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NAPPA HALL, ASKRIGG, NORTH YORKSHIRE
TREE-RING ANALYSIS OF TIMBERS

SCIENTIFIC DATING REPORT

Alison Arnold and Robert Howard

INTERVENTION
AND ANALYSIS

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SUMMARY

Analysis undertaken on samples from several areas at Nappa Hall resulted in the construction of three site sequences, two of which are dated. Site sequence NAPBSQ01 contains 67 samples and spans the period AD 1300–1476 and site sequence NAPBSQ02 contains three samples and spans the period AD 1478–1570.

The earliest timbers with precise felling dates are those of the roof over the old kitchen in the Service range, dated to AD 1461 and AD 1462, along with a single timber from the ground-floor ceiling of the Low-end tower dated to AD 1465. In the High-end tower there are a series of timbers felled in AD 1471 and 1472 (ground-floor ceiling) and AD 1476 (turret roof), whilst those from the Hall-range roof were felled in AD 1474. The East wing, Woodshed, and Stable/Coach-house range also contain timbers felled in the AD 1460s and AD 1470s, although in some instances, notably the roofs over the Woodshed and part of the Stable range, are reused in their current locations. The latest timbers, dating to the latter part of the sixteenth century, are from the Tack room ground-floor ceiling and roof in the service range.

CONTRIBUTORS

Alison Arnold and Robert Howard

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INTRODUCTION

Nappa Hall is a Grade I listed late-medieval manor house located on the north side of the River Ure (Figs 1–3). The complex consists of three ranges around a terraced courtyard (Fig 4). It is thought to have been built around AD 1459 for the Metcalfe family who retained possession until the early nineteenth century and then later regained ownership in the early twentieth century. It is believed to be the most important medieval manor house in northern England and is currently on the Heritage at Risk register.

North range

This range consists of a central Hall, flanked by a four-storey (solar) tower to its west (High-end tower), a two-storey tower to the east (Low-end tower), and Porch (Fig 5). This range is thought to date to the mid/late-fifteenth century although whether it was constructed as a single phase of work or over a number of years is unclear.

Hall

The roof over the Hall is of three crown-post trusses, each one consisting of principal rafters, tiebeams, collars, and crown posts (Fig 6). Between the trusses are common rafters and purlins. Purlins in bay 1 are moulded. At the east end of the Hall at ground-floor level is a beam which is thought possibly to be part of a screens passage.

High-end tower

Ground- and first-floor ceiling structures comprise three large, moulded main beams with common joists between, some of which have been replaced with modern joists; some of the floor boards also survive. The main joists of the second-floor ceiling are loose and lain on the floor below (Fig 7); none of the common joists from this level remain. In the north wall at second-floor level is a garderobe. The roof over this part of the building is a twentieth-century replacement.

In the south-east corner of the High-end tower is a doorway to the spiral stair of the turret, the roof of which consists of three trusses of rafters and tiebeams (Fig 8). This may potentially be a sixteenth-century alteration.

Low-end tower

The exposed ground-floor ceiling of this part of the building consists of a large main beam with common joists, some of which show signs of reuse and potential smoke-blackening (Fig 9).

Porch

Coming off the east end of the Hall is a single-storey porch, the roof of which is of a similar form to that of the Turret, ie a low-pitched roof with three trusses of tiebeams, common rafters, a ridgebeam, and purlins (east one missing) (Fig 10). Again, it is unclear as to whether this is mid/late-fifteenth century or a sixteenth-century alteration.

Woodshed

At the west end of the High end tower is a single-storey extension used to store wood. This building is divided into three areas by stone walls which support a ridgepiece and two sets of purlins, between which are common rafters (Fig 11). This building is likely to be a later addition although some of the roof timbers look more ancient and are possibly reused.

Service range

To the east of the North range is the Service range; this consists of a combination of buildings, domestic and agricultural in character, and may incorporate part of the medieval kitchens (Fig 12). This range may also have its origins in the fifteenth century and could be slightly earlier than the North range but reworked and extended at a later date.

Kitchen

The part of this range adjacent to the Low end tower is thought to be the old Kitchen. In its south wall survives the bresummer of the ground-floor smokehood (Fig 13). The roof over the Kitchen consists of principal rafters, tiebeams, purlins, and common rafters. The tiebeams have been cut through at some point and are supported by posts which can be seen to be moulded (Fig 14).

Tack room

To the south of the kitchen is the Dairy or Tack room. The exposed ground-floor ceiling consists of two main beams with common joists between, some of which show signs of previous use (Fig 15). The roof structure over this room has two principal-rafter trusses with tiebeams, between these are purlins and ridgepiece (Fig 16); there are some signs of reuse amongst some of the timbers here also. It has been suggested that this room might be eighteenth century in date.

To the south of the Tack room is a cow byre with a modern, softwood roof.

East wing

To the rear of the Kitchen is an extension (Fig 17) with a late nineteenth- /early twentieth-century roof. On the ground floor are some exposed ceiling beams (Fig 18).

Stable/Coach-house range

Barn

To the west-side of the courtyard is a long, seemingly single-phase building (Fig 19), thought to have been added in the early nineteenth century when Nappa Hall was used as a hunting lodge by the de Grey family. Possibly a one time barn it is currently used as stables, garage, and store.

The ground-floor ceiling is almost entirely constructed of late nineteenth- /early twentieth-century pine. The roof has nine trusses, again thought to be late-nineteenth/early twentieth century, of principal rafters and tiebeams (Fig 20). A large number of the purlins appear to be reused with some being moulded and/or chamfered; some common rafters also display signs of previous use in the form of empty mortices (Fig 21).

SAMPLING

A dendrochronological survey was requested by Lucy Jessop, English Heritage, as part of a rapid survey ahead of plans to repair, consolidate, and render the complex habitable. It was hoped to obtain independent dating evidence for the development of the various ranges, adding to the overall understanding of the building, and thus helping to inform decisions relating to its future restoration, conservation, management, and use.

A total of 110 timbers from various areas of the building was sampled by coring. Each sample was given the code NAP-B and numbered 1–110. The location of *in situ* samples was noted at the time of sampling and has been marked on Figures 22–32. Further details relating to the samples can be found in Table 1.

ANALYSIS AND RESULTS

Sixteen samples, ten from the North range (Hall, High end tower, Porch, and Woodshed), five from the Service range (Kitchen and Tack room), and one from the East wing had too few rings for secure dating and so were discarded prior to measurement. The remaining 94 samples were prepared by sanding and polishing and their growth-ring widths measured; the data of these measurements are given at the end of the report. All samples were then compared with each other by the Litton/Zainodin grouping programme (see Appendix), resulting in 73 samples matching to form three groups.

Firstly, 67 samples, from all areas matched each other and were combined at the relevant offset positions to form NAPBSQ01, a site sequence of 177 rings (Fig 33). This site sequence was compared against a series of relevant reference chronologies for oak where it was found to span the period AD 1300–1476. The evidence for this dating is given in Table 2.

Three samples from the tack room roof and ceiling grouped to form NAPBSQ02, a site sequence of 93 rings (Fig 34). This was dated to spanning the period AD 1478–1570 (Table 3).

Finally, three samples from the tack room roof matched each other and were combined to form NAPBSQ03, a site sequence of 87 rings (Fig 35). Attempts to date this site sequence and the remaining 21 ungrouped samples were unsuccessful and all remain undated.

INTERPRETATION

Tree-ring analysis has resulted in the successful dating of 70 timbers from all areas targeted, following assessment of dendrochronological potential for sampling. To aid interpretation each area is dealt with separately below and illustrated in Figure 36. Felling date ranges have been calculated using the estimate that mature oak trees in this region have 15–40 sapwood rings.

Service range

Kitchen

Twelve of the samples taken from the roof over this part of the building have been dated, three of which have complete sapwood. Samples NAP-B54 and NAP-B55 have the last-measured ring date of AD 1461, the felling date of the two timbers represented whilst sample NAP-B58, has the last-measured ring date of AD 1462, the felling date of the timber it represents. Seven further dated samples have the heartwood/sapwood boundary ring which in all cases is broadly contemporary and suggestive of a single felling. The average heartwood/sapwood boundary ring date is AD 1439, which allowing for sample NAP-B59 having a last-measured ring date of AD 1460 with incomplete sapwood, gives an estimated felling date within the range AD 1461–79, consistent with these timbers also having been felled in AD 1461 or AD 1462. The two samples without the heartwood/sapwood boundary have last-measured ring dates of AD 1419 and AD 1434, which again mean it is possible that these two timbers were also felled with the rest of the timber. The potential same-tree derivation for the timbers represented by samples NAP-B52 and NAP-B53 (one of the two samples without heartwood/sapwood boundary) combined with the overall level of cross-matching supports the likelihood of all of these timbers being felled in, or around, AD 1461–2.

Tack room

Five samples taken from the Tack room have been dated, three from the ground-floor ceiling, one from a stair runner, and one from the roof. The stair runner (NAP-B66) and a common joist (NAP-B65) were identified at the time of sampling as being reused. Four of the dated samples have the heartwood/sapwood boundary ring which suggests at least two separate fellings are represented amongst these timbers. The stair runner has the heartwood/sapwood boundary ring date of AD 1456, giving an estimated felling date within the range AD 1471–96. The two main ceiling beams and the principal rafter have similar heartwood/sapwood ring dates, the average of which is AD 1555, giving an estimated felling date for the three timbers represented within the range of AD 1570–95. The final dated sample, taken from the reused common joist has the last-measured heartwood ring date of AD 1410, giving a *terminus post quem* for felling of AD 1425.

North range

Low-end tower

Only one sample, taken from a common joist has been successfully dated. This sample has complete sapwood and the last-measured ring date of AD 1465, the felling date of the timber represented.

High-end tower

Fourteen of the timbers of the ground-, first- and second-floor ceiling frames have been dated. The overall level of cross-matching within this group of ceiling timbers, including at least one potential same-tree match between timbers from different ceilings, again suggests that this is likely to be a coherent group. One of these samples, NAP-B19, has complete sapwood and a last-measured ring date of AD 1471, the felling date of the timber represented. A second sample, NAP-B21, also has complete sapwood with a last-measured ring date a year later giving the timber represented a felling date of AD 1472. Eleven further samples have the heartwood/sapwood boundary which although displaying some variation are broadly contemporary and consistent with a single felling. The average heartwood/sapwood boundary ring date is AD 1444, allowing an estimated felling date range to be calculated for the 11 timbers represented within the range AD 1467–84, consistent with these timbers also having been felled in AD 1471 or 1472. This makes allowance for sample NAP-B22 having the last-measured ring date of AD 1466 with incomplete sapwood. Although treated as being of the same felling as the rest of the timber it should be noted that the heartwood/sapwood boundary ring dates of samples NAP-B26 and NAP-B27 are noticeably earlier than the rest of the timber. The two timbers represented are potentially from the same tree (matching each other at the high value of t=13.2) and it could be that these two simply represent a single tree with more than the average number of sapwood rings (to be felled in AD 1471 sample NAP-B27 would have to have 51 sapwood rings, which is certainly not unknown), or alternatively that they do have an earlier felling date and were left over from the AD 1460s works.

Hall

Fourteen of the timbers taken from the Hall have been dated, 13 from the roof and one from a lintel over the door between the hall and Low-end tower.

One of the roof samples, NAP-B11, has complete sapwood and a last-measured ring date of AD 1474, the felling date of the timber represented. Nine other roof samples have the heartwood/sapwood boundary ring, which in all cases are broadly contemporary. The average heartwood/sapwood boundary ring date is AD 1449, calculating to an estimated felling date range of AD 1472–89, consistent with an AD 1474 felling. This felling date range allows for sample NAP-B01 having the last-measured ring date of AD 1471 with incomplete sapwood. The other three dated roof samples do not have the heartwood/sapwood boundary ring date and so estimated felling date ranges cannot be calculated for the timbers represented, except to say that with last-measured heartwood ring dates in the first half of the fifteenth century it is possible that these timbers were also felled in AD 1474. The overall level of cross-matching between the individual ring sequences within this group of timbers does however suggest that they are likely to be a coherent group and hence all were probably felled in, or around, AD 1474.

The sample taken from the lintel does not have the heartwood/sapwood boundary ring. However, with a last-measured heartwood ring date of AD 1453, this timber has a *terminus post quem* for felling of AD 1468 which makes it possible that it was also felled in the AD 1470s.

Turret roof

Five of the samples taken from this structure have been dated. Sample NAP-B41, taken from a common rafter, has complete sapwood and the last-measured ring date of AD 1476, the felling date of the timber represented. Two other samples have similar heartwood/sapwood boundary ring dates, the average of which is AD 1449. This calculates to an estimated felling date for the two timbers represented within the range AD 1464–89, consistent with an AD 1476 felling. The other two dated samples do not have the heartwood/sapwood boundary ring but with last-measured ring dates of AD 1418 (NAP-B39) and AD 1437 (NAP-B42) it is possible that these were also felled in AD 1476. The potential same-tree derivation for the timbers represented by samples NAP-B41 and NAP-B42 supports the likelihood of all of these timbers being felled in, or around, AD 1476.

Woodshed

Five roof timbers from this building have been dated, all have the heartwood/sapwood boundary ring, the average of which is AD 1441, giving an estimated felling date for the timbers represented within the range AD 1456–81.

Porch

Only two timbers, both ridge beams, have been dated from the porch roof. One of these has a heartwood/sapwood boundary ring date of AD 1446, giving an estimated felling date range of AD 1461–86 for the timber represented. The other one does not have the heartwood/sapwood boundary ring but with a last-measured heartwood date of AD 1432, has a *terminus post quem* for felling of AD 1457, and hence both ridge beams may well be coeval.

Stable/Coach-house range

Barn

Eleven of the samples taken from the roof have been dated. All have the heartwood/sapwood boundary ring present and are clearly coeval. The average of these is AD 1446, giving an estimated felling date for the timbers represented to within the range AD 1461–86.

East wing

One of the ground-floor ceiling beams in this part of the building has been dated. This sample has the heartwood/sapwood boundary ring date of AD 1455, giving an estimated felling date range of AD 1470–95.

DISCUSSION

The dendrochronological dating has demonstrated that the majority of the extant oak timber in the various ranges under investigation was felled in the AD 1460s and AD 1470s and thus belongs to the period of ownership by James Metcalf and later, his son Thomas, who inherited the estate in AD 1472. It has also provided evidence for further works being undertaken in the late-sixteenth century.

The date of the Service range was unclear although it had been suggested that it might contain remnants of the medieval Kitchen and could indeed be the oldest part of the complex. This has now been supported by the dendrochronology which has identified the earliest timbers to be those of the roof of the old Kitchen. This is now known to have been constructed from timber felled in AD 1461 and AD 1462. The dated timber includes two moulded posts thought to have been inserted to support the tiebeams when they were cut through. The fact that these two timbers are the same date as the rest of the timber suggests that beams salvaged from a range/building of the same date as the kitchen, were used for modification. These two samples match especially well with those from the Hall roof and High-end tower floor frames.

The east wing, to the rear of the Kitchen, is also potentially fifteenth century in date, although slightly later, but this is based on the dating of only one timber. A ground-floor ceiling beam located in this extension has been dated to AD 1470–95, suggesting construction of this part of the building may have occurred in the last decades of the fifteenth century.

To the south of the kitchen is the Tack room which is now known to contain timber felled in AD 1471–96 and AD 1570–95. The two earlier timbers, a stair runner and a common joist, can both be seen to be reused whilst the later date relates to the two main ceiling joists and a roof timber. These dates suggest construction of the tack room in the last decades of the sixteenth century, somewhat earlier than previously thought and utilising reused timber from the latter part of the fifteenth century. The reused samples match those from the Hall, the High-end tower, and reused timbers of the Barn particularly well.

The Hall and flanking towers were thought to date to the mid/late-fifteenth century and this has now been confirmed by the dendrochronology with timbers from this period being identified in all elements of this range.

A common joist from the Low end tower ground-floor ceiling has been dated to AD 1465. However, in addition to the usual caveat of dating a building/range on the basis of a single timber, a number of the timbers within this structure displayed signs to suggest previous use, such as smoke blackening and empty mortices. Therefore, it must be recognised that this timber might not be in its original position and cannot securely date the ceiling.

The ground-, first-, and second-floor frames of the High-end tower contain timber which was felled in AD 1471 and AD 1472, with it thought likely that construction followed shortly after. The turret roof on top of this tower appears to be very slightly later, utilising timber which was felled in AD 1476. It had been suggested that this might be a sixteenth-century alteration but it can now be seen to be only slightly later than the tower itself.

The hall roof contains timber felled in AD 1474. In bay 1 is a pair of moulded purlins which were thought to be reused timbers. However, it can be seen that the samples representing these beams (NAP-B13 and NAP-B14) are the same date as the rest of the roof timber and possibly have simply been reset. The lintel over a door adjoining the hall to the east tower has a *terminus post quem* for felling of AD 1468 and could therefore be of the same date as the roof and represent an original doorway and lintel.

The porch roof contains at least one timber of AD 1461–86 and a second timber with a *terminus post quem* for felling of AD 1457, with construction likely to have occurred in the second half of the fifteenth century. Similar to the turret, it had been suggested that this structure was a sixteenth-century addition but can now be said to be broadly contemporary with the rest of the North range, dating to the mid/late-fifteenth century.

The Woodshed roof is now known to contain timbers which were felled in AD 1456–81. However, it is thought likely that these represent reused timbers and, therefore, do not date the building itself but are clearly likely to have been originally associated with the major works in the AD 1460s and AD 1470s.

A number of reused timbers have also been used in the construction of the roof over the eighteenth-century Stable/Coach house-range barn. These have now been dated to AD 1461–86 and are thought likely to have been reused from a range or other building on the site given their similarity in date to other ranges at Nappa Hall and the level at which they match other samples (see below).

Generally, the level of matching seen, not only between samples of the same area but also between different areas, is very good, suggesting the same source of timber was used for the different areas. Indeed, sample NAP-B99, taken from the barn, matches samples NAP-B41 and NAP-B42, taken from common rafters of the turret roof at the very high level of t=11.3 and 16.3, respectively, and is likely to represent timbers cut from the same tree.

Those reference chronologies which match most highly with the two dated site sequences produced from Nappa Hall (Tables 2 and 3) can be seen to be generally in the north-east of the country suggesting that the woodland source utilised is relatively local in both the fifteenth century and the late-sixteenth century.

BIBLIOGRAPHY

Arnold, A J, Howard, R E, and Litton, C D, 2003 *Tree-ring analysis of timbers from Dilston Castle, Dilston Hall, Corbridge, Northumberland*, Centre for Archaeol Rep, **88/2003**

Arnold, A J, and Howard, R E, 2007a Nottingham Tree-Ring Dating Laboratory, *Vernacular Architect*, **38**, 106–14

Arnold, A J, and Howard, R E, 2007b *Tree-ring analysis of timbers from All Hallows Church, Kirkburton, West Yorkshire*, EH Res Dep Rep Ser, **49/2007**

Arnold, A J, and Howard, R E, 2008 unpubl Norton Conyers Hall, Wath, North Yorkshire, computer file *NRCASQ01*, Nottingham Tree-ring Dating Laboratory

Arnold, A J, and Howard, R E, 2008 Additional dendrochronological dates from Nottingham Tree-Ring Dating Laboratory, *Vernacular Architect*, **39**, 107–11

Arnold, A J, and Howard, R E, 2009 *Willimoteswick, Bardon Mill, Northumberland,Tree-ring analysis of timbers*, EH Res Dep Rep Ser, **87/2009**

Arnold, A J,and Howard, R E, 2011 *Low Bishopley, Frosterley, Weardale, County Durham, Tree-Ring Dating of Timbers*, EH Res Dep Rep Ser, **22/2011**

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1991 Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect*, **22**, 40–3

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1992 Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect*, **23**, 51–6

Howard, R E, Laxton, R R, Litton, C D, Morrison, A, Sewell, J, and Hook, R, 1993 Nottingham University Tree-Ring Dating Laboratory, Derbyshire, Peak Park and RCHME dendrochronological survey 1991–2, *Vernacular Architect*, **24**, 43–4

Howard, R E, Laxton, R R, Litton, C D, and Roberts, H M, 1996 Nottingham University Tree-Ring Dating Laboratory: buildings of the religious estates in medieval Durham; dendrochronological survey 1994–5, *Vernacular Architect*, **27**, 85–6

Howard, R E, Laxton, R R, and Litton, C D, 2001 *Tree-ring analysis of timbers from Hallgarth Manor Cottages, Hallgarth, Pittington, County Durham*, Centre for Archaeol Rep, **86/2001**

Howard, R E, Laxton, R R, and Litton, C D, 2002a *Tree-ring analysis of timbers from Tunstall Hall Farm, Elwick Road, Hartlepool, Cleveland*, Anc Mon Lab Rep, **61/2002**

Howard, R E, Laxton, R R, and Litton, C D, 2002b *Tree-ring analysis of timbers from the Gatehouse, Markenfield Hall, near Ripon, North Yorkshire*, Centre for Archaeol Rep, 59/2002

Menuge, A, and Went D, 2013 *Nappa Hall, Askrigg, North Yorkshire: an investigation and assessment of the late medieval hall in its immediate setting*, EH Res Rep Ser, 44/2013

TABLES

Table 1: Details of samples from Nappa Hall, Askrigg, Wensleydale, North Yorkshire

Sample number	Sample location	Total rings*	Sapwood rings**	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
Hall						
Roof						
NAP-B01	Tiebeam, truss 2	145	21	1327	1450	1471
NAP-B02	North lower purlin, truss 1–2	112	h/s	1335	1446	1446
NAP-B03	North principal rafter, truss 2	109	--	1320	----	1428
NAP-B04	Crown post, truss 2	92	--	1334	----	1425
NAP-B05	North brace, crown post to principal rafter, truss 2	88	01	1356	1442	1443
NAP-B06	West brace, crown post truss 2 to collar purlin	66	06	1383	1442	1448
NAP-B07	Tiebeam, truss 3	151	06	1308	1452	1458
NAP-B08	North principal rafter, truss 3	114	h/s	----	----	----
NAP-B09	South principal rafter, truss 3	74	03	1381	1451	1454
NAP-B10	East brace, north principal, truss 3	78	23	1392	1446	1469
NAP-B11	Crown post, truss 3	109	26C	1366	1448	1474
NAP-B12	South brace, truss 3	104	--	1315	----	1418
NAP-B13	North middle purlin, truss 1–2 (moulded)	69	03	1389	1454	1457
NAP-B14	South middle purlin, truss 1–2 (moulded)	87	06	1381	1461	1467
Other hall timbers						
NAP-B15	Screen partition beam	58	18C	----	----	----
NAP-B16	First-floor moulded window lintel	NM	--	----	----	----
NAP-B17	Lintel over door between Hall and Low-end tower (Hall side)	99	--	1355	----	1453
NAP-B18	Lintel over door between Hall and Low-end tower (Low-end tower side)	NM	--	----	----	----
High end tower						
Ground-floor ceiling						
NAP-B19	Main beam 1 (north)	167	22C	1305	1448	1471
NAP-B20	Common joist 3, bay 1	99	h/s	----	----	----

NAP-B21	Common joist 5, bay 1	164	27C	1309	1445	1472
NAP-B22	Main beam 2	149	14	1318	1452	1466
NAP-B23	Main beam 3	110	04	1349	1454	1458
NAP-B24	Common joist 3, bay 4	104	04	1346	1445	1449
First-floor ceiling						
NAP-B25	Main beam 1 (north)	110	02	1335	1442	1444
NAP-B26	Common joist 3, bay 2	76	h/s	1353	1428	1428
NAP-B27	Common joist 4, bay 2	144	40	1317	1420	1460
NAP-B28	Main beam 2	117	h/s	1330	1446	1446
NAP-B29	Main beam 3	124	h/s	1319	1442	1442
NAP-B30	Common joist 3, bay 4	70	--	1379	----	1448
Second-floor ceiling beams						
NAP-B31	Loose beam 1	115	12	1351	1453	1465
NAP-B32	Loose beam 2	81	h/s	1367	1447	1447
NAP-B33	Loose beam 3	71	h/s	1388	1458	1458
Lintels						
NAP-B34	Garderobe inner lintel	55	--	----	----	----
NAP-B35	Garderobe outer lintel	NM	--	----	----	----
NAP-B36	North wall, first-floor window, inner lintel	NM	--	----	----	----
Turret roof						
NAP-B37	Tiebeam, truss 2	90	01	1356	1444	1445
NAP-B38	Tiebeam, truss 3	67	--	----	----	----
NAP-B39	Ridge beam	96	--	1323	----	1418
NAP-B40	South wallplate	64	h/s	1390	1453	1453
NAP-B41	South common rafter 2, bay 1	95	14C	1382	1462	1476
NAP-B42	North common rafter 1, bay 2	83	--	1355	----	1437
Low-end tower						
Ground-floor ceiling beams						
NAP-B43	Main east-west ceiling beam	148	19C	----	----	----
NAP-B44	Common joist 2 (from east, north side of beam)	55	15	----	----	----
NAP-B45	Common joist 5	68	16C	1398	1449	1465
NAP-B46	Common joist 6	47	13	----	----	----

NAP-B47	Common joist 7	50	14	----	----	----
Service Range						
NAP-B48	Smokehood beam	50	15	----	----	----
Roof						
NAP-B49	North principal rafter, truss 1(east truss)	88	h/s	1351	1438	1438
NAP-B50	South principal rafter, truss 1	112	09	1341	1443	1452
NAP-B51	Tiebeam, truss 1	57	--	1378	----	1434
NAP-B52	North principal rafter, truss 2	122	h/s	1322	1443	1443
NAP-B53	South principal rafter, truss 2	115	--	1305	----	1419
NAP-B54	North common rafter 2, bay 1	61	29C	1401	1432	1461
NAP-B55	South common rafter 2, bay 1	76	18C	1386	1443	1461
NAP-B56	South common rafter 1, bay 2	NM	--	----	----	----
NAP-B57	South common rafter 2, bay 3	114	h/s	1333	1446	1446
NAP-B58	Ridge, bay 3	81	23C	1382	1439	1462
NAP-B59	North purlin, bay 2	58	15	1403	1445	1460
NAP-B60	North post truss 1 (moulded)	85	h/s	1339	1423	1423
NAP-B61	North post truss 2 (moulded)	107	09	1336	1433	1442
Tack room						
Ground-floor ceiling						
NAP-B62	North main east-west ceiling beam	90	16	1478	1551	1567
NAP-B63	South main east-west ceiling beam	92	14	1479	1556	1570
NAP-B64	Common joist 5 (from east, north side north beam; reused)	NM	--	----	----	----
NAP-B65	Common joist 11 (reused)	111	--	1300	----	1410
NAP-B66	Stair runner (reused)	58	h/s	1399	1456	1456
Roof						
NAP-B67	North principal rafter, truss 1(east truss)	111	h/s	----	----	----
NAP-B68	South principal rafter, truss 1	61	h/s	1499	1559	1559
NAP-B69	North principal rafter, truss 2	65	--	----	----	----
NAP-B70	South principal rafter, truss 2	NM	--	----	----	----
NAP-B71	Tiebeam, truss 1	87	09	----	----	----
NAP-B72	South upper purlin, bay 1	NM	--	----	----	----
NAP-B73	North lower purlin, bay 1	NM	--	----	----	----

NAP-B74	South upper purlin, bay 2	60	--	----	----	----
NAP-B75	South lower purlin, bay 2	96	h/s	----	----	----
NAP-B76	Tiebeam, truss 2	139	03	----	----	----
NAP-B77	South lower purlin, bay 3	66	10	----	----	----
NAP-B78	North lower purlin, bay 2	72	--	----	----	----
East wing						
NAP-B79	Ground-floor beam 1	75	h/s	1381	1455	1455
NAP-B80	Ground-floor beam 2	NM	--	----	----	----
Porch						
Roof						
NAP-B81	Tiebeam, truss 2	85	03	----	----	----
NAP-B82	East wallplate, bay 2	NM	--	----	----	----
NAP-B83	Corbal	123	--	----	----	----
NAP-B84	Ridge beam, bay 1	122	--	1311	----	1432
NAP-B85	Tiebeam, truss 1	NM	--	----	----	----
NAP-B86	Ridge beam, bay 2	58	h/s	1389	1446	1446
Woodshed						
Roof						
NAP-B87	North upper purlin, bay 3	NM	--	----	----	----
NAP-B88	North lower purlin, bay 3	NM	--	----	----	----
NAP-B89	South upper purlin, bay 3	NM	--	----	----	----
NAP-B90	South lower purlin, bay 3	NM	--	----	----	----
NAP-B91	North common rafter 3, bay 3	93	h/s	----	----	----
NAP-B92	North common rafter 4, bay 3	81	h/s	1367	1447	1447
NAP-B93	North upper purlin, bay 2	55	h/s	----	----	----
NAP-B94	South upper purlin, bay 1	152	24C	----	----	----
NAP-B95	North common rafter 5, bay 1	69	04	1382	1446	1450
NAP-B96	North common rafter 3, bay 1	84	h/s	1367	1450	1450
NAP-B97	North lower purlin, bay 1	117	h/s	1316	1432	1432
NAP-B98	North lower purlin, bay 2	122	h/s	1307	1428	1428
Stable/Coach house barn						
Reused roof timbers						

NAP-B99	East lower purlin, bay 4	118	h/s	1329	1447	1447
NAP-B100	East middle purlin, bay 5	110	h/s	1328	1437	1437
NAP-B101	East lower purlin, bay 6	119	h/s	1324	1442	1442
NAP-B102	West middle purlin, bay 6	111	h/s	1345	1455	1455
NAP-B103	West common rafter 5, bay 6	83	h/s	1341	1423	1423
NAP-B104	East lower purlin, bay 7	103	h/s	1350	1452	1452
NAP-B105	East middle purlin, bay 7	107	h/s	1345	1451	1451
NAP-B106	West lower purlin, bay 7	125	h/s	1319	1443	1443
NAP-B107	West middle purlin, bay 7	72	02	1389	1458	1460
NAP-B108	East backing rafter, truss 6	98	h/s	1356	1453	1453
NAP-B109	East lower purlin, bay 9	56	h/s	----	----	----
NAP-B110	West lower purlin, bay 9	87	h/s	1363	1449	1449

*NM = not measured
**h/s = heartwood/sapwood boundary is the last-measured ring
C = complete sapwood retained on sample, last measured ring is the felling date

Table 2: Results of the cross-matching of site sequence NAPBSQ01 and relevant reference chronologies when the first-ring date is AD 1300 and the last-measured ring date is AD 1476

Reference chronology	*t*-value	Span of chronology	Reference
Tunstall Hall Farm, Hartlepool, Cleveland	9.4	AD 1316–1484	Howard *et al* 2002a
Seaton Holme, Easington, County Durham	9.0	AD 1375–1489	Arnold *et al* 2008
Willimoteswick, Bardon Mill, Northumberland	8.9	AD 1330–1575	Arnold and Howard 2009
Kepier Farm Hospital, Durham	8.9	AD 1304–1522	Howard *et al* 1996
35 The Close, Newcastle-upon-Tyne, Northumberland	8.8	AD 1365–1513	Howard *et al* 1991
Norton Conyers Hall, West Yorkshire	8.7	AD 1365–1486	Arnold and Howard, 2008 unpubl
Horbury Hall, Wakefield	8.6	AD 1368–1473	Howard *et al* 1992

Table 3: Results of the cross-matching of site sequence NAPBSQ02 and relevant reference chronologies when the first-ring date is AD 1478 and the last-measured ring date is AD 1570

Reference chronology	*t*-value	Span of chronology	Reference
Hallgarth Pittington, County Durham	7.4	AD 1336–1624	Howard *et al* 2001
Low Bishopley, Frosterley, Weardale, County Durham	7.0	AD 1501–1581	Arnold and Howard 2011
Grange Farm, Norton, Sheffield, South Yorkshire	6.8	AD 1436–1599	Arnold and Howard 2007a
Dilston Castle, Corbridge, Northumberland	6.5	AD 1402–1611	Arnold *et al* 2003
Markenfield Hall, Nr Ripon, North Yorkshire	6.4	AD 1388–1589	Howard *et al* 2002b
Frith Hall, Brampton, Derbyshire	6.2	AD 1480–1602	Howard *et al* 1993
All Hallows Church, Kirkburton, West Yorkshire	6.2	AD 1306–1633	Arnold and Howard 2007b

FIGURES

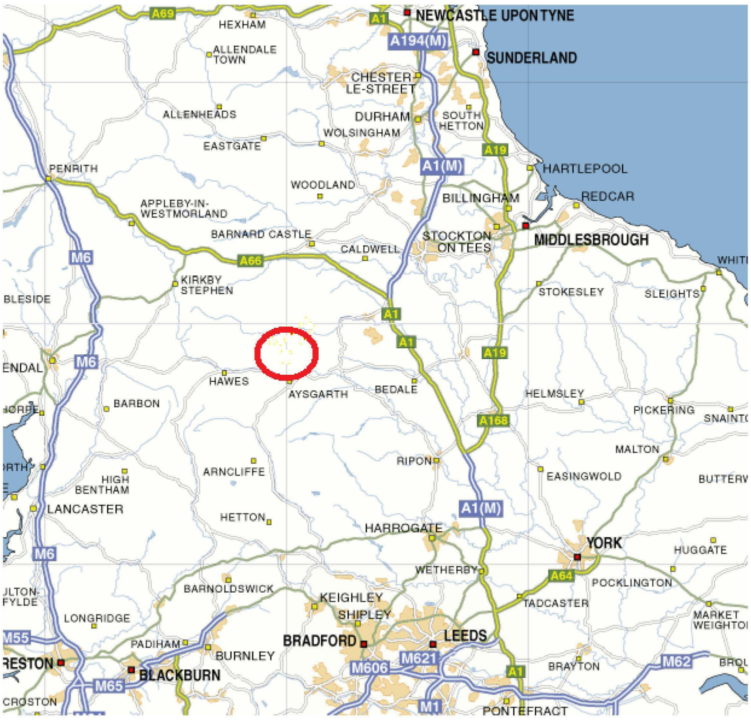

Figure 1: Map to show the general location of Askrigg, circled. © Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900.

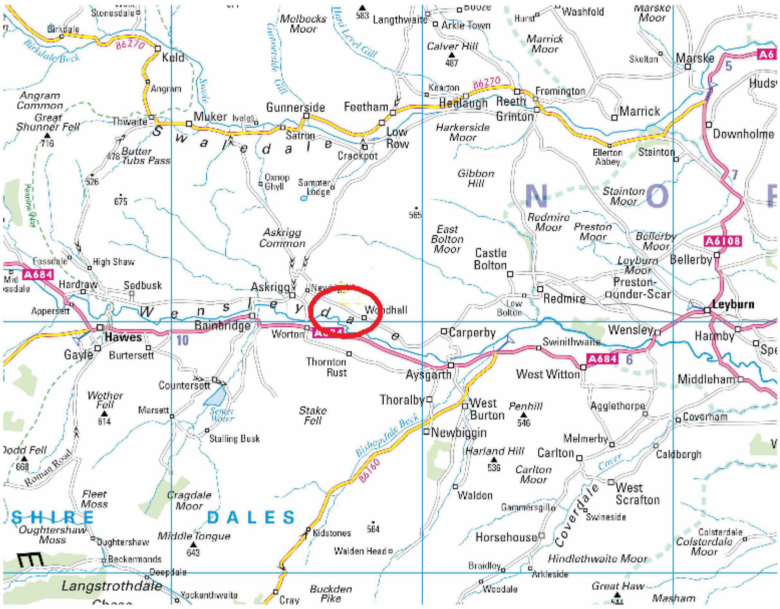

Figure 2: Map to show the general location of Nappa Hall, circled. © Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900

Figure 3: Map to show the location of Nappa Hall. © Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900.

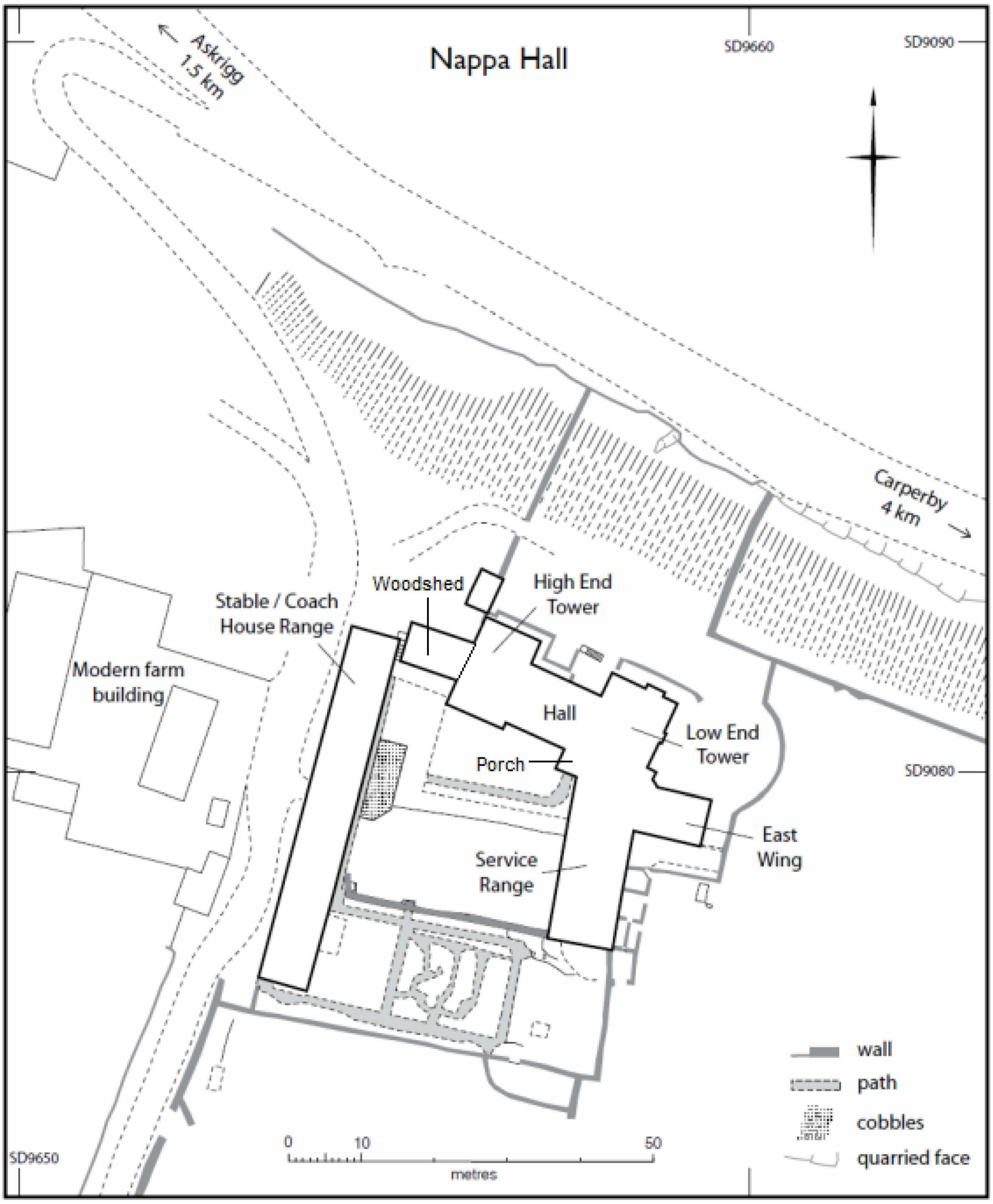

Figure 4: Plan of Nappa Hall, showing the areas investigated (Menuge and Went 2013, Fig 2)

Figure 5: North range, with Woodshed to left and Low-end tower to right (Alison Arnold)

Figure 6: Hall roof, truss 2 in the foreground, photograph taken from the south-east (Robert Howard)

Figure 7: High-end tower, first-floor ceiling frame (from above) with main beams from the second floor lain loose by the walls (Alison Arnold)

Figure 8: High-end tower, turret roof, truss 2 in foreground, photograph taken from the east (Robert Howard)

Figure 9: Low-end tower, ground-floor ceiling frame, photograph taken from the south-west (Robert Howard)

Figure 10: Porch roof, truss 2 in foreground, photograph taken from the south (Alison Arnold)

Figure 11: Woodshed, roof, bay 2, photograph taken from the south-west (Alison Arnold)

Figure 12: Service range, Kitchen to the left and cow byre to the right (Alison Arnold)

Figure 13: Service range, Kitchen, smokehood bressummer, photograph taken from the south-east (Robert Howard)

Figure 14: Service range, Kitchen roof, truss 1, photograph taken from the west (Alison Arnold)

Figure 15: Service range, Tack room, ground-floor ceiling, photograph taken from the north-west (Alison Arnold)

Figure 16: Service range, Tack room roof, truss 2, photograph taken from the west (Alison Arnold)

Figure 17: East wing, photograph taken from the south (Alison Arnold)

Figure 18: East wing, ground-floor ceiling beam, photograph taken from the east (Alison Arnold)

Figure 19: Stable/Coach-house range, photograph taken from the south-east (Robert Howard)

Figure 20: Stable/Coach-house range, stable roof, truss 6 in the foreground, photograph taken from the north (Robert Howard)

Figure 21: Stable/Coach-house range, stable roof, bay 7, photograph taken from the east (Robert Howard)

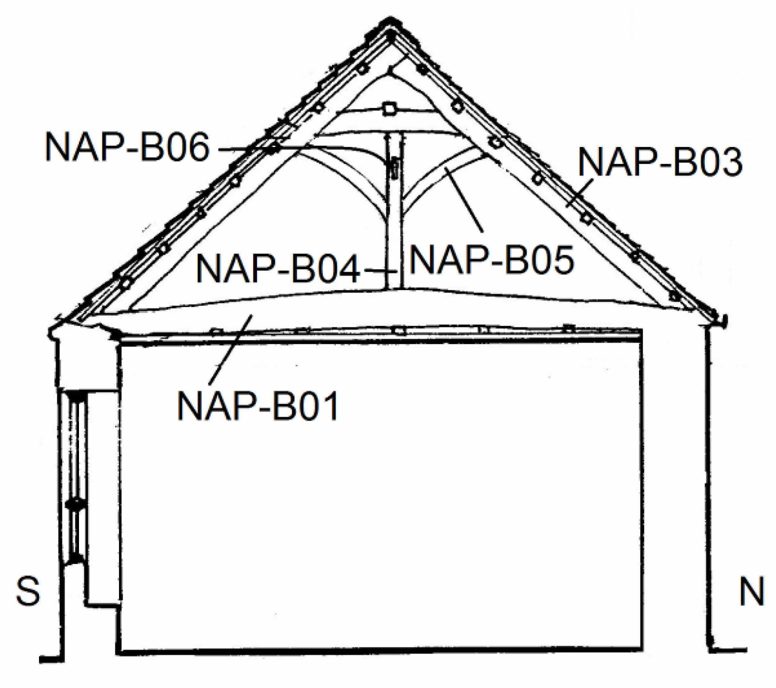

Figure 22: Hall, truss 2, showing the location of samples NAP-B01, NAP-B03–6 (John Warren)

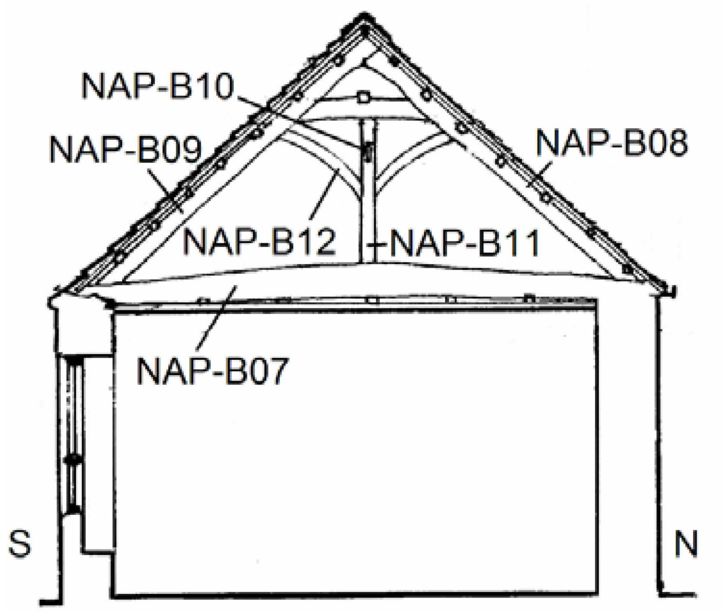

Figure 23: Hall, truss 3, showing the location of samples NAP-B07–12 (JohnWarren)

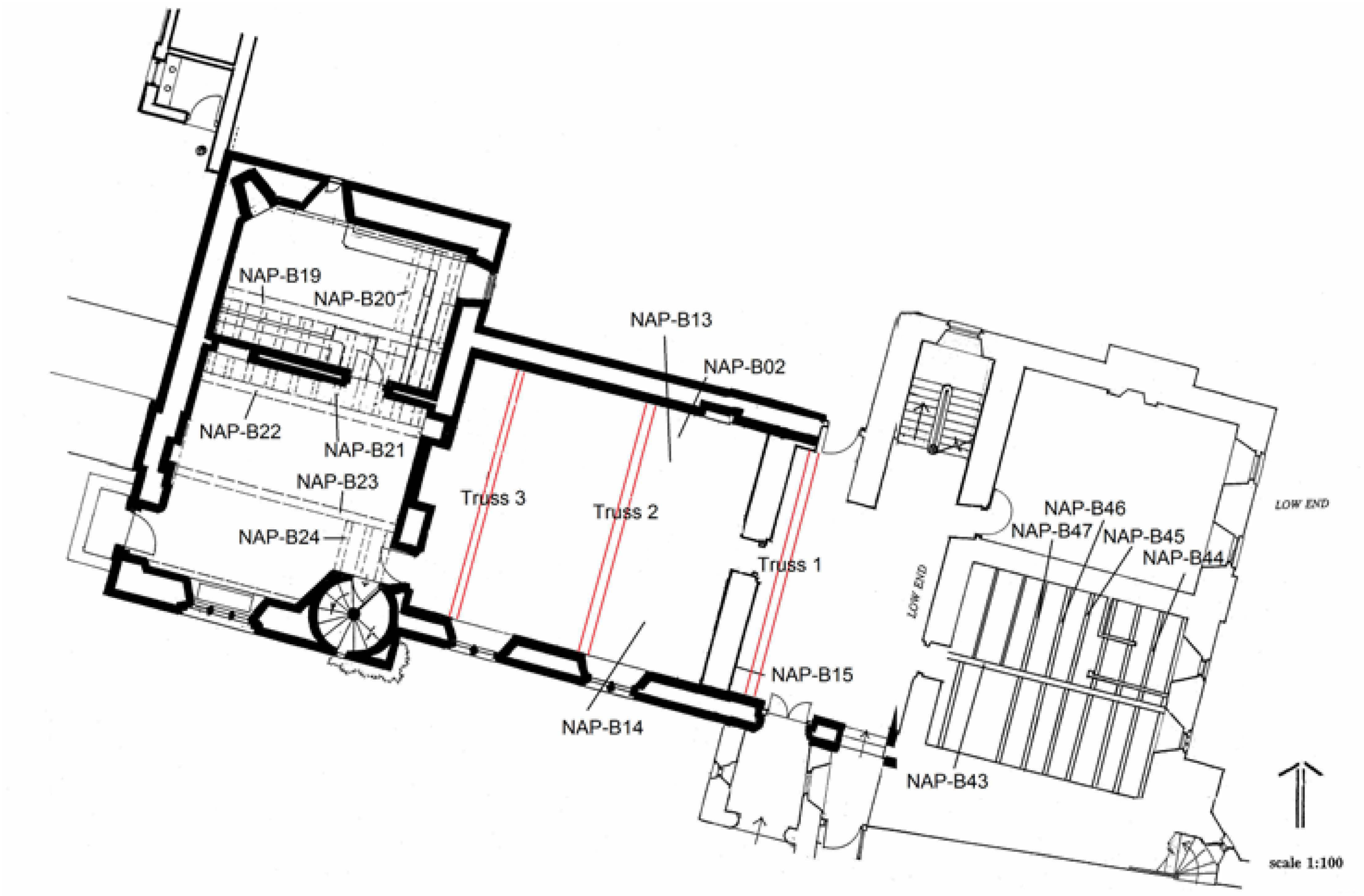

Figure 24: North range, ground-floor plan showing the location of samples NAP-B02, NAP-B13–15, NAP-B19–24, and NAP-B43–47 (John Warren)

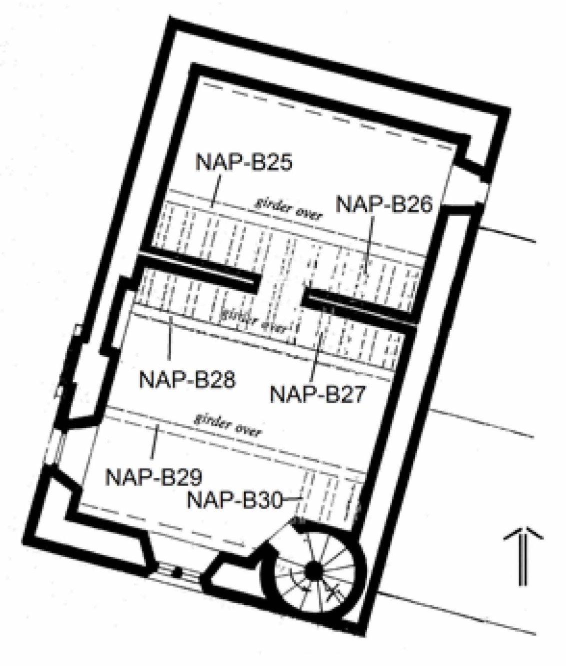

Figure 25: High-end tower, west tower, first-floor plan showing the location of samples NAP-B25–30 (John Warren)

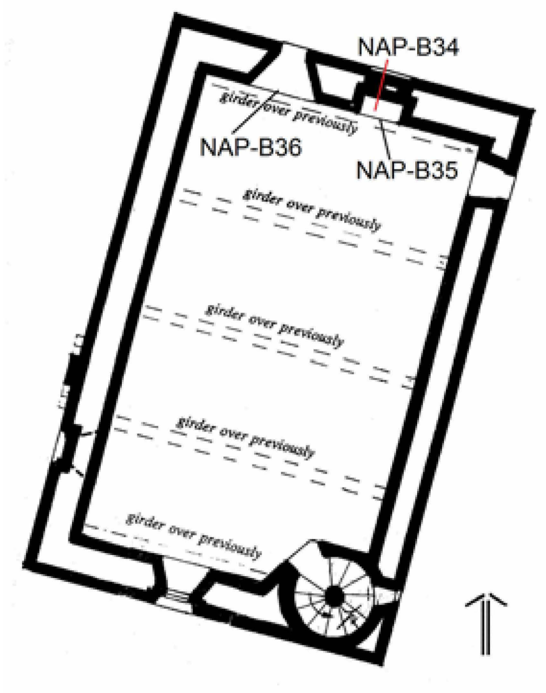

Figure 26: High-end tower, second-floor plan showing the location of samples NAP-B34–6 (John Warren)

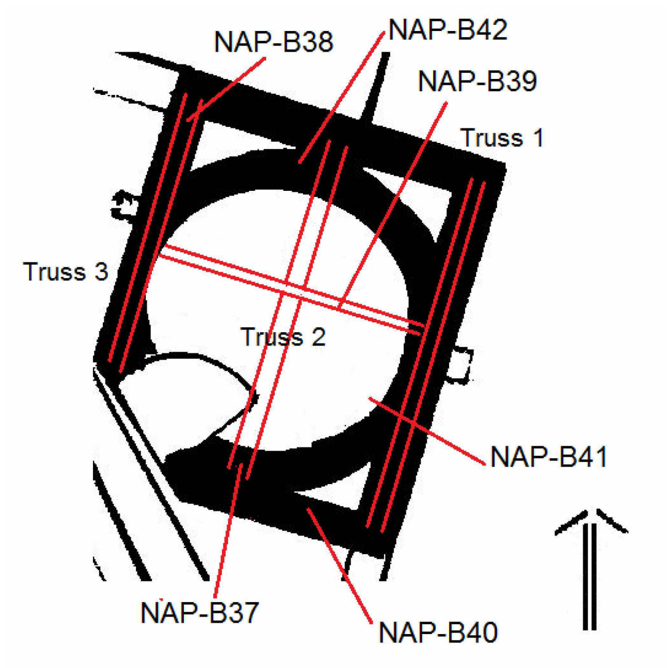

Figure 27: High-end tower, Turret roof, plan showing the location of samples NAP-B37–42 (John Warren)

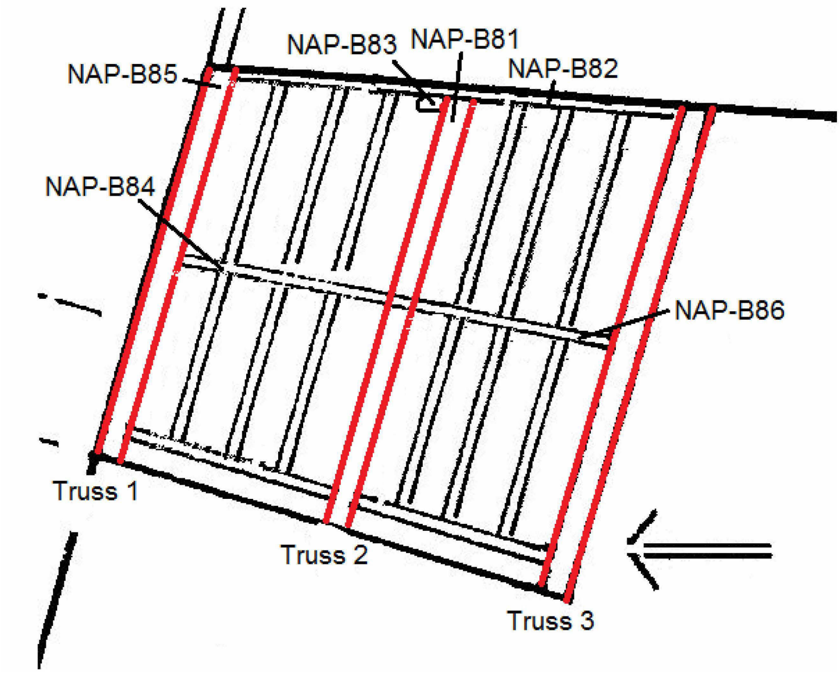

Figure 28: Porch roof, plan showing the location of samples NAP-B81–6 (John Warren)

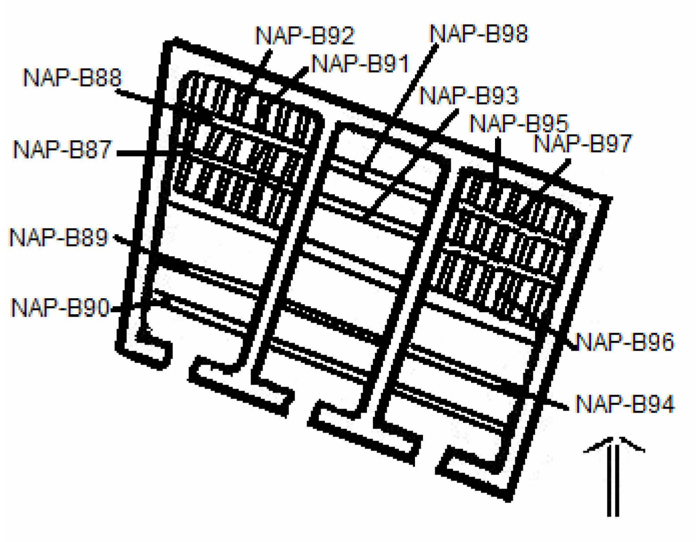

Figure 29: Woodshed, sketch plan showing the location of samples NAP-B87-97

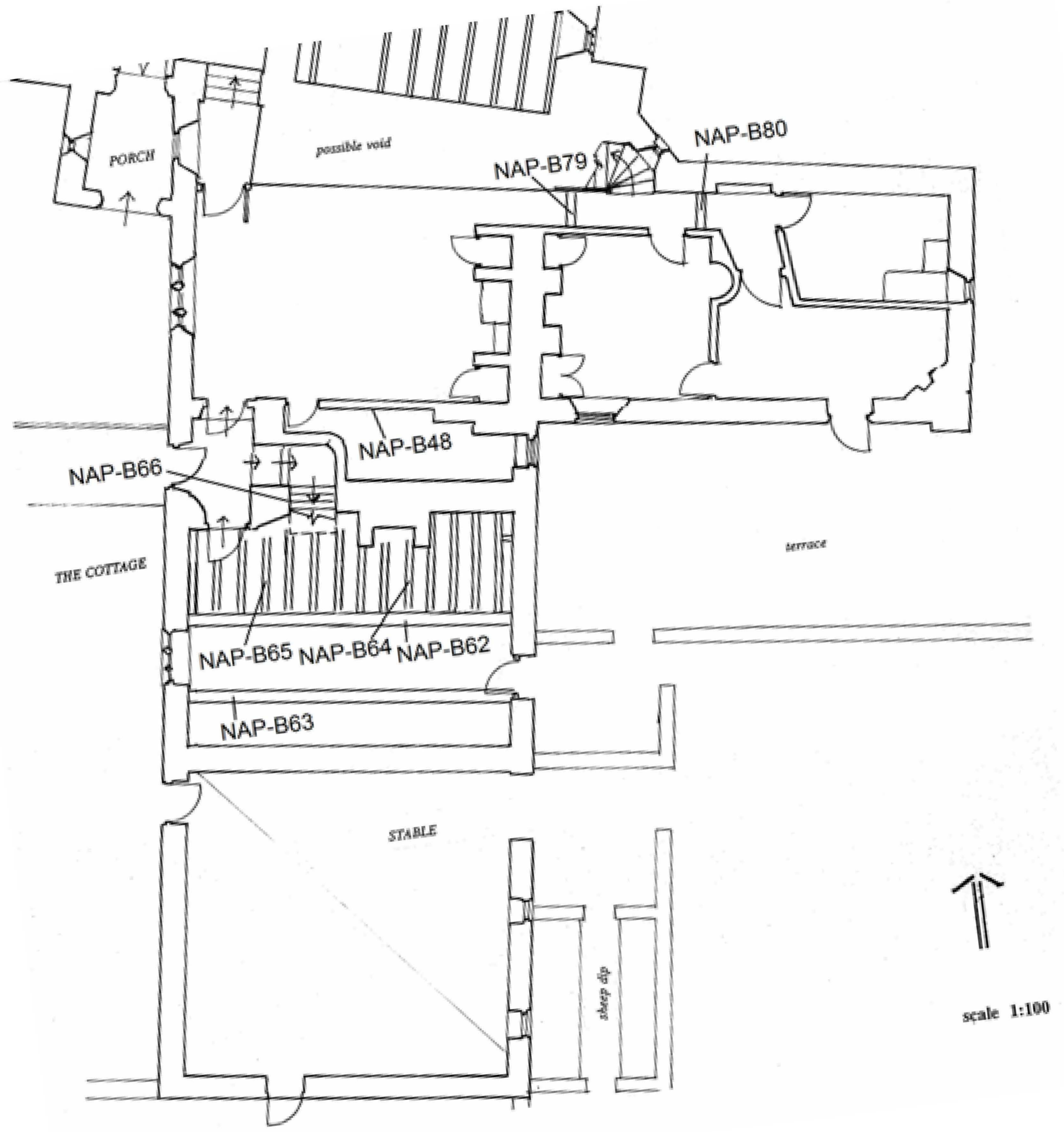

Figure 30: Service range and east wing, ground-floor plan showing the location of samples NAP-B48, NAP-B62–6, and NAP-B79–80 (John Warren)

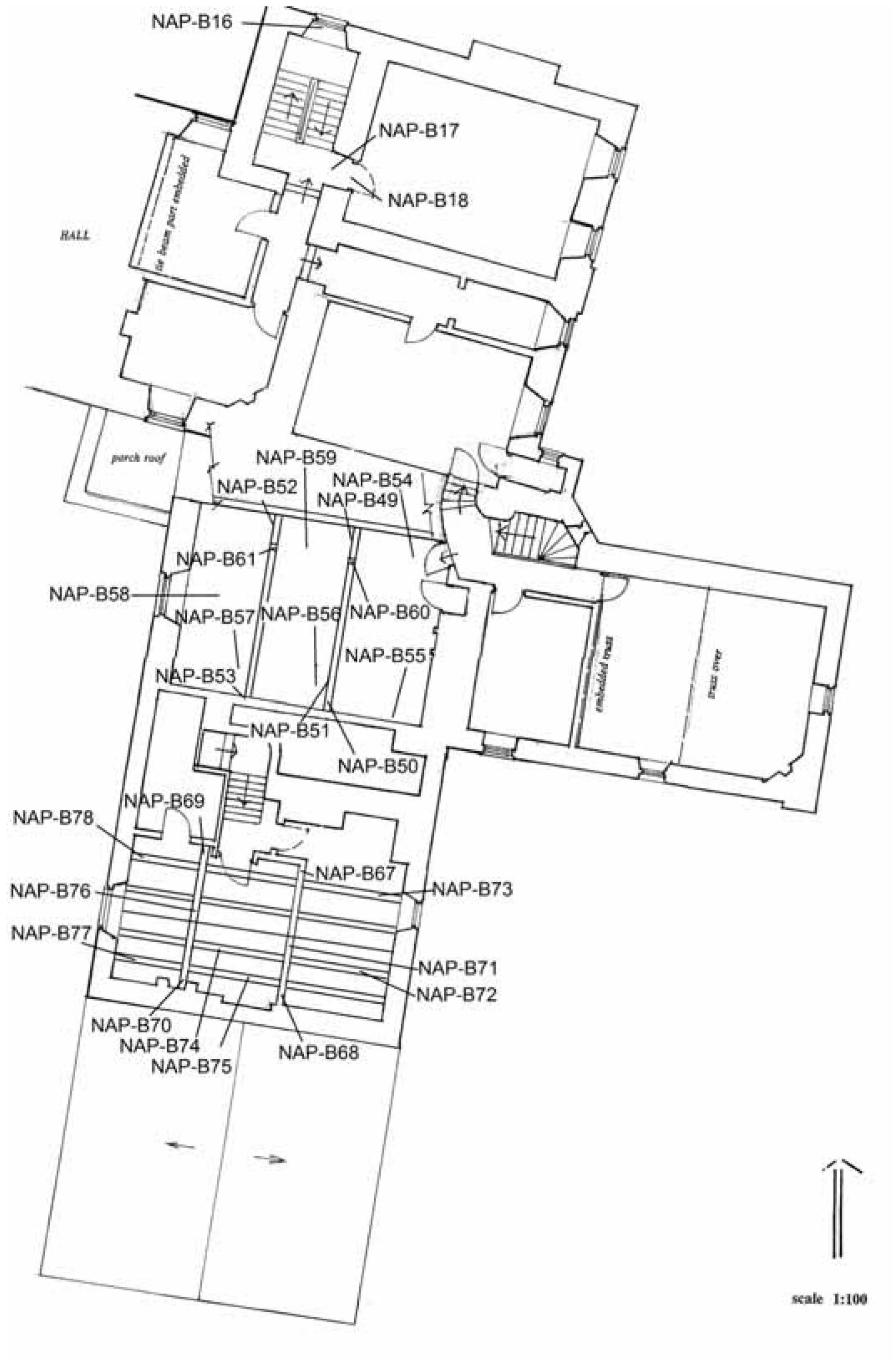

Figure 31: Low-end tower and service range, first-floor plan showing the location of samples NAP-B16–18, NAP-B49–61 and NAP-B67–78 (John Warren)

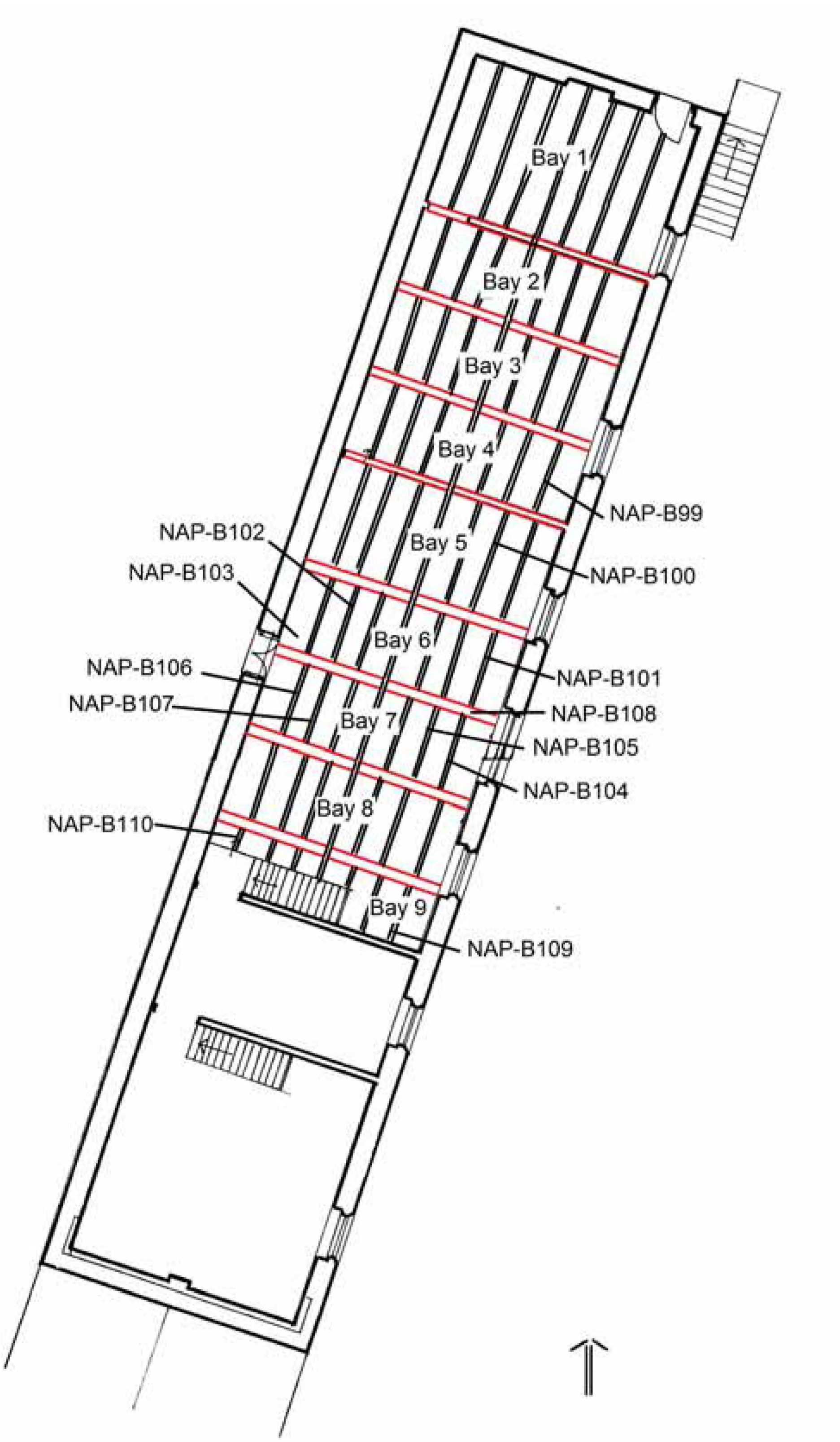

Figure 32: Stables/Coach-house range, first-floor plan showing the location of samples NAP-B99-110 (John Warren)

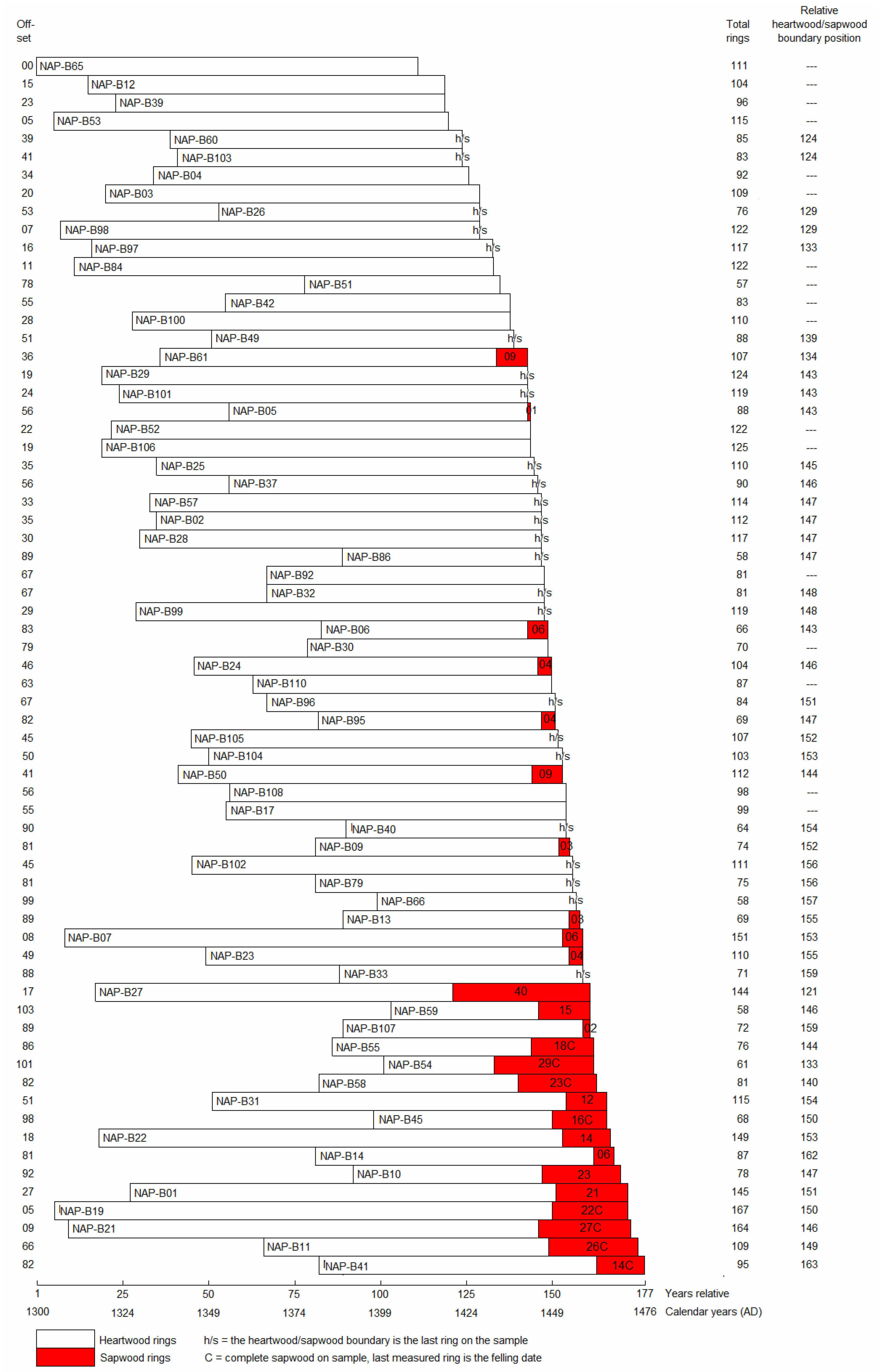

Figure 33: Bar diagram of samples in site sequence NAPBSQ01

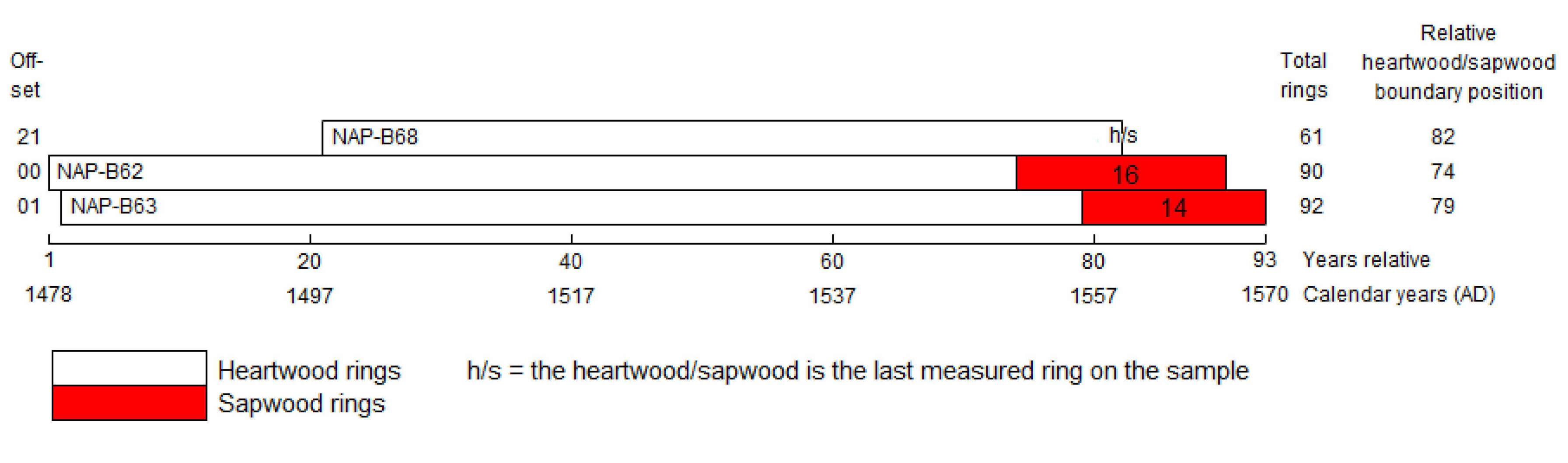

Figure 34: Bar diagram of samples in site sequence NAPBSQ02

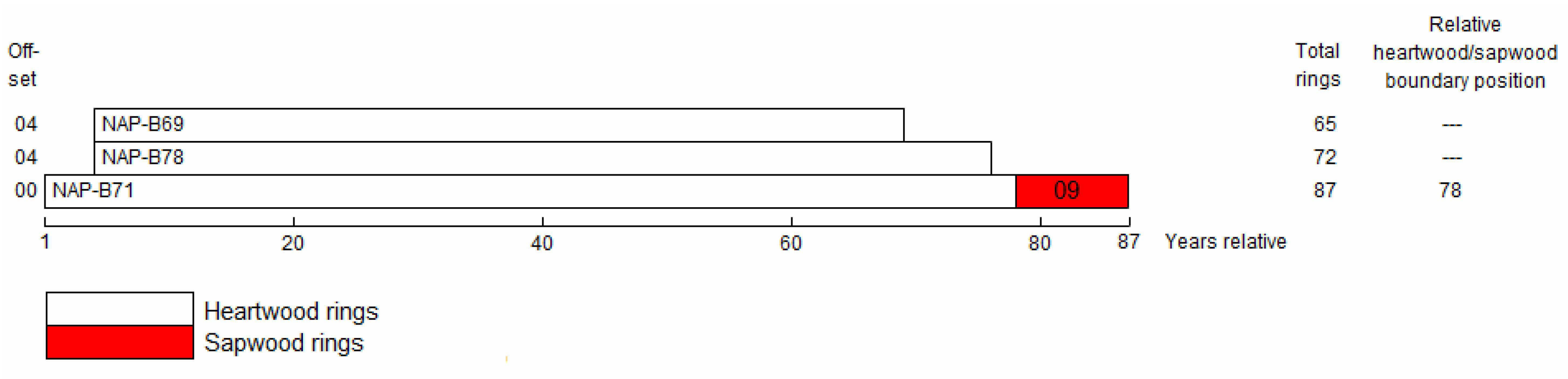

Figure 35: Bar diagram of samples in undated site sequence NAPBSQ03

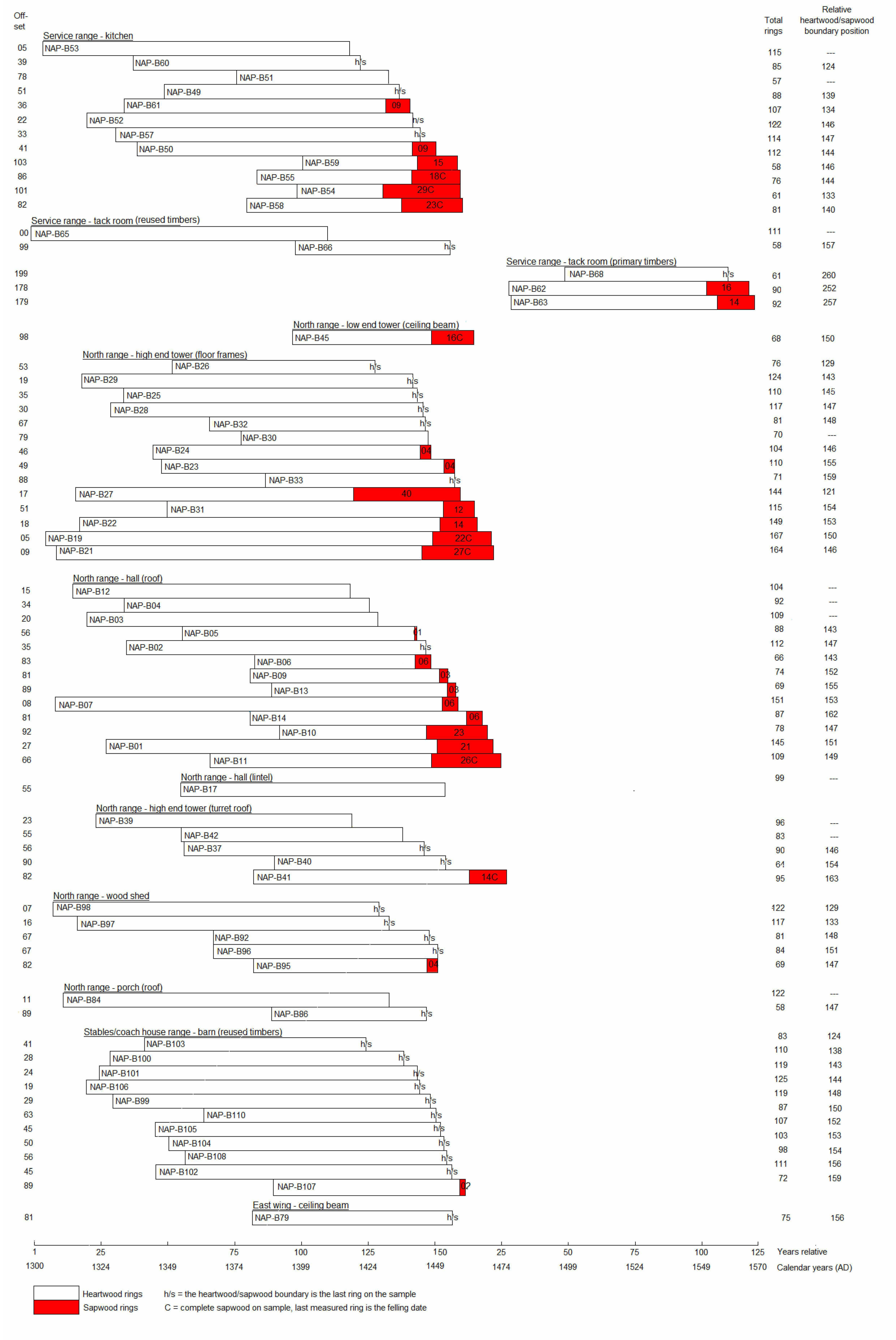

Figure 36: Bar diagram of all dated samples, sorted by area, from Nappa Hall

DATA OF MEASURED SAMPLES

Measurements in 0.01mm units

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168 204 264 165 113 108 152 149 134 128 139 134 133 78 144 93 128 118 134 125
99 105 142 115 124 141 107 126 129 69 107 102 138 120 109 117 99 116 95 100
102 91 87 80 96 101 81 80 74 92 81 62 90 94 111 94 96 91 83 67
64 79 124 111 107 105 95 80 78 75 81 117 79 94 116 89 99 103 81 92
107 64 39 26 45 49 53 57 74 74 101 72 58 61 67 79 79 76 84 66
44 61 88 69 81 82 79 63
NAP-B01B 100
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115 96 93 77 91 65 72 87 99 123 99 94 94 75 79 73 94 118 114 93
110 107 65 84 64 77 95 53 85 85 79 68 69 59 83 77 57 45 37 37
47 54 46 54 50 77 60 70 71 67 66 69 65 78 46 36 66 61 62 65
73 65 70 76 81 67 54 69 60 73 76 74 60 65 79 72 88 66 62 76
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124 121 112 136 146 153 126 133 128 137 128 155 182 196 190 143 157 126 150 120
192 151 96 125 111 136 136 104 104 92 94 119 77 98 89 110 72 77 71 68
62 56 62 78 62 94 77 65 65 51 49 66 54 77 59 49 76 73 52 59
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130 116 106 136 138 148 131 132 122 130 127 159 181 204 182 152 150 133 149 121
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187 271 163 100 160 134 164 172 187 158 122 140 157 131 104 124 115 84 90 52
66 47 110 103 105 82 96 70 91 104 105 106 93 74 71 39 50 69 72 69
61 59 63 54 61 55 62 86 61 50 68 74 98 73 92 114 95 61 95 138
139 157 246 114 138 124 109 130 168 177 128 120 108 104 80 92 82 121 85 129
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270 357 322 415 297 270 264 230 253 226 238 248 221 212 196 212 182 213 236 243
185 180 167 169 162 190 157 153 137 138 187 144 146 162 203 170
NAP-109B 56
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275 365 310 392 308 263 260 229 260 223 239 243 225 212 197 208 193 200 242 238
187 178 162 172 164 189 156 155 136 140 187 144 146 162 197 151
NAP-110A 87
173 213 264 200 216 119 129 154 198 217 135 140 141 102 110 139 135 114 111 124
87 88 82 82 83 85 81 61 69 79 76 85 78 104 95 89 110 156 133 125
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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 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

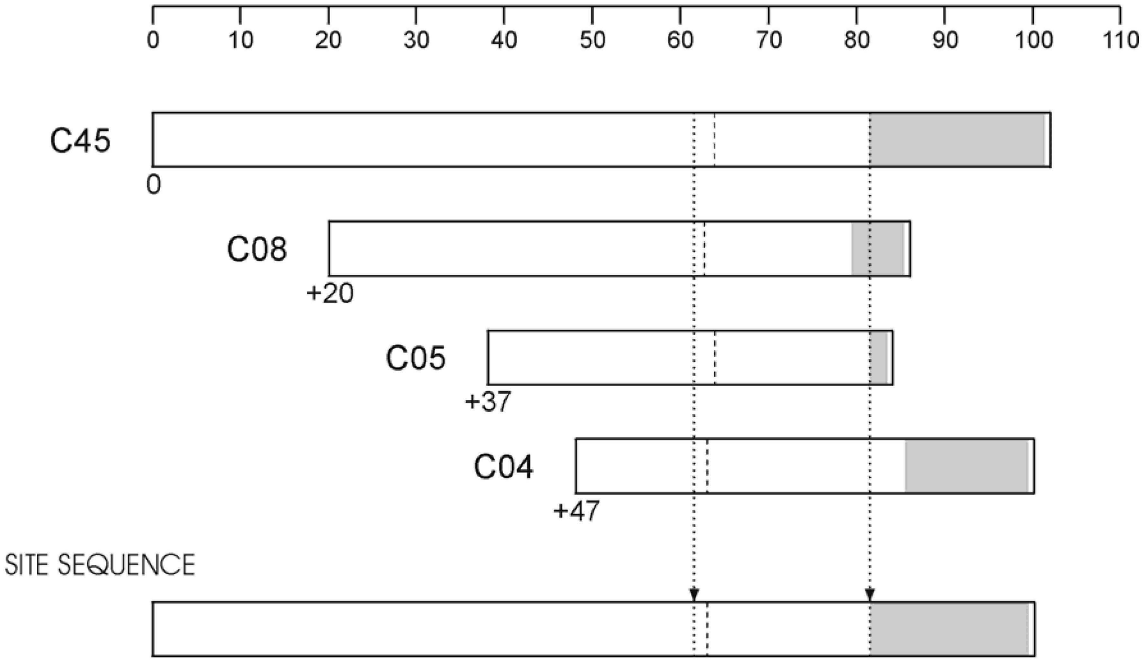


Figure A5: Cross-matching of four sequences from a Lincoln Cathedral roof and the formation of a site sequence from them

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.

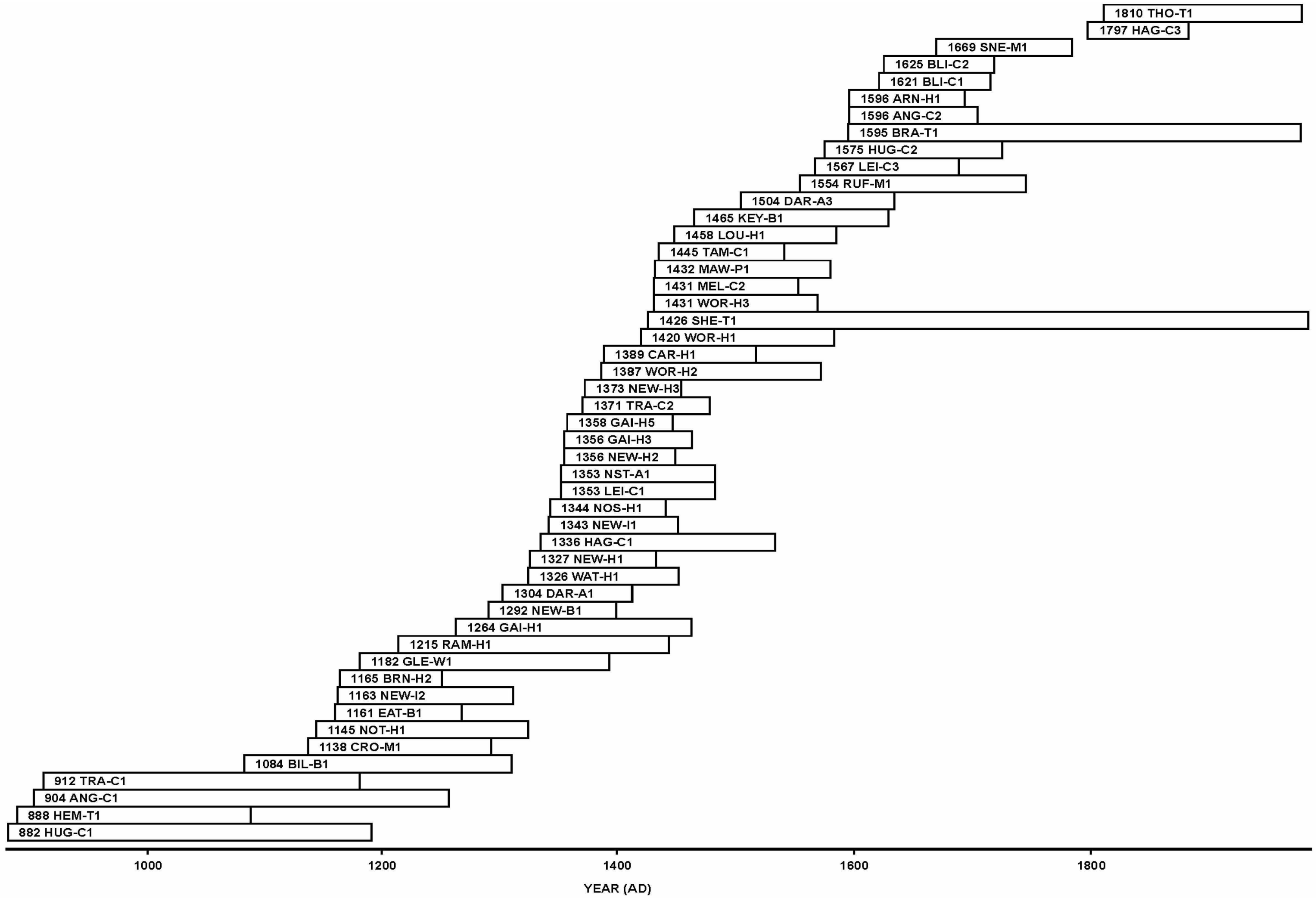
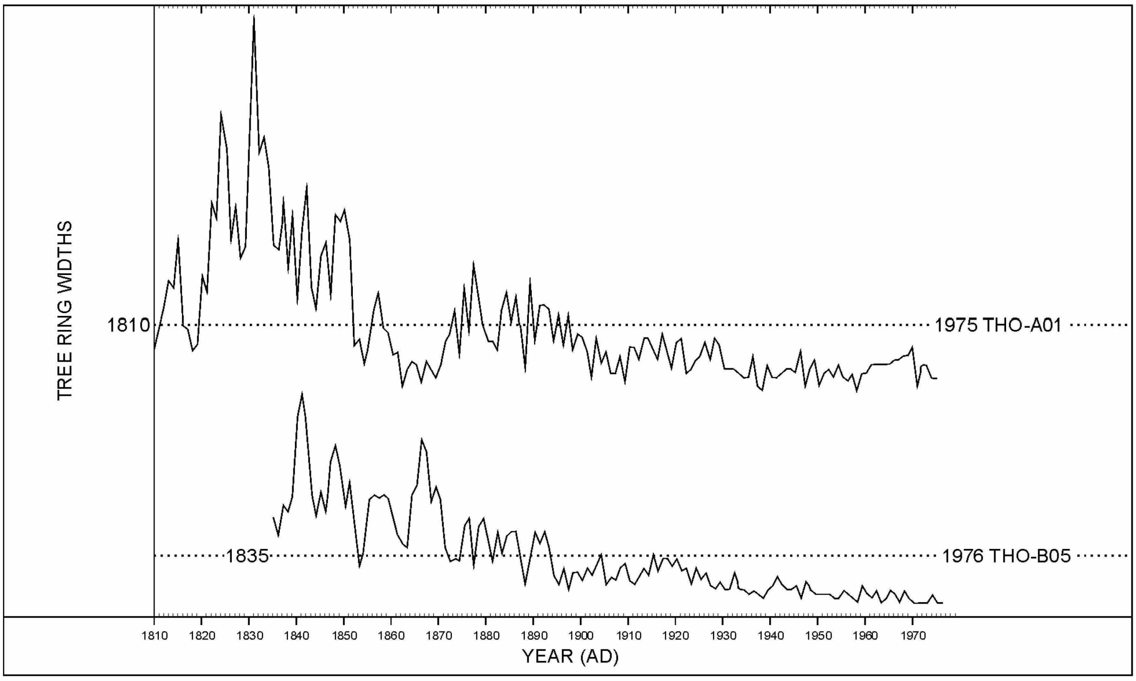


Figure A6: Bar diagram showing the relative positions and dates of the first rings of the component site sequences in the East Midlands Master Dendrochronological Sequence, EM08/87

(a)



(b)

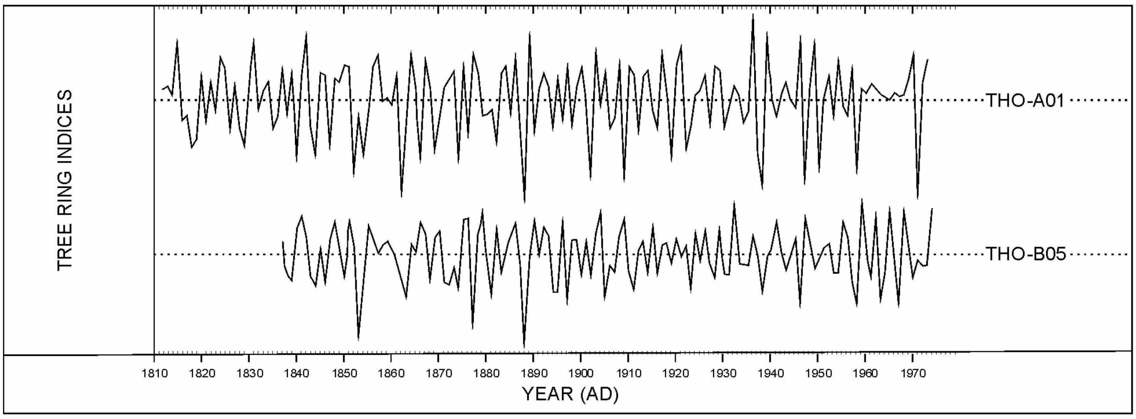


Figure A7 (a): The raw ring-widths of two samples, THO-A01 and THO-B05, whose felling dates are known

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

References

Baillie, M G L, and Pilcher, J R, 1973 A simple cross-dating program for tree-ring research, *Tree-Ring Bull*, **33**, 7–14

English Heritage, 1998 Dendrochronology: *Guidelines on Producing and Interpreting Dendrochronological Dates*, London

Hillam, J, Morgan, R A, and Tyers, I, 1987 Sapwood estimates and the dating of short ring sequences, Applications of tree-ring studies, *BAR* Int Ser, **3**, 165–85

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1984–95 Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect*, **15–26**

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1992 List 44 no 17 - Nottingham University Tree-Ring Dating Laboratory: tree-ring dates for buildings in the East Midlands, *Vernacular Architect*, **23**, 51–6

Hughes, M K, Milson, S J, and Legett, P A, 1981 Sapwood estimates in the interpretation of tree-ring dates, *J Archaeol Sci*, **8**, 381–90

Laxon, R R, Litton, C D, and Zainodin, H J, 1988 An objective method for forming a master ring-width sequence, *P A C T*, **22**, 25–35

Laxton, R R, and Litton, C D, 1988 *An East Midlands Master Chronology and its use for dating vernacular buildings, University of Nottingham*, Department of Archaeology Publication, Monograph Series III

Laxton, R R, and Litton, C D, 1989 Construction of a Kent master dendrochronological sequence for oak, AD 1158 to 1540, *Medieval Archaeol*, **33**, 90–8

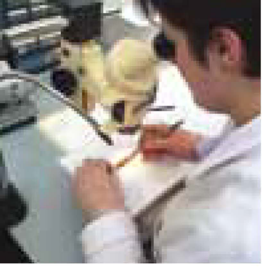
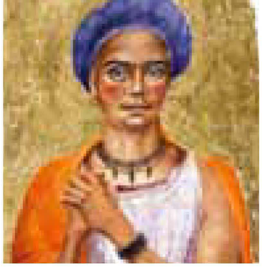
Laxton, R R, Litton, C D, and Howard, R E, 2001 *Timber: Dendrochronology of Roof Timbers at Lincoln Cathedral*, Engl Heritage Res Trans, 7

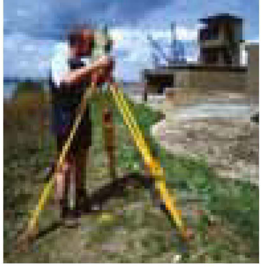
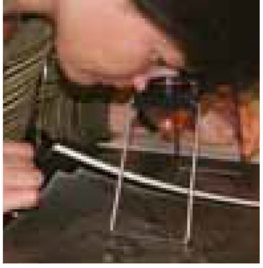
Litton, C D, and Zainodin, H J, 1991 Statistical models of dendrochronology, *J Archaeol Sci*¸**18**, 29–40

Miles, D W H, 1997 The interpretation, presentation and use of tree-ring dates, *Vernacular Architect*, **28**, 40–56

Pearson, S, 1995 *The Medieval Houses of Kent, an Historical Analysis*, London

Rackham, O, 1976 *Trees and Woodland in the British Landscape*, London


ENGLISH HERITAGE RESEARCH AND THE HISTORIC ENVIRONMENT

English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for the protection and sustainable management of the resource, and to promote the widest access, appreciation and enjoyment of our heritage. Much of this work is conceived and implemented in the context of the National Heritage Protection Plan. For more information on the NHPP please go to http://www.english-heritage.org.uk/professional/protection/national-heritage-protection-plan/.

The Heritage Protection Department provides English Heritage with this capacity in the fields of building history, archaeology, archaeological science, imaging and visualisation, landscape history, and remote sensing. It brings together four teams with complementary investigative, analytical and technical skills to provide integrated applied research expertise across the range of the historic environment. These are:

- Intervention and Analysis (including Archaeology Projects, Archives, Environmental Studies, Archaeological Conservation and Technology, and Scientific Dating)
- Assessment (including Archaeological and Architectural Investigation, the Blue Plaques Team and the Survey of London)
- Imaging and Visualisation (including Technical Survey, Graphics and Photography)
- Remote Sensing (including Mapping, Photogrammetry and Geophysics)

The Heritage Protection Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support community engagement and build this in to our projects and programmes wherever possible.

We make the results of our work available through the Research Report Series, and through journal publications and monographs. Our newsletter *Research News*, which appears twice a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities.

A full list of Research Reports, with abstracts and information on how to obtain copies, may be found on www.english-heritage.org.uk/researchreports

For further information visit www.english-heritage.org.uk

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