	North principal rafter, truss 1	76	no h/s	1459	------	1534
APT-A92	South common rafter 2, truss 1–2	nm	---	------	------	------
APT-A93	South common rafter 6, truss 1–2	40	h/s	1518	1557	1557
APT-A94	North common rafter 7, truss 1–2	54	11	1513	1555	1566
APT-A95	North principal rafter, truss 2	55	3	1493	1544	1547
APT-A96	South principal rafter, truss 2	70	3	1474	1540	1543
APT-A97	N common rafter 6, truss 2, w end	55	h/s	1505	1559	1559
APT-A98	S common rafter 7, truss 2, w end	62	12	1500	1549	1561
	Roof: N2.16–21					
APT-A99	South principal rafter, truss 2	54	h/s	------	------	------
APT-A100	Collar, truss 3	61	9	------	------	------
APT-A101	Collar, truss 2	nm	---	------	------	------
	Floor: N2.16–21					
APT-A102	North–south beam N2.21	nm	---	------	------	------
APT-A103	East–west beam N2.21	nm	---	------	------	------
APT-A104	North–south beam N2.18/19	42	no h/s	1502	------	1543
APT-A105	North–south beam N2.16/17	56	h/s	------	------	------
	Orangery roof: O2.01– 03e					
APT-A106	South 'purlin', bay 5	83	15C	1634	1701	1716
APT-A107	Cross-beam 5	82	8	1628	1701	1709
APT-A108	South 'purlin', bay 6	50	h/s	------	------	------
APT-A109	North 'purlin', bay 6	54	15C	1653	1691	1706
APT-A110	North 'purlin', bay 5	87	17C	1629	1698	1715
APT-A111	North joist, bay 4	54	12C	1660	1701	1713
APT-A112	North common rafter 4, bay 4	54	22C	1671	1702	1724
APT-A113	North common rafter 10, bay 6	56	15C	1652	1692	1707
APT-A114	North common rafter 11, bay 6	nm	---	------	------	------
APT-A115	South 'purlin', bay 2	77	20C	1640	1696	1716
APT-A116	Cross-beam 2	100	17C	1617	1699	1716
APT-A117	North 'purlin', bay 4	84	17C	1633	1699	1716
APT-A118	South 'purlin', bay 4	65	16C	1651	1699	1715
	Hall roof: H2.03					
APT-A119	West lower purlin, truss 3–4	nm	---	------	------	------
APT-A120	West archbrace, truss 3	nm	---	------	------	------
APT-A121	Collar, truss 3	nm	---	------	------	------
APT-A122	East queen strut, truss 5	46	5	1412	1452	1457
APT-A123	West queen strut, truss 5	40	no h/s	1397	------	1436
APT-A124	West principal rafter, truss 5	nm	---	------	------	------

	Hall porch floor: H2.04					
APT-A125	Joist 2	nm	---	------	------	------
APT-A126	Joist 3	nm	---	------	------	------
APT-A127	Joist 5	nm	---	------	------	------
	Roof, south end: W2.09–10					
APT-A128	West common rafter 3, bay 3	85	h/s	1366	1450	1450
APT-A129	East common rafter 1, bay 3	82	h/s	1370	1451	1451
APT-A130	East principal rafter, truss 2	89	no h/s	1351	------	1439
APT-A131	East common rafter 2, bay 2	61	h/s	1394	1454	1454
APT-A132	East common rafter 1, bay 2	55	h/s	1406	1460	1460
APT-A133	West principal rafter, truss 3	86	h/s	1371	1456	1456
APT-A134	West common rafter 2, bay 2	54	h/s	------	------	------
APT-A135	East common rafter 2, bay 3	86	h/s	1364	1449	1449
APT-A136	West common rafter 1, bay 4	67	h/s	1532	1598	1598
APT-A137	East upper purlin, bay 3	55	no h/s	1330	------	1384
	Roof, north end: W2.04–08					
APT-A138	West upper purlin, bay 7	78	17C	1399	1459	1476
APT-A139	East upper purlin, bay 7	69	h/s	1398	1466	1466
APT-A140	West common rafter 4, bay 7	44	h/s	1506	1549	1549
APT-A141	West principal rafter, truss 6	68	h/s	1390	1457	1457
APT-A142	East upper purlin, bay 9	74	h/s	1387	1460	1460
APT-A143	East common rafter 5, bay 9	nm	---	------	------	------
APT-A144	East common rafter 4, bay 9	nm	---	------	------	------
APT-A145	East common rafter 1, bay 10	nm	---	------	------	------
	Matted passage east wall: H2.05					
APT-A146	South stud	51	h/s	1641	1691	1691
APT-A147	Main post	nm	---	------	------	------
APT-A148	East wall	108	no h/s	------	------	------
	Kitchen ceiling: N1.14					
APT-A149	West main beam	nm	---	------	------	------
APT-A150	East main beam	nm	---	------	------	------
APT-A151	Common joist 1	nm	---	------	------	------
APT-A152	Common joist 3	nm	---	------	------	------
APT-A153	Common joist 4	54	no h/s	1556	------	1609
	Ceiling of King's Chamber and passageway ceiling: S2.04/04a					
APT-A154	Joist 3	nm	---	------	------	------
APT-A155	Joist 6	66	19c	1554	AD 1600	1619
APT-A156	Joist 9	nm	---	------	------	------
APT-A157	Joist 2	57	h/s	1545	1601	1601
APT-A158	Joist 4	nm	---	------	------	------
APT-A159	Joist 5	nm	---	------	------	------
APT-A160	Joist 8	40	no h/s	------	------	------
APT-A161	Joist 9	59	no h/s	1527	------	1585
APT-A162	Joist 13	57	h/s	1543	1599	1599
APT-A163	Joist 14	55	h/s	1546	1600	1600
APT-A164	Joist 15	56	h/s	1546	1601	1601
APT-A165	Joist 16	55	h/s	1542	1596	1596
APT-A166	Joist 17	nm	---	------	------	------

	Granary House roof: HG2.03–07					
APT-A167	East purlin, truss 1–2	84	19C	1480	1544	1563
APT-A168	West purlin, truss 1–2	79	6	1471	1543	1549
APT-A169	Collar, truss 2	70	h/s	1474	1543	1543
APT-A170	East queen strut, truss 2	55	h/s	1500	1554	1554
APT-A171	Collar, truss 3	73	h/s	1474	1546	1546
APT-A172	West common rafter 2, bay 3	nm	---	------	------	------
APT-A173	West common rafter 6, bay 3	61	h/s	1486	1546	1546
APT-A174	West purlin, truss 3–4	56	no h/s	1465	------	1520
APT-A175	Collar, truss 4	40	h/s	1519	1558	1558
	Granary floors: HG1.01/2.01					
APT-A176	N-S beam (east), 1st floor	98	23C	1616	1690	1713
APT-A177	E-W beam, bay 2, 1st floor	107	25C	1608	1689	1714
APT-A178	N-S beam (west), 1st floor	63	16	1649	1695	1711
APT-A179	N-S beam (west), ground floor	92	4	1605	1691	1696
APT-A180	E-W beam, bay 3, ground floor	124	7	1574	1690	1697
	Granary roof: HG3.01					
APT-A181	N brace/strut, truss 1 (east/rear)	73	h/s	1477	1549	1549
APT-A182	N principal rafter, truss 2 (middle)	58	h/s	1486	1543	1543
APT-A183	Tiebeam, truss 1	54	h/s	------	------	------
APT-A184	South principal rafter, truss 1	41	h/s	1501	1541	1541
APT-A185	South principal rafter, truss 2	59	h/s	1482	1540	1540
APT-A186	North purlin, truss 2–3	64	6	1492	1549	1555
APT-A187	South purlin, truss 2–3	62	20C	1507	1548	1568
APT-A188	N principal, truss 3 (west/front)	54	h/s	1495	1548	1548
	Floor of Dining Room, Drawing Room, King's Chamber and passageway: S2.02–04a					
APT-A200	West main joist to fireplace, S2.02	75	h/s	------	------	------
APT-A201	Main joist to S2.04/04a	126	26C	1496	1595	1621
APT-A202	West main joist to fireplace, S2.03	55	h/s	------	------	------
APT-A203	Main joist to party wall, S2.03/04	120	17C	1502	1604	1621
APT-A204	Common joist, S2.03	92	no h/s	1476	------	1567
APT-A205	East main joist to fireplace, S2.03	86	h/s	1519	1604	1604
APT-A206	Common joist, S2.03	56	h/s	1674	1729	1729
APT-A207	Common joist, S2.03	73	27C	1549	1594	1621
APT-A208	Common joist, S2.03	75	23C	1666	1717	1740
APT-A209	Common joist, S2.03	75	h/s	1527	1601	1601
APT-A210	Common joist, S2.03	nm	---	------	------	------
	Floor adjacent to Oak Stair: E2.02					
APT-A211	Stair beam	102	h/s	1505	1606	1606
APT-A212	Trimmer beam	127	16C	1494	1604	1620
	Truncated trusses, floor level: S3.05–12					
APT-A215	Collar, truss 9	155	no h/s	1370	------	1524

	North-west stable, west roof: St2.12					
APT-A220	South principal rafter, main truss	101	h/s	1497	1597	1597
APT-A221	S purlin, main truss to east end	62	no h/s	1446	------	1507
APT-A222	S purlin, main truss to west end	64	h/s	1435	1498	1498
APT-A223	South common rafter 2, bay 1	55	h/s	------	------	------
APT-A224	South common rafter 5, bay 1	75	h/s	1530	1604	1604
APT-A225	South common rafter 2, bay 2	78	no h/s	1513	------	1590
APT-A226	South common rafter 3, bay 2	49	h/s	------	------	------
	North-west stable, east roof: St2.13					
APT-A231	Tiebeam, truss 3 (west side)	76	6	1471	1546	1546
APT-A232	North queen strut, truss 3	75	h/s	------	------	------
APT-A233	N purlin truss 1–2 (east-middle)	99	h/s	1441	1539	1539
APT-A234	South purlin, truss 1–2	87	h/s	1455	1541	1541
APT-A235	N purlin, truss 2–3 (middle-west)	104	no h/s	1431	------	1534
APT-A236	South purlin, truss 2–3	107	h/s	1403	1509	1509
APT-A237	Tiebeam truss 1 (east, by door)	84	16C	1482	1549	1565
	West stable range roof: St2.06–10					
APT-A240	East principal rafter, truss 4	nm	---	------	------	------
APT-A241	East common rafter 3, bay 3	nm	----	------	------	------
APT-A242	West principal rafter, truss 4	nm	---	------	------	------
APT-A243	East common rafter 2, bay 3	nm	---	------	------	------
APT-A244	West common rafter 3, bay 4	nm	---	------	------	------
APT-A245	East principal rafter, truss 3	nm	---	------	------	------
APT-A246	East common rafter 3, bay 2	nm	---	------	------	------
APT-A247	West common rafter 6, bay 1	nm	---	------	------	------
	Floor: S3.06–11					
APT-A250	S3.10. Joist 1	58	22C	1564	AD 1599	1621
APT-A251	S3.06. Joist 5	67	no h/s	1468	------	1534
APT-A252	S3.06. Joist 6	60	6	------	------	------
APT-A253	S3.10. Joist 3	88	no h/s	1501	------	1588
APT-A254	S3.10. Joist 4	46	2	1564	1607	1609
APT-A255	S3.11. Joist 1	56	no h/s	1505	------	1560
APT-A256	S3.11. Joist 2	56	no h/s	1505	------	1560
APT-A257	S3.11. Joist 3	nm	---	------	------	------
APT-A258	S3.11. Joist 5	52	no h/s	1506	------	1557
	Lady Westmorland's room floor: H2.13					
APT-A261	Joist 1	58	no h/s	1391	------	1448
APT-A262	Joist 2	72	h/s	1429	1500	1500
APT-A263	Joist 3	nm	---	------	------	------
APT-A264	Joist 4	84	h/s	1413	1496	1496
APT-A265	Joist 5	70	no h/s	1391	------	1460
APT-A266	Joist 6	83	no h/s	1380	------	1462
APT-A267	Joist 7	91	h/s	1407	1497	1497
APT-A268	Joist 8	90	h/s	1408	1497	1497

	Matted passage east wall: H2.05					
APT-A271	Stud post 1	63	21C	1629	1670	1691
APT-A272	Stud post 2	nm	---	------	------	------
APT-A273	Stud post 3	71	no h/s	1594	------	1664
APT-A274	Stud post 4	nm	---	------	------	------
APT-A275	Stud post 5	107	14C	1576	1668	1682
APT-A276	Stud post 6	44	17C	1648	1674	1691
APT-A277	Stud post 7	nm	---	------	------	------
	Cellar: N0.01					
APT-A281	Main N-S beam	57	5	1514	1565	1570
APT-A282	Main E-W beam	82	no h/s	1459	------	1540
APT-A283	West joist 3	55	h/s	1499	1553	1553
APT-A284	West joist 4	49	no h/s	1494	------	1542
APT-A285	West joist 5	71	no h/s	1479	------	1549
APT-A286	West joist 7	80	h/s	1476	1555	1555
APT-A287	West joist 10	65	15	1505	1554	1569
APT-A288	West joist 12	58	5	1503	1555	1560
	Long Gallery wall panelling: E2.01					
APT-A300	No code seen	100	no h/s	------	------	------
APT-A301	Panel F88	153	3	------	------	------
APT-A302	Panel W1 RH1	128	no h/s	1439	------	1566
APT-A303	Panel 8	112	2	1503	1612	1614
APT-A304	Panel F90	96	h/s	------	------	------
APT-A305	Panel W1 RH5	105	no h/s	1433	------	1537
APT-A306	Panel W1 RH2	160	no h/s	------	------	------
APT-A307	Board W11	70	no h/s	1526	------	1595
APT-A308	Column 8	64	no h/s	1520	------	1583
APT-A309	Column 12a	59	no h/s	1548	------	1606
APT-A310	Column 12b	48	no h/s	1564	------	1611
APT-A311	No code seen	84	no h/s	1524	------	1607
APT-A312	Panel G92–98	73	no h/s	1535	------	AD 1607
	Roof, east dormers: E3.01–13					
APT-A321	Sill beam below dormer 4	84	19C	1611	1675	1694
APT-A322	Sill beam below dormer 5–6	43	no h/s	1620	------	1662
APT-A323	Sill beam below dormer 7	nm	---	------	------	------
APT-A324	Sill beam below dormer 8–9	48	no h/s	1650	------	1697
APT-A325	Sill beam below dormer 3	nm	---	------	------	------
	Roof, reused timbers: E3.01–13					
APT-A331	West principal rafter, truss 14	68	3	1539	1603	1606
APT-A332	Collar, truss 11	78	h/s	1527	1604	1604
APT-A333	West principal rafter, truss 11	119	26C	1503	1595	1621
APT-A334	Collar, truss 10	98	9	1513	1601	1610
APT-A335	Collar, truss 9	109	14	1506	1600	1614
APT-A336	Collar, truss 8	130	17	1483	1595	1612
APT-A337	Collar, truss 7	115	22C	1506	1598	1620
APT-A338	Collar, truss 6	91	no h/s	1502	------	1592
APT-A339	West principal rafter, truss 6	99	h/s	1510	1608	1608
APT-A340	Collar, truss 5	116	27C	1506	1594	1621
APT-A341	West principal rafter, truss 4	112	15	1497	1593	1608
APT-A342	Collar, truss 4	72	no h/s	1484	------	1555

	West roof off main roof: E3.12					
APT-A351	South common rafter, frame 1	70	h/s	------	------	------
APT-A352	South common rafter, frame 2	55	h/s	1509	1563	1563
APT-A353	South common rafter, frame 3	76	6	1500	1569	1575
APT-A354	South common rafter, frame 4	61	h/s	------	------	------
APT-A355	South common rafter, frame 5	72	h/s	------	------	------
APT-A356	South common rafter, frame 6	77	h/s	------	------	------
	Roof, west pitch common rafters: E3.07–13					
APT-A361	Rafter, frame 26	54	h/s	1627	1680	1680
APT-A362	Rafter, frame 25	55	h/s	------	------	------
APT-A363	Rafter, frame 24	55	h/s	1632	1686	1686
APT-A364	Rafter, frame 5	59	5	1620	1673	1678
APT-A365	Rafter, frame 2	nm	---	------	------	------
APT-A366	Rafter, frame 27	54	h/s	1616	1669	1669
APT-A367	Rafter, frame 29	56	10	------	------	------
APT-A368	Rafter, frame 32	58	h/s	1613	1670	1670
APT-A369	Rafter, frame 54	nm	---	------	------	------
APT-A370	Rafter, frame 53	nm	---	------	------	------
APT-A371	Rafter, frame 55	nm	---	------	------	------
APT-A372	Rafter, frame 61	55	h/s	------	------	------
	Partition sills and door jambs: E3.10–13					
APT-A381	Central door, north jamb	76	14	1553	1614	1628
APT-A382	Central door, south jamb	nm	---	------	------	------
APT-A383	Partition sill, south beam	86	21C	1537	1601	1622
APT-A384	Partition sill, middle beam	nm	---	------	------	------
APT-A385	Partition sill, north beam	nm	---	------	------	------
	Library roof: N3.06					
APT-A401	South principal rafter, truss 1	78	2	1647	1722	1724
APT-A402	North queen strut, truss 1	48	h/s	1673	1720	1720
APT-A403	North purlin, truss 1–2	73	no h/s	1610	------	1682
APT-A404	South purlin, truss 1–2	93	h/s	1625	1717	1717
APT-A405	South common rafter 4, bay 1	95	24C	1644	1714	1738
APT-A406	North common rafter 7, bay 1	91	23C	1648	1715	1738
APT-A407	North purlin, truss 2–3	116	17C	1622	1720	1737
APT-A408	South purlin, truss 2–3	108	19C	1630	1718	1737
APT-A409	South common rafter 7, bay 2	74	24C	1666	1715	1739
APT-A410	North principal rafter, truss 3	109	19C	1630	1719	1738
APT-A411	South principal rafter, truss 3	96	no h/s	1618	------	1713
APT-A412	North common rafter 4, bay 3	78	no h/s	1638	------	1715
APT-A413	North common rafter 6, bay 3	98	15	1631	1713	1728
APT-A414	North purlin, truss 3–4	97	no h/s	1613	------	1709
	Hall roof: H2.03					
APT-A421	S lower windbrace, east bay 1	84	no h/s	1346	------	1429
APT-A422	Collar, truss 4	71	no h/s	1357	------	1427
APT-A423	East archbrace, truss 2	61	no h/s	1376	------	1436
APT-A424	East queen strut, truss 4	63	2	1389	1449	1451
APT-A425	West queen strut, truss 3	72	no h/s	1379	------	1450
APT-A426	West queen strut, truss 2	62	no h/s	1337	------	1398

	Old Dining Room floor: N2.15					
APT-A431	East joist 4	88	no h/s	1309	------	1396
APT-A432	East joist 6	88	h/s	1362	1449	1449
APT-A433	East joist 8	103	2	1350	1450	1452
APT-A434	West joist 7	157	5	1303	1454	1459
APT-A435	East joist 10	150	no h/s	1292	------	1441
APT-A436	East joist 14	61	18C	1409	1451	1469
APT-A437	West joist 3	63	9	1396	1449	1458
APT-A438	West joist 4	nm	---	------	------	------
APT-A439	West joist 6	nm	---	------	------	------
	Floors: H2.10/11/12					
APT-A441	Joist 4, H2.10	51	h/s	------	------	------
APT-A442	Joist 5, H2.10	60	21	1408	1446	1467
APT-A443	Joist 7, H2.10	56	no h/s	------	------	------
APT-A444	Joist 8, H2.10	52	7	1417	1461	1468
APT-A445	Cross beam, H2.11	54	h/s	1470	1535	1535
APT-A446	West beam, H2.11	54	h/s	1485	1538	1538
APT-A447	East beam, H2.11	57	no h/s	------	------	------
APT-A448	Joist 3, H2.11	nm	---	------	------	------
APT-A449	Joist 4, H2.12	54	no h/s	1422	------	1475
APT-A450	Joist 5, H2.12	55	no h/s	1424	------	1478
APT-A451	Joist 6, H2.12	42	12	1417	1446	1458
APT-A452	Joist 7, H2.12	54	16	1411	1448	1464
	Floor adjacent to Oak Stair: E2.02					
APT-A453	Joist 4	nm	---		------	
APT-A454	Joist 5	nm	---	------	------	------
APT-A455	Joist 7	nm	---		------	
APT-A456	Joist 8	nm	---	------	------	------
APT-A457	Joist 9	nm	---	------	------	------
	Floor: H2.02					
APT-A458	Joist 1	nm	---	------	------	------
APT-A459	Joist 2	nm	---	------	------	------
APT-A460	Joist 3	nm	---	------	------	------
APT-A461	Joist 4	nm	---	------	------	------
	Cottage roof: N2.01					
APT-A471	North principal rafter, truss 1	51	11	1677	1716	1727
APT-A472	South upper purlin, truss 1–2	nm	---	------	------	------
APT-A473	North principal rafter, truss 2	51	h/s	1668	1718	1718
APT-A474	South principal rafter, truss 2	62	11	1663	1713	1724
APT-A475	Tiebeam, truss 2	47	no h/s	1645	------	1691
APT-A476	North principal rafter, truss 3	nm	---	------	------	------
APT-A477	South principal rafter, truss 3	68	h/s	1636	1703	1703
APT-A478	Tiebeam, truss 3	58	h/s	1643	1700	1700
APT-A479	North common rafter 5 bay 3	54	h/s	1502	1555	1555
APT-A480	North common rafter 6 bay 3	60	h/s	1468	1527	1527

	Archway roof: W2.01					
APT-A481	Collar, south truss	62	10	1640	1691	1701
APT-A482	Collar, middle truss	54	14	1654	1693	1707
APT-A483	West common rafter 7	44	h/s	------	------	------
APT-A484	East common rafter 12	40	20	1674	1693	1713
APT-A485	East common rafter 13	nm	---	------	------	------
APT-A486	West common rafter 16	47	21	1668	1693	1714
APT-A487	Ceiling beam N1.11	nm	---	------	------	------
APT-A488	Ceiling beam N2.04/5	nm	---	------	------	------
	Floor: N2.12					
APT-A491	Joist 3	67	no h/s	1457	------	1523
APT-A492	Joist 1	66	h/s	1470	1535	1535
APT-A493	Joist 2	58	h/s	1472	1529	1529
APT-A494	Joist 4	53	no h/s	1461	------	1513
	Long Gallery wall panelling: E2.01					
APT-A501	Column 26	55	11	1563	1606	1617
APT-A502	Column 23	63	no h/s	1530	------	1592
APT-A503	Column 15	81	6	1532	1606	1612
APT-A504	Column 8	78	no h/s	1529	------	1606
APT-A505	Column 28	88	no h/s	1521	------	1608
APT-A506	Column 12	80	no h/s	1498	------	1577
APT-A507	Column 29	96	no h/s	1507	------	1602
APT-A508	Column 13	70	no h/s	1526	------	1595
	Lady Westmorland's room bay window ceiling: H2.13					
APT-A511	Joist 1 (from east)	44	no h/s	1693	------	1736
APT-A512	Joist 2	nm	---	------	------	------
APT-A513	Joist 3	nm	---	------	------	------
APT-A514	Joist 6	nm	---	------	------	------
APT-A515	Joist 7	52	h/s	1698	1749	1749
APT-A516	Outer main ceiling beam	64	h/s	1684	1747	1747
APT-A517	Inner main ceiling beam	49	h/s	1698	1746	1746

Table 3: Results of the cross-matching of site chronology APTASQ01 and relevant reference chronologies when first ring date is AD 1292 and last ring date is AD 1639

Reference chronology	Span of chronology	*t*-value	Reference
Chicksands Priory, Chicksands, Bedfordshire	AD 1200–1541	12.4	Howard *et al* 1998
Oakham Castle, Oakham, Rutland	AD 1383–1620	12.4	Arnold and Howard 2013
Kingsbury Hall, Kingsbury, Warwickshire	AD 1391–1564	10.8	Arnold *et al* 2006
Willington Dovecote, Bedfordshire	AD 1394–1542	10.7	Miles and Worthington 1998
Hays Wharf, Southwark, London	AD 1248–1647	10.6	Tyers 1996a; 1996b
Stoneleigh Abbey, Stoneleigh, Warwickshire	AD 1398–1658	10.0	Howard *et al* 2000
Sinai Park, nr Burton, Staffordshire	AD 1227–1750	9.9	Tyers 1997
St Andrews Church, Wimpole, Cambridgeshire	AD 1469–1615	9.9	Bridge 1998
Black Ladies, Brewood, Staffordshire	AD 1372–1671	9.4	Tyers 1999
Polesworth Abbey Gatehouse, Polesworth, Warwickshire	AD 1446–1582	8.9	Arnold and Howard 2007

Table 4: Results of the cross-matching of site chronology APTASQ02 and relevant reference chronologies when first ring date is AD 1574 and last ring date is AD 1749

Reference chronology	Span of chronology	*t*-value	Reference
South Luffenham Hall, Leicestershire	AD 1594–1709	9.1	Arnold *et al* 2002 unpubl
Lyddington Bed House, Lyddington, Rutland	AD 1645–1744	11.7	Arnold *et al* forthcoming
Croome Court, Croome D'Abitot, Worcestershire	AD 1639–1753	11.3	Arnold *et al* 2004a
Oakham Castle, Oakham, Rutland	AD 1598–1737	11.0	Arnold and Howard 2013
Claydon House, Middle Claydon, Buckinghamshire	AD 1613–1756	10.3	Tyers 1995
De Grey Mausoleum, Flitton, Bedfordshire	AD 1510–1726	10.2	Arnold *et al* 2003
Old Barn, Shottery, Stratford-upon-Avon, Warwickshire	AD 1591–1735	9.4	Howard *et al* 1996
Wren Wing, Easton Neston, Northamptonshire	AD 1468–1686	9.4	Arnold and Howard 2007 unpubl
Chapter House roof, Worcester Cathedral, Worcestershire	AD 1558–1660	9.2	Arnold *et al* 2004b

Table 5: Summary of the results allowing comparison between the expected date based on documentary and survey evidence as at 2008 and the dendrochronologically derived dating evidence

Rooms	Description	Samples	Expected date (AD)	Felling date (AD)
Hall Range				
H2.02	Floor	458–61		no date
H2.03	Hall roof	119–24 421–6	*c* 1480–1500	1466–91
H2.04	Hall porch floor	125–7	*c* 1480–1500	no date
H2.05	Matted Passage roof	39–46	*c* 1560s	1688, 1690, 1692
H2.05	Matted Passage east wall	146–8 271–7	*c* 1560s	1682, 1691, 1706–31
H2.06/07	Great Chamber/cross-wing roof	1–12	16th century	1474–98
H2.10/11/12	Floors	441–52	-	1468–87, 1476–1501, after 1493, 1552–77
H2.10/12	Old Parlour/cross-wing roof	13–22	16th century	1470–95
H2.13	Lady Westmorland's room floor	261–8	-	1513–38
H2.13	Lady Westmorland's room bay window ceiling	511–7	16th century?	1762–87
H2.14	Newel stair partition wall	81–4	*c* 1560s	1559, 1561–86
H3.01	Cock Loft roof	85–90	16th century	1510–35, 1559, 1560
H3.02	Roof adjacent to Cock Loft	91–8	16th century	1567-91
North range				
N0.01	Cellar	281–8	-	1570–94, 1580–1605
N1.14	Kitchen ceiling	149–53	-	after 1624
N2.01	Cottage roof	471–80	-	1542–67, 1570–95, 1717–42, 1731–56
N2.11	Old Kitchen roof	23–32	17th century	1639, 1704–28
N2.12	Floor	491–4	-	1547–72
N2.14/15	Old Dining Room roof	33–8	*c* 1550–1630	1621–46, 1635–60
N2.15	Old Dining Room floor	431–9	-	1469
N2.16–21	Floor	102–5	-	after 1558
N2.16–21	Roof	99–101	-	no date
N3.05	Gatehouse vice	47–51	16th century	1560–85, 1613–36, 1684
N3.06	Library roof	401–14	-	1737, 1738, 1739

East range				
E2.01	Long Gallery wall panelling	300–12 501–8	-	1623–48
E2.02	Floor adjacent to Oak Stair	211–2 453–7	-	1620, 1621–46
E3.01–13	Roof	52–62	*c* 1620s	1621, 1696–1719
E3.01–13	Roof, east dormers	321–5	-	1694, after 1712
E3.01–13	Roof, reused timbers	331–42	-	1620, 1621
E3.07–13	Roof, west pitch common rafters	361–72	-	1691–1716
E3.12	West roof off main roof	351–6	-	1581–1606
E3.10-13	Partition sills and door jambs	381–5	-	1622, 1629–54
West range				
W2.01	Archway roof	481–8	-	1715–33
W2.04–08	Roof, north end	138–45	16th century	1476, 1564–89
W2.09-10	Roof, south end	128–37	16th century	1468–93, 1613–38
South range				
S2.02-04a	Floor of Dining Room, Drawing Room, King's Chamber and passageway	200–210	-	1621, 1740, 1744–69
S2.04/04a	Ceiling of King's Chamber and passageway ceiling	154–66	-	1620–1
S3.01–03	Roof	72–80	17th century	1558–83, 1630
S3.05–12	Truncated trusses, floor level	63–71 215	*c* 1620s	1613–30
S3.06–11	Floor	250–8	-	1621
Orangery				
O2.01–03e	Orangery roof	106–18	*c* 1718	1706, 1707, 1713, 1715, 1716, 1724
Granary				
HG1.01/2.01	Granary floors	176–80	16th century	1713, 1714
HG3.01	Granary roof	181–8	16th century	1568
HG2.03–07	Granary House roof	167–75	-	1563
Stables				
St2.06–10	West stable range roof	240–7	-	no date
St2.12	North-west stable, west roof	220–6	-	1513–38, 1616–41
St2.13	North-west stable, east roof	231–7	-	1524-49, 1565

DATA OF MEASURED SAMPLES

Measurements in 0.01mm units

APT-A01A 65
235 285 285 323 269 271 241 272 352 260 224 197 223 187 221 167 153 134 128 95
113 110 91 158 155 240 200 202 336 332 163 159 185 221 258 197 220 347 240 185
186 175 175 188 232 230 226 227 310 395 267 211 149 146 179 170 195 151 172 163
162 189 188 189 175
APT-A01B 65
259 291 277 340 263 270 248 297 358 269 206 207 218 192 232 161 163 139 126 101
109 111 82 163 157 244 198 199 336 333 152 159 196 205 259 195 222 350 250 183
193 174 173 185 231 214 267 188 331 401 239 201 158 147 170 178 205 156 171 157
166 184 204 202 180
APT-A02A 70
316 320 310 347 330 262 290 402 318 407 372 286 327 389 332 228 281 284 299 310
264 404 259 333 314 328 209 291 415 420 343 355 286 444 242 306 228 223 239 290
210 195 207 220 233 309 194 211 211 234 206 178 180 189 216 170 161 216 234 203
220 247 288 194 213 231 252 211 177 200
APT-A02B 70
309 311 295 334 329 285 291 417 323 379 372 303 309 391 330 230 279 312 303 297
257 387 267 330 284 330 230 307 398 423 334 353 288 428 247 301 239 218 237 287
202 213 206 209 234 298 213 197 220 231 214 185 187 180 201 151 180 191 245 191
218 233 282 209 205 239 239 214 177 201
APT-A03A 106
296 249 251 355 227 192 191 171 252 157 126 175 138 93 167 150 124 109 76 61
89 80 90 52 58 59 87 57 63 130 128 75 165 148 117 149 110 141 143 177
208 133 94 75 74 104 96 80 126 95 83 113 141 124 110 179 97 86 90 62
66 118 52 54 76 92 59 84 81 40 61 60 76 76 132 108 90 71 73 93
103 111 94 90 143 92 72 68 99 103 92 84 72 79 66 97 107 68 47 70
38 49 59 76 59 100
APT-A03B 106
294 253 259 358 218 198 186 178 250 163 129 183 131 97 153 156 136 97 74 65
82 87 71 70 61 61 93 61 63 127 132 89 173 144 159 141 111 145 141 187
218 132 80 80 79 98 89 86 130 91 81 115 132 130 104 174 81 82 96 75
70 111 60 61 76 90 51 74 85 33 51 64 75 94 121 106 96 66 85 90
104 107 89 87 147 82 79 73 97 102 84 97 69 72 66 85 131 81 56 54
45 53 49 76 69 93
APT-A04A 87
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200 138 176 115 117 123 113 165 85 107 129 148 111 120 160 132 122 135 97 116
111 69 76 88 98 113 105 98 73 118 83 146 81 93 134 106 71 57 86 109
112 80 95 133 89 63 85 67 85 89 85 72 90 71 123 117 75 60 67 46
61 78 87 114 94 77 102
APT-A04B 87
428 312 236 355 311 309 222 269 349 255 229 248 225 184 182 121 167 146 186 253
187 136 173 111 131 122 129 149 109 109 142 152 116 119 157 127 122 137 95 132
106 78 63 94 94 115 101 99 71 118 92 134 96 89 127 109 67 48 90 123
119 84 72 139 89 63 80 73 97 89 76 77 93 82 100 124 81 75 54 59
61 67 96 106 95 76 101

APT-A05A 55
146 144 112 209 167 90 70 133 116 138 124 148 114 224 109 206 128 180 195 150
122 110 109 110 136 149 240 268 160 150 134 125 183 170 179 190 196 174 180 182
127 100 121 90 100 178 184 139 123 161 166 152 176 181 185
APT-A05B 55
191 159 124 186 157 91 56 108 114 191 169 135 102 196 120 215 115 165 201 136
125 120 102 123 140 155 232 268 154 129 143 123 186 180 172 196 220 159 176 178
126 102 110 88 99 173 193 143 111 159 159 158 174 175 179
APT-A06A 57
187 130 153 156 157 172 166 176 166 174 194 161 156 171 147 179 208 104 116 152
185 130 114 143 138 118 128 140 146 122 156 152 140 113 138 111 121 121 107 150
112 72 102 75 131 123 134 150 128 115 146 192 125 166 122 170 189
APT-A06B 57
161 135 150 150 157 177 166 167 162 168 200 165 151 181 149 172 205 100 118 144
183 119 124 140 140 106 128 151 156 118 143 155 137 109 145 117 123 111 114 149
124 65 91 85 126 127 145 148 128 108 152 186 142 159 130 169 197
APT-A07A 74
175 101 167 298 334 422 311 382 320 279 303 207 223 236 217 253 316 294 211 259
267 245 271 305 240 340 360 261 251 358 283 184 256 242 254 309 244 348 253 304
300 308 212 246 312 424 409 308 306 412 219 247 192 202 246 269 201 234 220 225
261 287 230 225 225 244 220 138 161 159 165 128 129 159
APT-A07B 74
200 89 166 310 336 406 325 373 324 260 304 218 207 239 207 276 299 300 224 311
287 282 282 307 234 355 330 242 250 304 274 192 244 258 253 315 243 353 233 314
298 319 204 241 296 429 384 298 271 398 204 254 197 208 225 279 198 231 239 226
244 293 217 242 222 244 206 143 169 155 166 106 136 157
APT-A08A 67
399 381 261 139 81 127 189 178 144 177 137 228 175 141 262 323 239 353 267 338
294 152 242 364 300 230 124 83 91 79 108 114 105 134 122 89 152 171 162 131
163 117 129 133 88 103 122 50 57 114 121 174 141 134 80 68 81 130 123 137
137 133 88 74 119 167 197
APT-A08B 67
443 392 249 145 90 122 201 138 139 185 143 229 186 154 256 321 249 355 274 325
301 158 232 337 301 261 118 95 96 80 106 122 102 134 101 116 147 178 167 134
177 119 123 126 89 95 132 49 63 96 137 166 136 128 68 80 70 133 123 146
125 127 91 58 138 176 196
APT-A09A 87
150 175 131 113 98 69 49 84 98 96 55 75 92 55 67 68 106 145 119 150
106 160 166 129 95 117 208 159 156 134 114 132 114 185 116 161 236 167 131 157
210 171 149 152 204 208 140 150 128 91 137 181 170 202 285 292 328 237 220 211
145 119 111 155 156 144 151 147 129 151 183 201 169 216 239 230 211 156 151 95
95 126 173 133 133 133 129
APT-A09B 87
145 152 128 98 108 59 56 77 109 75 64 81 81 73 83 73 107 142 125 146
114 152 169 137 92 112 234 146 156 139 102 134 119 177 117 160 222 163 124 160
211 178 140 156 196 212 140 154 134 92 133 186 164 202 284 301 343 237 224 215
150 123 138 173 176 150 157 162 138 156 162 206 176 226 240 244 204 152 133 98
93 117 164 141 124 139 142
APT-A10A 64
231 259 208 258 358 246 253 297 302 171 243 235 229 257 202 285 206 258 276 303
196 220 345 464 423 318 305 400 241 284 227 229 303 280 270 264 234 265 257 314
248 230 244 243 205 157 174 161 180 127 137 171 184 194 174 155 237 161 147 151
181 158 160 180

APT-A10B 64
228 269 193 256 339 266 236 286 264 152 245 230 218 258 188 289 209 272 259 306
197 225 327 463 442 333 295 371 226 278 224 274 280 301 247 269 232 251 270 312
248 237 242 240 200 160 182 167 184 131 120 172 190 193 168 167 230 158 149 143
194 151 149 187
APT-A11A 92
278 533 378 289 396 289 224 156 177 206 292 213 322 242 378 286 169 276 348 286
365 251 208 184 105 80 106 109 102 102 90 105 94 110 54 131 110 177 170 138
157 184 127 63 39 24 20 18 21 19 22 32 27 23 28 39 38 34 24 46
57 54 56 66 98 38 42 46 37 49 72 81 111 179 153 194 222 164 139 83
61 94 145 133 126 140 248 190 205 235 226 187
APT-A11B 92
277 483 355 273 407 276 232 152 166 217 278 200 323 237 378 282 188 265 333 280
334 244 192 199 102 97 114 118 103 100 97 107 93 105 49 127 112 183 174 136
157 193 109 71 46 34 20 11 21 24 34 26 26 27 18 44 42 26 24 49
52 51 51 69 87 43 45 42 34 50 79 71 117 183 144 195 222 167 128 88
69 87 145 135 129 127 249 195 192 251 220 191
APT-A12A 80
274 423 386 280 331 203 244 118 165 239 168 257 323 237 331 360 354 414 327 251
250 342 306 268 234 391 242 172 124 146 178 253 172 261 174 163 201 195 159 115
117 123 128 173 145 186 159 239 234 284 253 238 188 229 225 201 277 315 242 240
258 248 236 244 236 205 199 233 195 294 226 246 197 311 312 226 228 206 236 243
APT-A12B 80
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250 335 306 269 219 404 228 176 120 155 172 251 156 253 179 157 221 166 138 144
117 112 143 168 169 190 143 240 229 298 270 235 206 220 213 200 268 303 253 233
264 247 249 235 242 210 207 225 198 292 223 238 211 300 328 238 228 219 221 253
APT-A13A 60
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APT-A14A 81
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APT-A14B 81
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APT-A15B 85
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APT-A17A 91
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APT-A17B 91
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APT-A18A 65
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APT-A18B 65
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APT-A20B 74
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APT-A22B 92
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APT-A27B 43
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APT-A28A 88
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APT-A32B 57
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APT-A34B 76
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APT-A35B 55
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APT-A41A 93
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APT-A41B 93
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APT-A42A 89
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APT-A42B 89
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APT-A43A 75
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APT-A43B 75
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APT-A46A 51
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APT-A46B 51
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APT-A47A 54
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APTA115B 77
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APTA116A 100
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APTA116B 100
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351 639 619 482 436 448 515 466 456 462 356 488 338 401 269 196 130 141 439 254
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APTA117A 84
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APTA117B 84
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APTA118A 65
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153 192 235 142 184
APTA118B 65
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167 215 209 140 178
APTA122A 46
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185 178 209 209 208 278
APTA122B 46
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APTA123A 40
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APTA123B 40
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APTA128B 85
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APTA129A 82
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73 76
APTA129B 82
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APTA130B 89
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APTA131A 61
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APTA133A 86
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110 149 140 132 127 162
APTA133B 86
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123 194 168 137 126 90 173 132 227 251 219 199 221 263 246 180 149 119 109 127
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APTA134A 54
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APTA134B 54
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88 104 131 91 69 121 110 89 77 91 92 80 70 111
APTA135A 86
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45 30 43 58 50 57 43 57 63 58 36 37 40 51 38 68 65 69 76 88
68 76 52 43 47 66
APTA135B 86
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110 116 119 79 107 68 44 42 36 76 63 68 49 66 40 47 52 59 38 60
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78 70 59 38 62 76
APTA136A 67
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190 187 187 143 162 177 148 184 263 182 139 123 161 166 189 176 195 233 124 151
159 203 252 206 247 186 222
APTA136B 67
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APTA137A 55
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245 264 142 198 254 99 156 211 161 261 170 71 386 281 198 230 275 243 252 372
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421 299 294 243 304 296 274 270 176 170 189 156 166 171 256 179 113 164 148 174
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APTA139A 69
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APTA139B 69
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189 171 209 191 201 187 154 210 194
APTA140A 44
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APTA140B 44
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99 106 78 101
APTA141A 68
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APTA141B 68
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APTA142A 74
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APTA142B 74
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APTA146B 51
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APTA148A 108
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104 100 94 110 89 148 168 216
APTA148B 108
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98 95 122 93 95 147 160 173
APTA153A 54
284 343 507 413 404 460 577 558 400 403 262 351 365 366 375 365 274 258 202 175
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APTA153B 54
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APTA155A 66
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104 120 147 189 179 161
APTA155B 66
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APTA157A 57
334 276 213 279 380 221 210 213 200 168 298 157 113 189 165 193 151 167 116 74
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APTA157B 57
297 266 233 282 386 236 215 220 180 144 302 155 99 178 185 196 185 157 142 81
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APTA160A 40
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APTA160B 40
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APTA161A 59
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APTA161B 59
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133 209 329 196 311 211 277 273 310 148 114 259 227 201 163 221 135 146 185 181
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APTA162A 57
330 280 281 235 223 302 391 242 259 170 223 254 284 180 178 273 192 377 175 184
178 150 174 122 132 132 209 214 231 167 335 308 246 231 266 208 276 329 253 317
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APTA162B 57
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201 181 255 299 328 337 322 164 157 173 247 244 280 245 182 385 316
APTA163A 55
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APTA163B 55
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APTA164A 56
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APTA164B 56
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APTA165A 55
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APTA165B 55
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APTA167A 84
398 227 328 389 286 230 195 343 344 339 312 235 165 187 236 197 163 144 129 192
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222 138 242 275

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APTA168A 79
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APTA168B 79
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APTA169A 70
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APTA169B 70
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APTA170A 55
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APTA170B 55
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APTA171A 73
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APTA171B 73
257 304 291 322 167 314 263 172 94 132 117 142 112 169 144 194 228 200 120 123
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APTA173A 61
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APTA174A 56
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APTA174B 56
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APTA175A 40
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APTA175B 40
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APTA176B 98
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APTA177A 107
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APTA177B 107
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APTA178A 63
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206 189 274

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APTA179B 92
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APTA180A 124
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184 210 220 192
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APTA181A 73
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APTA182A 58
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APTA182B 58
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APTA184A 41
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269 353 255 340 238 241 198 175 199 240 207 124 173 206 355 330 244 281 307 296
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APTA185B 59
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APTA186A 64
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APTA186B 64
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APTA188B 54
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APTA200B 75
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APTA205A 86
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APTA205B 86
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APTA225A 78
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APTA225B 78
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APTA226B 49
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APTA231A 76
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APTA231B 76
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APTA232B 75
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APTA253B 88
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APTA254B 46
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APTA255A 56
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APTA265A 70
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APTA265B 70
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APTA266A 83
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191 189 171
APTA266B 83
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APTA341A 112
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APTA356B 77
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APTA368B 58
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APTA402A 48
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APTA402B 48
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APTA425B 72
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APTA434B 157
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54 67 71 62 85 52 50 72 66 58 87 89 84 56 54 46 71 115 70 48
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43 60 69 54 88 77 95 87 98 89 88 93 75 110 104 86 105 168 84 74
86 131 70 66 62 54 77 51 61 78 97 118 127 69 59 84 94 118 91 113
150 112 107 124 107 101 66 83 87 104
APTA435B 150
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78 59 79 122 184 96 101 68 125 168 125 113 69 74 60 151 140 115 110 66
60 46 75 94 86 72 64 96 86 61 63 45 77 60 84 69 51 47 62 84
58 62 74 61 92 50 45 69 63 60 99 78 90 57 44 48 82 117 72 57
48 47 86 94 76 105 87 67 110 119 118 106 73 92 100 85 108 72 65 75
48 46 66 65 91 67 94 89 91 94 78 85 89 105 100 92 95 178 79 73
88 128 62 68 55 57 75 64 74 77 96 124 116 71 69 78 92 130 88 110
147 110 116 115 108 107 77 77 84 105

APTA436A 61
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218 162 188 349 183 308 280 365 419 321 113 146 162 186 227 220 217 226 261 211
301 175 225 216 266 236 242 276 200 209 239 273 318 226 186 145 164 213 223 209
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APTA436B 61
213 198 209 276 273 198 131 135 184 266 175 229 199 177 201 217 213 221 189 206
212 178 192 332 190 300 266 336 410 302 122 153 164 213 263 251 237 245 296 228
319 188 203 229 247 237 238 256 199 197 224 275 311 216 187 159 157 223 221 204
266
APTA437A 63
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107 109 108 118 116 136 117 163 176 111 92 89 142 129 135 139 180 134 103 116
113 118 95 83 105 128 122 142 146 117 112 89 94 115 70 91 129 154 154 138
191 184 246
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218 229 240
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103 153 120 139 144 127 134 100 102 128 102 76 85 111 130 137 112 143 108 83
92 82 82 102 116 94 125 76 109 78 78 108 92 106 86 97
APTA443B 56
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96 159 115 134 149 118 134 103 99 122 112 75 88 120 119 122 116 142 102 88
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392 285 287 338 528 412 658 506 377 344 264 307 306 271 322 281 316 295 348 343
446 377 305 313 317 254 346 248 211 238 241 217
APTA444B 52
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355 366 309 316 314 261 329 242 215 222 235 123

APTA445A 54
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107 116 108 137 152 182 156 117 74 133 120 143 169 182 156 168 131 109 114 114
48 94 94 77 78 77 128 98 119 138 143 197 156 227
APTA445B 54
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104 87 114 136 145 184 162 128 62 114 124 129 169 180 156 164 147 101 126 116
52 99 97 68 79 83 105 120 117 144 142 212 147 209
APTA446A 54
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274 191 131 76 120 118 117 169 226 213 223 186 177 206 205 127 116 113 82 90
89 138 260 287 287 201 313 305 284 173 210 115 152 225
APTA446B 54
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271 205 124 76 110 120 130 158 232 214 231 176 175 198 193 143 125 120 76 81
85 142 256 282 308 194 319 291 290 168 229 100 130 245
APTA447A 57
178 168 174 209 182 231 182 209 150 128 135 276 223 197 88 68 50 55 88 82
81 79 99 94 114 138 161 195 137 153 183 59 32 31 69 52 45 79 154 109
108 106 119 155 152 163 160 160 159 109 113 92 143 143 130 100 176
APTA447B 57
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APTA449A 54
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78 100 71 105 122 112 147 129 131 101 109 111 115 194
APTA449B 54
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APTA450A 55
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APTA450B 55
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71 103 112 134 136 123 129 110 109 114 109 171 147 117 133
APTA451A 42
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348 345 401 301 381 375 533 491 282 292 221 261 218 173 199 215 173 203 153 241
211 267
APTA451B 42
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362 342 386 278 371 401 537 451 299 299 198 242 211 179 220 200 203 199 185 226
196 252
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206 250 208 234 190 267 360 267 207 240 242 139 195 152

APTA452B 54
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412 309 205 227 274 253 265 305 259 293 268 267 242 211 271 336 379 220 247 255
295 258 283 318 286 232 188 310 235 256 297
APTA471B 51
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286 232 236 219 288 216 219 248 436 373 281 177 184 250 219 273 243 236 300 276
235 242 157 274 328 429 294 344 291 319 372
APTA473B 51
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218 231 135 329 333 436 293 373 336 323 370
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370 391 306 352 272 371 396 411 315 241 319 246 285 207 342 330 256 287 222 292
238 174 195 336 261 264 192 198 209 240 228 193 165 297 365 323 154 136 201 195
222 228 189 234 178 175 200 181 253 239 313 195 281 246 250 270 308 302 331 346
233 303
APTA474B 62
315 390 317 343 271 371 393 396 336 247 290 281 277 194 360 344 224 311 195 289
249 163 198 353 248 265 217 174 184 274 212 187 164 291 376 321 160 121 211 201
215 208 209 222 162 161 226 168 234 234 327 210 285 220 268 262 325 292 338 343
205 305
APTA475A 47
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243 141 157 261 173 248 479 302 329 303 226 242 306 273 226 187 175 364 111 91
159 270 240 297 217 179 300
APTA475B 47
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246 144 163 267 176 249 485 306 313 317 258 254 279 264 227 206 152 353 104 109
149 303 226 308 234 177 263
APTA477A 68
226 250 311 268 330 317 326 386 316 313 339 248 320 221 234 210 195 165 128 208
148 336 360 254 301 318 268 216 302 211 185 140 202 170 136 191 119 174 150 121
88 137 130 125 135 94 126 123 78 80 164 145 148 139 129 121 181 134 113 139
179 276 218 138 101 155 145 193
APTA477B 68
235 182 324 265 320 327 345 361 296 305 338 253 327 233 266 186 214 141 128 196
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85 146 122 118 141 79 138 119 75 88 157 148 147 142 130 116 180 128 133 137
176 268 227 134 114 154 143 198
APTA478A 58
472 415 390 324 256 298 151 161 105 139 67 57 238 187 162 233 177 232 232 215
184 267 214 152 176 289 127 243 284 185 209 156 144 201 377 344 185 207 99 186
119 96 138 371 227 373 195 98 157 118 233 136 200 138 195 173 189 177

APTA478B 58
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192 273 218 151 172 312 118 319 262 174 231 143 139 186 342 339 180 236 102 222
108 77 148 363 226 377 191 75 169 115 218 146 164 134 178 183 169 156
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199 254 249 298 170 148 220 313 277 235 146 194 229 229
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168 302 273 206 229 236 168 170 169 222 370 290 284 183 217 157 157 144 173 196
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123 184 200 154 184 185 172 173 158 182 154 154 129 199 164 102 70 101 135 142
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188 224 252 219 279 358 420 339 269 231 134 108 86 80 69 151 96 80 122 97
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150 130 199 257 277 194 196 194 208 187 123 217 188 182
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271 224 102 198 163 159 239 169 245 155 128 112 214 291 298 306 209 273 172 140
158 141 202 280 253 178 186 226 231 217 111 201 192 181
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317 271 242 199 164 170 154 169 181 174 272 239 268 273 155 210 205 176 182 125
119 159 171 222
APTA483B 44
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295 262 230 210 168 180 150 159 191 174 267 241 258 271 178 196 225 176 181 129
131 147 182 220
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APTA484B 40
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156 144 166 193 184 132 155 170 123 215 191 123 165 186 181 185 158 160 176 192

APTA486A 47
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149 150 121 162 177 181 199
APTA486B 47
151 190 243 265 218 280 264 193 202 234 265 214 199 153 251 266 223 207 255 211
255 236 180 179 188 156 156 188 185 244 183 95 113 108 82 114 122 114 135 115
142 142 136 161 153 183 199
APTA491A 67
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129 106 183 185 155 144 146 128 155 140 102 112 166 143 116 167 160 102 103 91
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214 151 224 283 242 208 157 176 201 196 264 233 221 207 220 171 198 175 188 200
125 115 178 187 146 145 129 123 130 161 116 119 138 166 119 179 175 97 109 96
108 147 233 135 179 218 222
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367 347 427 283 360 555 352 246 242 343 321 370 260 185 263 229 210 340 331 335
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301 324 406 257 365 540 355 263 210 396 297 383 266 204 262 223 192 354 333 342
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180 164 98 84 147 131 165 213 142 115 135 109 62 74 82 91 101 101
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APTA494B 53
123 169 164 156 192 188 174 216 162 186 193 309 159 188 258 221 192 159 212 227
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APTA503A 81
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APTA505A 88
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APTA508A 70
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APTA515A 52
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APTA516A 64
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203 293 294 281
APTA516B 64
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188 292 307 276
APTA517A 49
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APTA517B 49
420 273 298 331 381 570 391 305 334 287 316 376 309 339 355 455 246 284 268 377
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APPENDIX: TREE-RING DATING

The Principles of Tree-Ring Dating

Tree-ring dating, or dendrochronology as it is known, is discussed in some detail in the Nottingham Tree-ring Dating Laboratory's Monograph, *An East Midlands Master Tree-Ring Chronology and its uses for dating Vernacular Building* (Laxton and Litton 1988) and *Dendrochronology: Guidelines on Producing and Interpreting Dendrochronological Dates* (English Heritage 1998). Here we will give the bare outlines. Each year an oak tree grows an extra ring on the outside of its trunk and all its branches just inside its bark. The width of this annual ring depends largely on the weather during the growing season, about April to October, and possibly also on the weather during the previous year. Good growing seasons give rise to relatively wide rings, poor ones to very narrow rings and average ones to relatively average ring widths. Since the climate is so variable from year to year, almost random-like, the widths of these rings will also appear random-like in sequence, reflecting the seasons. This is illustrated in Figure A1 where, for example, the widest rings appear at irregular intervals. This is the key to dating by tree rings, or rather, by their widths. Records of the average ring widths for oaks, one for each year for the last 1000 years or more, are available for different areas. These are called master chronologies. Because of the random-like nature of these sequences of widths, there is usually only one position at which a sequence of ring widths from a sample of oak timber with at least 70 rings will match a master. This will date the timber and, in particular, the last ring.

If the bark is still on the sample, as in Figure A1, then the date of the last ring will be the date of felling of the oak from which it was cut. There is much evidence that in medieval times oaks cut down for building purposes were used almost immediately, usually within the year or so (Rackham 1976). Hence if bark is present on several main timbers in a building, none of which appear reused or are later insertions, and if they all have the same date for their last ring, then we can be quite confident that this is the date of construction or soon after. If there is no bark on the sample, then we have to make an estimate of the felling date; how this is done is explained below.

The Practice of Tree-Ring Dating at the Nottingham Tree-Ring Dating Laboratory

1. **Inspecting the Building and Sampling the Timbers.** Together with a building historian the timbers in a building are inspected to try to ensure that those sampled are not reused or later insertions. Sampling is almost always done by coring into the timber, which has the great advantage that we can sample *in situ* timbers and those judged best to give the date of construction, or phase of construction if there is more than one in the building. The timbers to be sampled are also inspected to see how many rings they have. We normally look for timbers with at least 70 rings, and preferably more. With fewer

rings than this, 50 for example, sequences of widths become difficult to match to a unique position within a master sequence of ring widths and so are difficult to date (Litton and Zainodin 1991). The cross-section of the rafter shown in Figure A2 has about 120 rings; about 20 of which are sapwood rings – the lighter rings on the outside. Similarly the core has just over 100 rings with a few sapwood rings.

To ensure that we are getting the date of the building as a whole, or the whole of a phase of construction if there is more than one, about 8–10 samples per phase are usually taken. Sometimes we take many more, especially if the construction is complicated. One reason for taking so many samples is that, in general, some will fail to give a date. There may be many reasons why a particular sequence of ring widths from a sample of timber fails to give a date even though others from the same building do. For example, a particular tree may have grown in an odd ecological niche, so odd indeed that the widths of its rings were determined by factors other than the local climate! In such circumstances it will be impossible to date a timber from this tree using the master sequence whose widths, we can assume, were predominantly determined by the local climate at the time.

Sampling is done by coring into the timber with a hollow corer attached to an electric drill and usually from its outer rings inwards towards where the centre of the tree, the pith, is judged to be. An illustration of a core is shown in Figure A2; it is about 150mm long and 10mm diameter. Great care has to be taken to ensure that as few as possible of the outer rings are lost in coring. This can be difficult as these outer rings are often very soft (see below on sapwood). Each sample is given a code which identifies uniquely which timber it comes from, which building it is from and where the building is located. For example, CRO-A06 is the sixth core taken from the first building (A) sampled by the Laboratory in Cropwell Bishop. Where it came from in that building will be shown in the sampling records and drawings. No structural damage is done to any timbers by coring, nor does it weaken them.

During the initial inspection of the building and its timbers the dendrochronologist may come to the conclusion that, as far as can be judged, none of the timbers have sufficient rings in them for dating purposes and may advise against sampling to save further unwarranted expense.

All sampling by the Laboratory is undertaken according to current Health and Safety Standards. The Laboratory's dendrochronologists are insured.

Figure A1: A wedge of oak from a tree felled in 1976. It shows the annual growth rings, one for each year from the innermost ring to the last ring on the outside just inside the bark. The year of each ring can be determined by counting back from the outside ring, which grew in 1976

Figure A2: Cross-section of a rafter, showing sapwood rings in the left-hand corner, the arrow points to the heartwood/sapwood boundary (H/S); and a core with sapwood; again the arrow is pointing to the H/S. The core is about the size of a pencil

Figure A3: Measuring ring widths under a microscope. The microscope is fixed while the sample is on a moving platform. The total sequence of widths is measured twice to ensure that an error has not been made. This type of apparatus is needed to process a large number of samples on a regular basis

Figure A4: Three cores from timbers in a building. They come from trees growing at the same time. Notice that, although the sequences of widths look similar, they are not identical. This is typical

2. Measuring Ring Widths. Each core is sanded down with a belt sander using medium-grit paper and then finished by hand with flourgrade-grit paper. The rings are then clearly visible and differentiated from each other with a result very much like that shown in Figure A2. The core is then mounted on a movable table below a microscope and the ring-widths measured individually from the innermost ring to the outermost. The widths are automatically recorded in a computer file as they are measured (see Fig A3).

3. Cross-Matching and Dating the Samples. Because of the factors besides the local climate which may determine the annual widths of a tree's rings, no two sequences of ring widths from different oaks growing at the same time are exactly alike (Fig A4). Indeed, the sequences may not be exactly alike even when the trees are growing near to each other. Consequently, in the Laboratory we do not attempt to match two sequences of ring widths by eye, or graphically, or by any other subjective method. Instead, it is done objectively (ie statistically) on a computer by a process called cross-matching. The output from the computer tells us the extent of correlation between two sample sequences of widths or, if we are dating, between a sample sequence of widths and the master, at each relative position of one to the other (offsets). The extent of the correlation at an offset is determined by the *t*-value (defined in almost any introductory book on statistics). That offset with the maximum *t*-value among the *t*-values at all the offsets will be the best candidate for dating one sequence relative to the other. If one of these is a master chronology, then this will date the other. Experiments carried out in the past with sequences from oaks of known date suggest that a *t*-value of at least 4.5, and preferably at least 5.0, is usually adequate for the dating to be accepted with reasonable confidence (Laxton and Litton 1988; Laxton *et al* 1988; Howard *et al* 1984–1995).

This is illustrated in Figure A5 with timbers from one of the roofs of Lincoln Cathedral. Here four sequences of ring widths, LIN-C04, 05, 08, and 45, have been cross-matched with each other. The ring widths themselves have been omitted in the bar diagram, as is usual, but the offsets at which they best cross-match each other are shown; eg the sequence of ring widths of C08 matches the sequence of ring widths of C45 best when it is at a position starting 20 rings after the first ring of C45, and similarly for the others. The actual *t*-values between the four at these offsets of best correlations are in the matrix. Thus at the offset of +20 rings, the *t*-value between C45 and C08 is 5.6 and is the maximum found between these two among all the positions of one sequence relative to the other.

It is standard practice in our Laboratory first to cross-match as many as possible of the ring-width sequences of the samples in a building and then to form an average from them. This average is called a site sequence of the building being dated and is illustrated in Figure A5. The fifth bar at the bottom is a site sequence for a roof at Lincoln Cathedral and is constructed from the matching sequences of the four timbers. The site sequence width for each year is the average of the widths in each of the sample sequences which has a width for that year. Thus in Fig A5 if the widths shown are 0.8mm for C45, 0.2mm for C08, 0.7mm for C05, and 0.3mm for C04, then the corresponding width of the site

sequence is the average of these, 0.55mm. The actual sequence of widths of this site sequence is stored on the computer. The reason for creating site sequences is that it is usually easier to date an average sequence of ring widths with a master sequence than it is to date the individual component sample sequences separately.

The straightforward method of cross-matching several sample sequences with each other one at a time is called the 'maximal *t*-value' method. The actual method of cross-matching a group of sequences of ring-widths used in the Laboratory involves grouping and averaging the ring-width sequences and is called the 'Litton-Zainodin Grouping Procedure'. It is a modification of the straightforward method and was successfully developed and tested in the Laboratory and has been published (Litton and Zainodin 1991; Laxton *et al* 1988).

4. Estimating the Felling Date. As mentioned above, if the bark is present on a sample, then the date of its last ring is the date of the felling of its tree (or the last full year before felling, if it was felled in the first three months of the following calendar year, before any new growth had started, but this is not too important a consideration in most cases). The actual bark may not be present on a timber in a building, though the dendrochronologist who is sampling can often see from its surface that only the bark is missing. In these cases the date of the last ring is still the date of felling.

Quite often some, though not all, of the original outer rings are missing on a timber. The outer rings on an oak, called sapwood rings, are usually lighter than the inner rings, the heartwood, and so are relatively easy to identify. For example, sapwood can be seen in the corner of the rafter and at the outer end of the core in Figure A2, both indicated by arrows. More importantly for dendrochronology, the sapwood is relatively soft and so liable to insect attack and wear and tear. The builder, therefore, may remove some of the sapwood for precisely these reasons. Nevertheless, if at least some of the sapwood rings are left on a sample, we will know that not too many rings have been lost since felling so that the date of the last ring on the sample is only a few years before the date of the original last ring on the tree, and so to the date of felling.

Various estimates have been made and used for the average number of sapwood rings in mature oak trees (English Heritage 1998). A fairly conservative range is between 15 and 50 and that this holds for 95% of mature oaks. This means, of course, that in a small number of cases there could be fewer than 15 and more than 50 sapwood rings. For example, the core CRO-A06 has only 9 sapwood rings and some have obviously been lost over time – either they were removed originally by the carpenter and/or they rotted away in the building and/or they were lost in the coring. It is not known exactly how many sapwood rings are missing, but using the above range the Laboratory would estimate between a minimum of 6 (=15-9) and a maximum of 41 (=50-9). If the last ring of CRO-A06 has been dated to 1500, say, then the estimated felling-date range for the tree from which it came originally would be between 1506 and 1541. The Laboratory uses this estimate for sapwood in areas of England where it has no prior information. It

also uses it when dealing with samples with very many rings, about 120 to the last heartwood ring. But in other areas of England where the Laboratory has accumulated a number of samples with complete sapwood, that is, no sapwood lost since felling, other estimates in place of the conservative range of 15 to 50 are used. In the East Midlands (Laxton *et al* 2001) and the east to the south down to Kent (Pearson 1995) where it has sampled extensively in the past, the Laboratory uses the shorter estimate of 15 to 35 sapwood rings in 95% of mature oaks growing in these parts. Since the sample CRO-A06 comes from a house in Cropwell Bishop in the East Midlands, a better estimate of sapwood rings lost since felling is between a minimum of 6 (=15-9) and 26 (=35-9) and the felling would be estimated to have taken place between 1506 and 1526, a shorter period than before. Oak boards quite often come from the Baltic region and in these cases the 95% confidence limits for sapwood are 9 to 36 (Howard *et al* 1992, 56).

Even more precise estimates of the felling date and range can often be obtained using knowledge of a particular case and information gathered at the time of sampling. For example, at the time of sampling the dendrochronologist may have noted that the timber from which the core of Figure A2 was taken still had complete sapwood but that some of the soft sapwood rings were lost in coring. By measuring into the timber the depth of sapwood lost, say 20mm, a reasonable estimate can be made of the number of sapwood rings lost, say 12 to 15 rings in this case. By adding on 12 to 15 years to the date of the last ring on the sample a good tight estimate for the range of the felling date can be obtained, which is often better than the 15 to 35 years later we would have estimated without this observation. In the example, the felling is now estimated to have taken place between AD 1512 and 1515, which is much more precise than without this extra information.

Even if all the sapwood rings are missing on a sample, but none of the heartwood rings are, then an estimate of the felling-date range is possible by adding on the full compliment of, say, 15 to 35 years to the date of the last heartwood ring (called the heartwood/sapwood boundary or transition ring and denoted H/S). Fortunately it is often easy for a trained dendrochronologist to identify this boundary on a timber. If a timber does not have its heartwood/sapwood boundary, then only a *post quem* date for felling is possible.

5. Estimating the Date of Construction. There is a considerable body of evidence collected by dendrochronologists over the years that oak timbers used in buildings were not seasoned in medieval or early modern times (English Heritage 1998; Miles 1997, 50–5). Hence, provided that all the samples in a building have estimated felling-date ranges broadly in agreement with each other, so that they appear to have been felled as a group, then this should give an accurate estimate of the period when the structure was built, or soon after (Laxton *et al* 2001, fig 8; 34–5, where 'associated groups of fellings' are discussed in detail). However, if there is any evidence of storage before use, or if there is evidence the oak came from abroad (eg Baltic boards), then some allowance has to be made for this.

6. Master Chronological Sequences. Ultimately, to date a sequence of ring widths, or a site sequence, we need a master sequence of dated ring widths with which to cross-match it, a Master Chronology. To construct such a sequence we have to start with a sequence of widths whose dates are known and this means beginning with a sequence from an oak tree whose date of felling is known. In Figure A6 such a sequence is SHE-T, which came from a tree in Sherwood Forest which was blown down in a recent gale. After this other sequences which cross-match with it are added and gradually the sequence is 'pushed back in time' as far as the age of samples will allow. This process is illustrated in Figure A6. We have a master chronological sequence of widths for Nottinghamshire and East Midlands oak for each year from AD 882 to 1981. It is described in great detail in Laxton and Litton (1988), but the components it contains are shown here in the form of a bar diagram. As can be seen, it is well replicated in that for each year in this period there are several sample sequences having widths for that year. The master is the average of these. This master can now be used to date oak from this area and from the surrounding areas where the climate is very similar to that in the East Midlands. The Laboratory has also constructed a master for Kent (Laxton and Litton 1989). The method the Laboratory uses to construct a master sequence, such as the East Midlands and Kent, is completely objective and uses the Litton-Zainodin grouping procedure (Laxton *et al* 1988). Other laboratories and individuals have constructed masters for other areas and have made them available. As well as these masters, local (dated) site chronologies can be used to date other buildings from nearby. The Laboratory has hundreds of these site sequences from many parts of England and Wales covering many short periods.

7. Ring-Width Indices. Tree-ring dating can be done by cross-matching the ring widths themselves, as described above. However, it is advantageous to modify the widths first. Because different trees grow at different rates and because a young oak grows in a different way from an older oak, irrespective of the climate, the widths are first standardized before any matching between them is attempted. These standard widths are known as ring-width indices and were first used in dendrochronology by Baillie and Pilcher (1973). The exact form they take is explained in this paper and in the appendix of Laxton and Litton (1988) and is illustrated in the graphs in Figure A7. Here ring-widths are plotted vertically, one for each year of growth. In the upper sequence of (a), the generally large early growth after 1810 is very apparent as is the smaller later growth from about 1900 onwards when the tree is maturing. A similar phenomenon can be observed in the lower sequence of (a) starting in 1835. In both the widths are also changing rapidly from year to year. The peaks are the wide rings and the troughs are the narrow rings corresponding to good and poor growing seasons, respectively. The two corresponding sequence of Baillie-Pilcher indices are plotted in (b) where the differences in the immature and mature growths have been removed and only the rapidly changing peaks and troughs remain, that are associated with the common climatic signal. This makes cross-matching easier.

t-value/offset Matrix

	C45	C08	C05	C04
C45		+20	+37	+47
C08	5.6		+17	+27
C05	5.2	10.4		+10
C04	5.9	3.7	5.1	

Bar Diagram

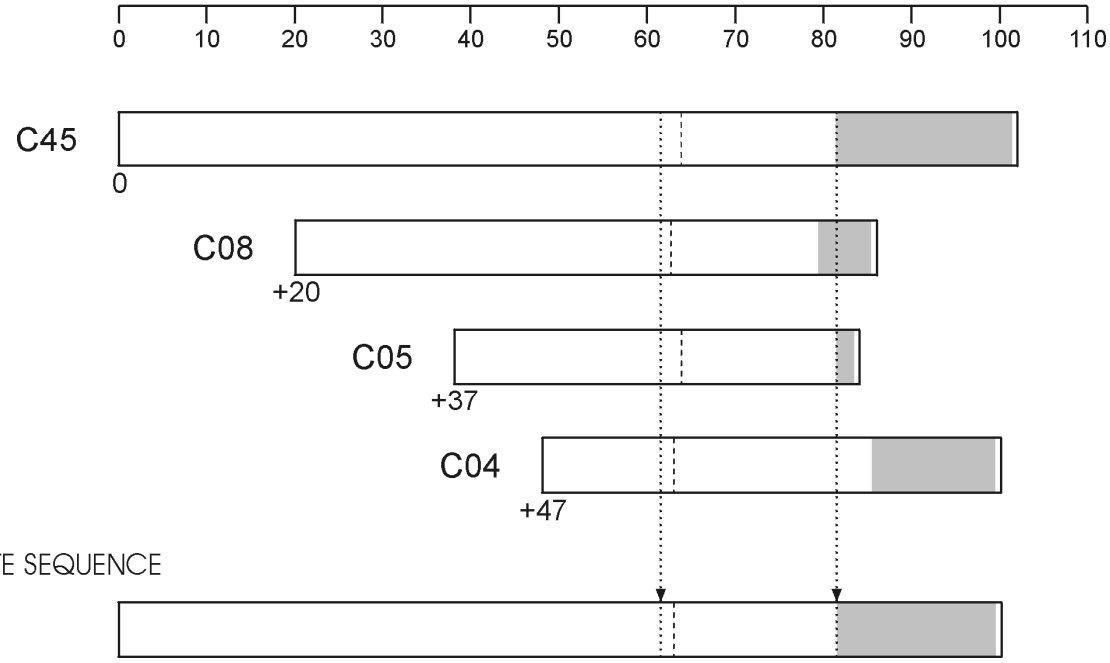


Figure A5: Cross-matching of four sequences from a Lincoln Cathedral roof and the formation of a site sequence from them

The bar diagram represents these sequences without the rings themselves. The length of the bar is proportional to the number of rings in the sequence. Here the four sequences are set at relative positions (offsets) to each other at which they have maximum correlation as measured by the *t*-values. The *t*-value/offset matrix contains the maximum *t*-values below the diagonal and the offsets above it. Thus, the maximum *t*-value between C08 and C45 occurs at the offset of +20 rings and the *t*-value is then 5.6. The site sequence is composed of the average of the corresponding widths, as illustrated with one width

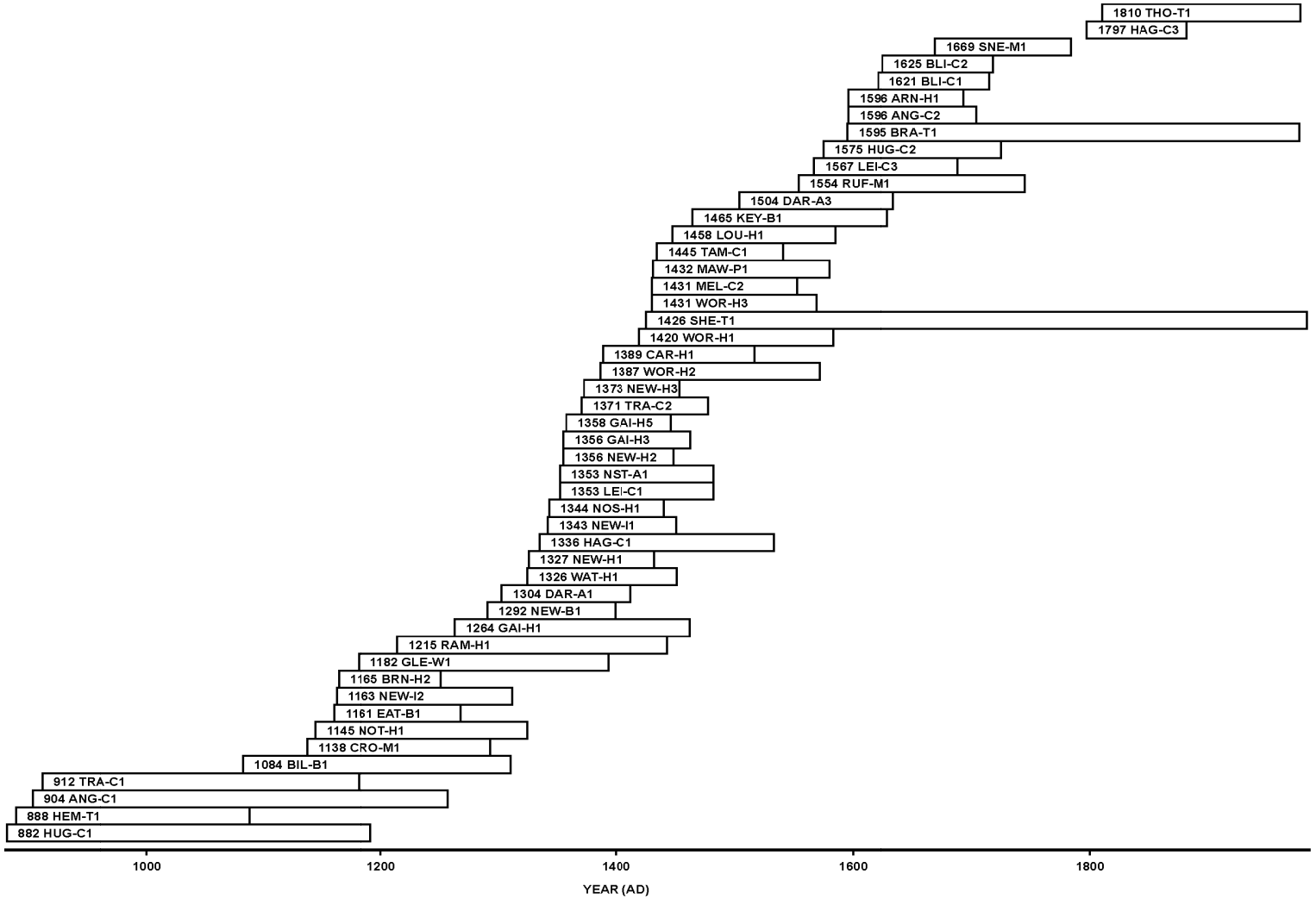
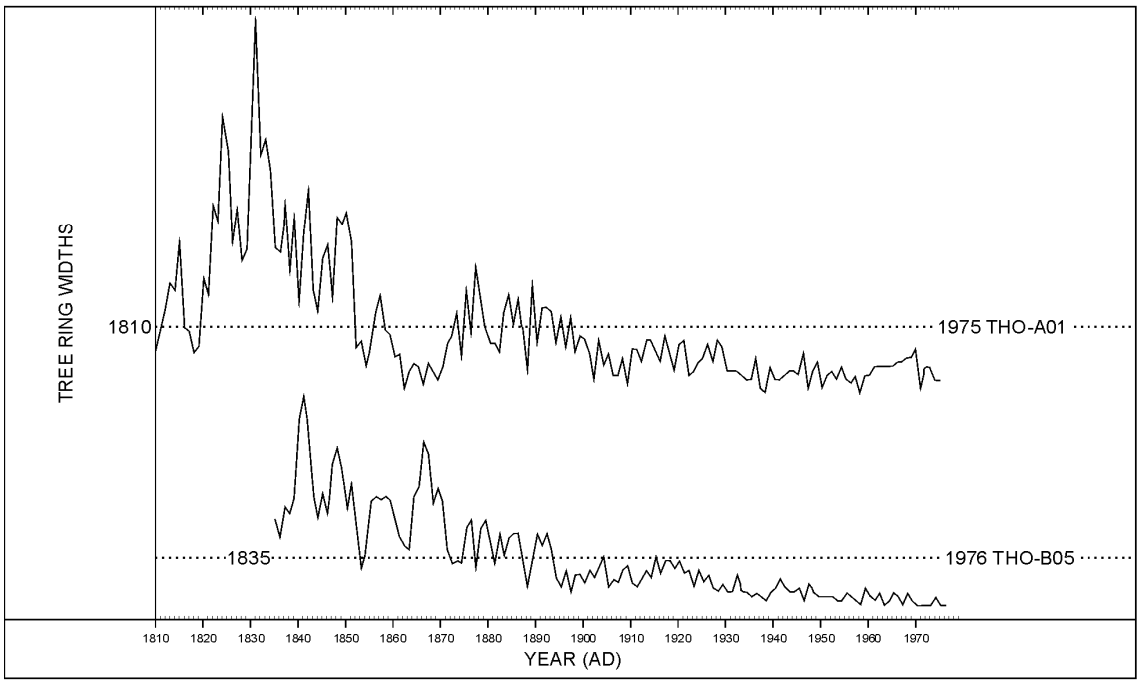


Figure A6: Bar diagram showing the relative positions and dates of the first rings of the component site sequences in the East Midlands Master Dendrochronological Sequence, EM08/87

(a)



(b)

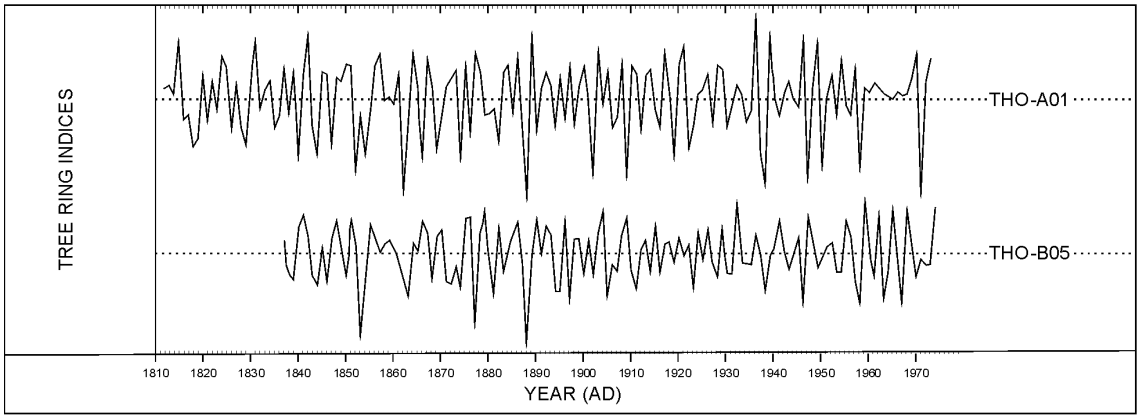


Figure A7 (a): The raw ring-widths of two samples, THO-A01 and THO-B05, whose felling dates are known

Here the ring widths are plotted vertically, one for each year, so that peaks represent wide rings and troughs narrow ones. Notice the growth-trends in each; on average the earlier rings of the young tree are wider than the later ones of the older tree in both sequences

Figure A7 (b): The Baillie-Pilcher indices of the above widths

The growth trends have been removed completely

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