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Dendrochronology, timber analysis, and historic building consultants

1–5 BRIDGE STREET, BIDEFORD, DEVON, TREE-RING ANALYSIS OF TIMBERS

A J ARNOLD
R E HOWARD

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SUMMARY

Analysis by dendrochronology of 24 oak samples and three pine samples obtained from these buildings has resulted in the production of two dated oak site chronologies and one undated pine site chronology.

The first oak site chronology, BIDASQ01, comprising 14 samples from 1, 2, 3, and 5 Bridge Street is 223 rings long, these rings dated as spanning the years 1484–1706. The second oak site chronology, BIDASQ02, comprises four samples, all of them from number 3 Bridge Street. This site chronology is 88 rings long, these rings dated as spanning the years 1632–1720.

Taken overall, the interpretation of the sapwood on the dated samples would indicate that a number of timbers were cut as part of a single programme of felling some time between, say, 1620–35. Such timbers include those used in the second-floor ceiling and two fireplace lintels of 1 Bridge Street, and the roof of 2 Bridge Street. These timbers were used in conjunction with a few others, also from the roof of 2 Bridge Street, which had been felled earlier (and probably at different times to each other) in the late-sixteenth century or early-seventeenth century. Further timbers, felled in 1706, were used for the main ground-floor ceiling beams of 5 Bridge Street. The final phase of felling is represented by the roof timbers of 3 Bridge Street which were felled in 1720.

The third site chronology, BIDPSQ03, comprises samples from two pine beams to the ground-floor ceilings of 1 and 2 Bridge Street. Although undated, it would appear that the two timbers are coeval with each other and represent a single phase of felling.

Three oak samples remain ungrouped and undated.

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

Introduction

The buildings that now comprise numbers 1–5 stand on the south side of Bridge Street (SS 453 264, Figs 1a/b and 2a/b) as it rises steeply away from the west bank of the river Torridge. Parts of the building, particularly number 1 Bridge Street (see plan Fig 3), were formerly the Royal Mail public house, the pub gradually extending along the street to incorporate numbers 2 and 3, and then number 4 and 5 Bridge Street, into its premises (number 5 previously having been a shop). The pub had been closed, and the buildings unoccupied, for some considerable time before recently being purchased. Although a full drawn survey and record has not been undertaken as part of this programme of tree-ring dating, the description for number 1 Bridge Street lists it as being of early seventeenth century date (though remodelled externally in the mid-nineteenth century), and as having an early seventeenth century broad-rib ceiling divided by inserted partitions.

Within, apart from a single beam to the second-floor ceiling of number 1 Bridge Street (Fig 4a), and single lintels to the first- and ground-floor fireplaces (Figs 4b/c), there are no oak timbers to the lower rooms of this part of the building. The ground-floor ceilings of numbers 1, 2, and 3 Bridge Street, however, are formed of a series of large pine beams from which run smaller joists, also of pine (Fig 4d). There are no lower timbers to 4 Bridge Street while the ground-floor ceiling of number 5 (Fig 4e) comprises five main oak beams without any smaller common joists.

The roofs of these buildings are of varied form. That to 1 Bridge Street is in essence of lean-too construction formed, north–south, against the east wall of number 2 Bridge Street. It is composed of a variety of small softwood timbers of different sizes, forming a few common rafter frames. None of these appear to be particularly aged, all probably being of nineteenth and twentieth century date. It is also likely that one or two of the roof timbers are of pine.

The east–west roof to number 2 Bridge Street (Fig 4f) comprises two principal rafter trusses, the trusses having collars but no tiebeams. The collars are pegged to the principals with slightly unusual notched-lap tennons. The principal carry single through-purlins to each pitch of the roof. There appear to be no original, or early, common rafters, these all appearing to be modern, late-twentieth century timbers.

The east–west roof to number 3 Bridge Street (Fig 4g) also comprises two principal rafter trusses, again with collars, but no tiebeams. The collars in these trusses are face-lapped to the principals and fixed with nails. There are two sets of purlins to each pitch of this roof, these being carried on the backs of the principal rafters. There is some evidence, by way of redundant mortices and peg holes, and by the way that some of the joints are ill-fitting, that some timber in this roof may have been reused, or that the roof has been reconfigured and more recent repair pieces have been inserted. The timbers appear to present a less integral structure. There again appear to be no original, or early, common rafters, these all appearing to be modern replacements

The roofs to both 4 and 5 Bridge Street are entirely modern.

Sampling

Sampling and analysis by tree-ring dating of the timbers within numbers 1–5 Bridge Street, were commissioned by David Carter, Archaeological Surveyor and Historic Buildings Consultant, on behalf of the owners of the buildings, Mr and Mrs Prouse, prior to the conservation and development of the site. It was hoped that tree-ring dating would provide dates for each of the component part of the building and establish some order of sequential development of the site and its historic repair or alteration.

With the aim of fulfilling this brief, core samples were obtained from a total of 24 different suitable oak timbers from those available within 1, 2, 3 and 5 Bridge Street (there being no timbers in number 4 Bridge Street) and from the suitable pine timbers available in numbers 1 and 2 Bridge Street (there being no suitable pine timbers available elsewhere). An attempt was made to distribute the samples between the different types of beam available. Each oak sample was given the code BID-A (for Bideford – site 'A'), and numbered 01–24, with each pine timber being given the code BID-P (for Bideford 'pine'), and numbered 25–27.

The positions of the sampled timbers were located and recorded at the time of coring, the details of these samples being given in Table 1. These details include the specific timber sampled and its location, the total number of rings each sample has, and how many of these, if any, are sapwood rings. The individual date span of each dated sample is also given. In this Table the trusses, bays, and individual timbers, have been located on a site north–south/east–west basis as appropriate, with trusses 1 and 2 being in the roof of 2 Bridge Street, and trusses 3 and 4 being in the roof of 3 Bridge Street. The ground-floor ceiling beams of 5 Bridge Street have been numbered from north to south.

Acknowledgements

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank the owner of 1–5 Bridge Street, Mr and Mrs Prouse, for commissioning and generously funding this programme of tree-ring analysis. We would also like to thank David Carter for his help and advice in relation to the understanding of this building and for the provision of plans used in this report.

Tree-ring dating

Tree-ring dating relies on a few simple, but quite fundamental, principles. Firstly, as is commonly known, trees (particularly oak trees, the timber most commonly used in building construction until the introduction of pine from the late eighteenth century onwards) grow by adding one, and only one, growth-ring to their circumference each, and every, year. Each new annual growth-ring is added to the outside of the previous year's growth just below the bark. The width of this annual growth-ring is largely, though not exclusively, determined by the weather conditions during the growth period (roughly March–September). In general, good conditions produce wider rings and poor conditions produce narrower rings. Thus, over the lifetime of a tree, the annual growth-rings display a climatically influenced pattern. Furthermore, and importantly, all trees growing in the same area at the same time will be

influenced by the same growing conditions and the annual growth-rings of all of them will respond in a similar, though not identical, way.

Secondly, because the weather over a certain number of consecutive years (the statistically reliable minimum calculated as being 54 years) is unique, so too is the growth-ring pattern of the tree. The pattern of a shorter period of growth, 20, 30**,** or even 40 consecutive years, might conceivably be repeated two or even three times in the last one thousand years, and is considered less reliable. A short pattern might also be repeated at different time periods in different parts of the country because of differences in regional micro-climates. It is less likely, however, that such problems would occur with the pattern of a longer period of growth, that is, anything in excess of 54 years or so. In essence, a short period of growth, anything less than 54 rings, is not reliable, and the longer the period of time under comparison the better.

Tree-ring dating relies on obtaining the growth pattern of trees from sample timbers of unknown date by measuring the width of the annual growth-rings. This is done to a tolerance of 1/100 of a millimeter. The growth patterns of these samples of unknown date are then compared with a series of reference patterns or chronologies, the date of each ring of which is known. When the growth-ring sequence of a sample 'cross-matches' repeatedly at the same date span against a series of different reference chronologies the sample can be said to be dated. The degree of cross-matching, that is the measure of similarity between sample and reference, is denoted by a '*t*-value'; the higher the value the greater the similarity. The greater the similarity the greater is the probability that the patterns of samples and references have been produced by growing under the same conditions *at the same time*. The statistically accepted fully reliable minimum *t*-value is 3.5.

However, rather than attempt to date each sample individually it is usual to first compare all the samples from a single building, or phase of a building, with one another, and attempt to cross-match each one with all the others from the same phase or building. When samples from the same phase do cross-match with each other they are combined at their matching positions to form what is known as a 'site chronology'. As with any set of data, this has the effect of reducing the anomalies of any one individual (brought about in the case of tree-rings by some non-climatic influence) and enhances the overall climatic signal. As stated above, it is the climate that gives the growth pattern its distinctive pattern. The greater the number of samples in a site chronology the greater is the climatic signal of the group and the weaker is the non-climatic input of any one individual.

Furthermore, combining samples in this way to make a site chronology usually has the effect of increasing the time-span that is under comparison. As also mentioned above, the longer the period of growth under consideration, the greater the certainty of the cross-match. Any site chronology with less than about 55 rings is generally too short for reliable dating.

Having obtained a date for the site chronology as a whole, the date spans of the constituent individual samples can then be found, and from this the felling date of the trees represented may be calculated. Where a sample retains complete sapwood, that is, it has the last or outermost ring produced by the tree before it was cut, the last measured ring date is the felling date of the tree.

Where the sapwood is not complete it is necessary to estimate the likely felling date of the tree. Such an estimate can be made with a high degree of reliability because oak trees generally have between 15 to 40 sapwood rings. For example, if a sample with, say, 12 sapwood rings has a last sapwood ring date of 1400 (and therefore a heartwood/sapwood boundary ring date of 1388), it is 95% certain that the tree represented was felled sometime between 1403 (1400+3 sapwood rings (12+3=15)) and 1428 (1400+28 sapwood rings (12+28=40)).

Analysis of the Bridge Street samples

Each of the 27 samples obtained from the timbers within 1–5 Bridge Street was prepared by sanding and polishing. It was seen at this time that three of the oak samples, BID-A09, A16, and A19, had fewer than 50 rings, less than the minimum number for the reliable dating of oak, and these were rejected from this programme of analysis. One of the pine samples, BID-A27, also had less than 50 rings, and it too was rejected. The widths of the annual growth rings of the remaining 21 oak and two pine samples were, however, measured, and the data of these measurements then compared with each other as described in the notes above. By this process three separate groups of cross-matching samples could be formed.

The first group comprises 14 oak samples, the majority of them from either number 1, 2, or 5 Bridge Street, with only one sample (BID-A18) being from number 3 Bridge Street. The 14 cross-matching oak samples were combined at their indicated off-set positions (see bar diagram Fig 5) to form BIDASQ01, a site chronology with an overall length of 223 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1484 to 1706. The evidence for this dating is given in the *t*-values of Table 2.

The second group comprises four oak samples, all of them from number 3 Bridge Street. These four oak samples were also combined at their indicated off-set positions (see bar diagram Fig 6) to form BIDASQ02, a site chronology with an overall length of 88 rings. This site chronology was then also satisfactorily dated by repeated and consistent comparison with a number of oak reference chronologies as spanning the years 1632 to 1720. The evidence for this dating is given in the *t*-values of Table 3.

The third group to form comprises two pine samples, both of them from the main ground-floor ceiling beams of 1 and 2 Bridge Street. These two pine samples were also combined at their indicated off-set positions (see bar diagram Fig 7) to form BIDPSQ03, a site chronology with an overall length of 131 rings. This site chronology was then compared to a full range of pine reference chronologies, both those held not only by the Nottingham Tree-ring dating Laboratory, but also by others, but there was no satisfactorily cross-matching, and these samples must, therefore, remain undated.

Each of the two site oak chronologies, BIDASQ01 and SQ02, was then compared with each other, and with the three remaining measured but ungrouped oak samples. There was however, no further satisfactory cross-matching. Each of these three ungrouped oak samples was then compared individually with the full corpus of reference material for oak,

but there was no further satisfactory cross-matching, and these must, therefore, remain undated.

This analysis may be summarised as below:

Site chronology / samples	Number of samples	Number of rings	Date span
BIDASQ01 (oak)	14	223	1484–1706
BIDASQ02 (oak)	4	88	1632–1719
BIDPSQ03 (pine)	2	131	undated
Undated oak	3	---	---
Unmeasured oak	3	---	---
Unmeasured pine	1	---	---

Interpretation

Site chronology BIDASQ01

Site chronology BIDASQ01 comprises 14 samples, the majority of them from 1, 2 and 5 Bridge Street, with one sample from 3 Bridge Street. Interpretation of the sapwood on the samples (see bar diagram Fig 5) would suggest that a number of timbers, probably those represented by samples BID-A01 (a second-floor ceiling beam) and BID-A03 (the ground-floor fireplace lintel) from 1 Bridge Street (and *possibly* BID-A02, the first-floor fireplace lintel, though this cannot be proven by dendrochronology), and BID-A05, A06, and A07 from the roof 2 Bridge Street, were felled in the 1620s or early 1630s. These timbers appear to have been used in conjunction with a few other timbers (represented by BID-A08, 10, and A11), also from 2 Bridge Street, which had been felled earlier, and probably at different times to each other) in the late sixteenth century or early seventeenth century.

It is uncertain if these earlier, late-sixteenth/early-seventeenth century, timbers represent a primary and original phase of building, with the later, 1620–30s, timbers being repair or replacement pieces, or if the earlier timbers are simply an assortment of older timbers salvaged from elsewhere and reused in an early-seventeenth century roof to this building. However, given that the earlier timbers do not appear to represent a single-phase episode of felling (which would be expected were they felled for a particular building project), and that the later timbers do, the latter interpretation appears more likely.

Further timbers, felled in 1706 and represented by samples BID-A20, A20, A23, and A24, were used for the main ground-floor ceiling beams of 5 Bridge Street.

Sample BID-A18, from the roof of 3 Bridge Street has an estimated felling date in the range 1687–1712. Given that other timbers in the roof of number 3 were felled in 1720 (see below), this timber would appear to be either a timber reused in this roof, or a piece which was stored for a few years before being used in the work of 1720.

It may be noticed from Table 2 that site chronology BIDASQ01 matches particularly well (with a value of *t*=9.2) with a reference chronology made up of material from Egloskerry, near Launceston, in Cornwall, about 30 miles south of Bideford. Although, of course, the exact source of the Egloskerry trees is itself not known, the level of cross-matching between these and the Bridge Street timber suggests that the two sets of trees had been growing in roughly the same locality.

Site chronology BIDASQ02

Site chronology BIDASQ02 comprises four samples, BID-A012, A13, A14, and A15, from the roof of 3 Bridge Street. Two of these samples, BID-A14 and A15, retain complete sapwood, both having the last growth ring produced by the trees before they were cut down. In both cases the last, complete, sapwood ring, and thus the felling of the trees, is the same at 1720.

A further sample in this site chronology, BID-A12, is from a timber with complete sapwood, but from which a small portion was lost in coring. In this instance the lost sapwood portion suggests that the tree represented was also felled in 1720. The final sample of this group, BID-A13, retains only the heartwood sapwood boundary, meaning all the sapwood rings, but *only* the sapwood rings are missing. In this case, given that the heartwood/sapwood boundary is at the same relative position and date as that on the other samples in this group, there is little reason to suppose that the timber was not also felled in 1720.

The level of cross-matching between site chronology BIDASQ02 and the reference chronologies, as given in Table 3, does not show any particularly high t-value cross-matches with any specific site. It is thus not possible to suggest a possible location for the source woodland.

Site chronology BIDPSQ03

Site chronology BIDPSQ03 comprises two pine samples. This site chronology, and thus neither of the samples, can be dated. This is not unusual in dendrochronology at the present time when the pine reference chronology database is still in its relative infancy. It is in theory possible that as the number and range, both geographically and temporally, increase in the future, these two pine samples might be dated.

Undated oak samples

Three measured oak samples remain undated. Although, as might be seen from Table 1, one sample, BID-A17, has only 52 rings, which is towards to lower end of the acceptable number the other two ungrouped and undated oak samples, BID-A04 and A22, both have sufficient, and indeed high, numbers of rings. Neither of them shows any particular problems, such as compression or distortion, which might make cross-matching difficult, and the there is no obvious reason for their lack of dating. It is very common in tree-ring analysis, however, to have a small number of samples left undated.

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Table 1: Details of tree-ring samples from 1–5 Bridge Street, Bideford, Devon

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	No.1 Bridge Street					
BID-A01	Main, second-floor, east–west ceiling beam	113	h/s	1484	1596	1596
BID-A02	First-floor fireplace lintel	74	no h/s	1510	------	1583
BID-A03	Ground-floor fireplace lintel	101	h/s	1506	1606	1606
	No.2 Bridge Street					
BID-A04	North principal rafter, truss 1	82	23	------	------	------
BID-A05	South principal rafter, truss 1	93	15	1528	1605	1620
BID-A06	Collar, truss 1	54	6	1554	1601	1607
BID-A07	North principal rafter, truss 2	109	16	1513	1605	1621
BID-A08	South principal rafter, truss 2	89	2	1496	1582	1584
BID-A09	North purlin, truss 2 – west	nm	---	------	------	------
BID-A10	South purlin, truss 1 – 2	69	10	1502	1560	1570
BID-A11	Collar, truss 2	84	h/s	1487	1570	1570
	No.3 Bridge Street					
BID-A12	North principal rafter, truss 3	78	11c	1633	1699	1710
BID-A13	South principal rafter, truss 3	68	h/s	1632	1699	1699
BID-A14	South purlin, truss 2 – 3	54	23C	1667	1697	1720
BID-A15	North principal rafter, truss 4	72	21C	1649	1699	1720
BID-A16	South principal rafter, truss 4	nm	---	------	------	------
BID-A17	Collar, truss 4	52	17	------	------	------

Table 1: Continued

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	No.3 Bridge Street					
BID-A18	North lower purlin, west gable – truss 4	69	h/s	1604	1672	1672
BID-A19	South upper, truss 3 – 4	nm	---	------	------	------
	No.5 Bridge Street					
BID-A20	Ground-floor ceiling beam 1 (from north/street)	171	34c	1530	1666	1700
BID-A21	Ground-floor ceiling beam 2	172	31c	1531	1671	1702
BID-A22	Ground-floor ceiling beam 3	160	h/s	------	------	------
BID-A23	Ground-floor ceiling beam 4	171	48C	1536	1658	1706
BID-A24	Ground-floor ceiling beam 5	136	h/sc	1544	1679	1679
	Pine timbers					
BID-A25	Ground-floor ceiling beam (no.2 Bridge St)	104	h/s	------	------	------
BID-A26	Ground-floor ceiling beam (no.2 Bridge St)	124	h/s	------	------	------
BID-A27	Ground-floor ceiling beam (no.1 Bridge St)	nm	---	------	------	------

*h/s = the last ring on the sample is at the heartwood/sapwood boundary, i.e., only the sapwood rings are missing
c = complete sapwood is found on the sampled timber but all or part of it has been lost from the core in sampling
C = complete sapwood is retained on the sample, the last measured ring date ids the felling date of the timber represented
nm = sample not measured

Table 2: Results of the cross-matching of site chronology BIDASQ01 and the reference chronologies when the first ring date is 1484 and the last ring date is 1706

Reference chronology	*t*-value	
Treludick House, Egloskerry, Cornwall	9.2	(Arnold and Howard 2007)
England Master Chronology	8.3	(Baillie and Pilcher 1982 unpubl)
South composite working mean	7.4	(Howard 2002 unpubl)
East Midlands Master Chronology	7.3	(Laxton and Litton 1988)
26 Westgate Street, Gloucester	6.9	(Howard *et al* 1998)
Middleton Hall, Middleton, Warwicks	6.9	(Arnold *et al* 2006)
St Briavels Castle, Glos	6.8	(Howard *et al* 1999)
Manor House, Templecombe, Somerset	6.7	(Howard *et al* 1997)

Table 3: Results of the cross-matching of site chronology BIDASQ02 and the reference chronologies when the first ring date is 1632 and the last ring date is 1720

Reference chronology	*t*-value	
Wolfeton Riding House, Charminster, Dorset	6.1	(Bridge 2005)
Worcester Cathedral composite chronology	6.0	(Arnold *et al* 2003b)
Merton 2 (Oxford)	5.8	(Miles and Worthington 2006)
Hampshire county chronology	5.7	(Miles 2003)
Green's Mill, Snenton, Nottm	5.6	(Laxton *et al* 1982)
Old Barn, Shottery, Stratford, Warwicks	5.4	(Howard *et al* 1996)
Clothall Bury Farmhouse, Herts	5.4	(Arnold *et al* 2003a)

Site chronologies BIDASQ01 and BIDASQ02 are composites of the data of the relevant cross-matching samples as seen in the bar diagrams Figures 5 and 6. This composite data produces 'average' tree-ring patterns, where the overall climatic signal of the growth is enhanced, and the possible erratic variations of any one individual sample are reduced. These 'average' site chronologies are then compared with several hundred reference patterns covering every part of Britain for all time periods. Each site chronology dates only at the time periods indicated, each table giving only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity).

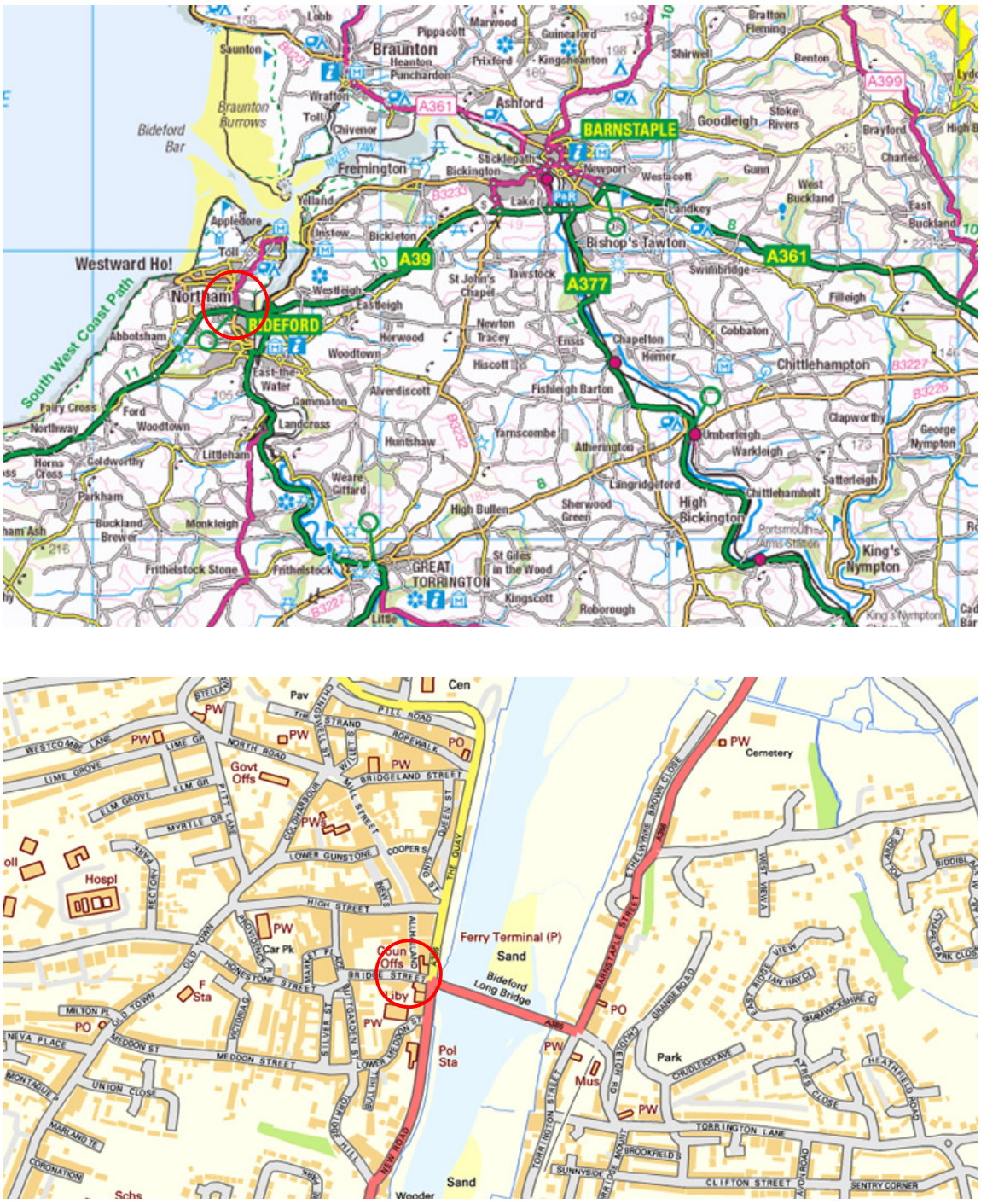


Figure 1a/b: Maps to show location of Bideford (top) and Bridge Street (bottom)

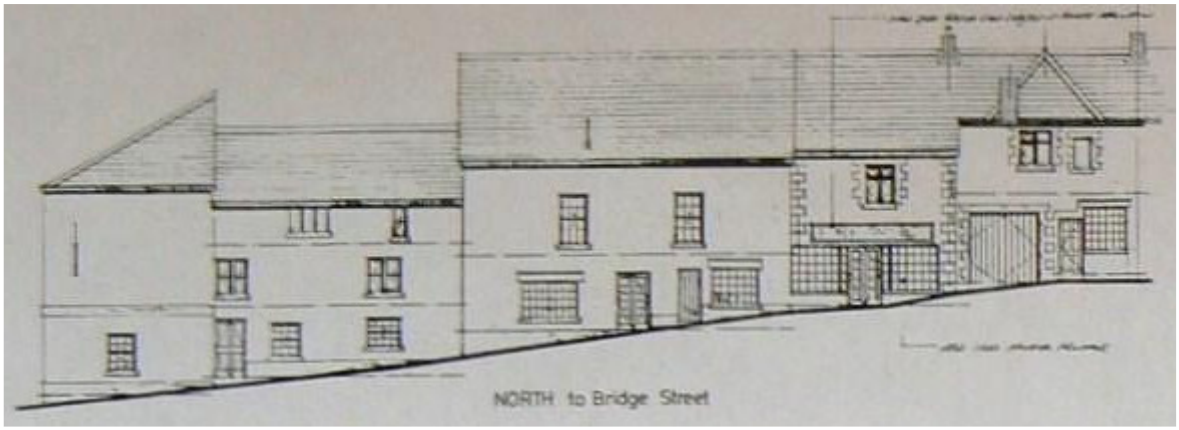


Figure 2a/b: View of numbers 1–5, looking down Bridge Street towards the river Torridge (top), with drawn elevation to Bridge Street (bottom)

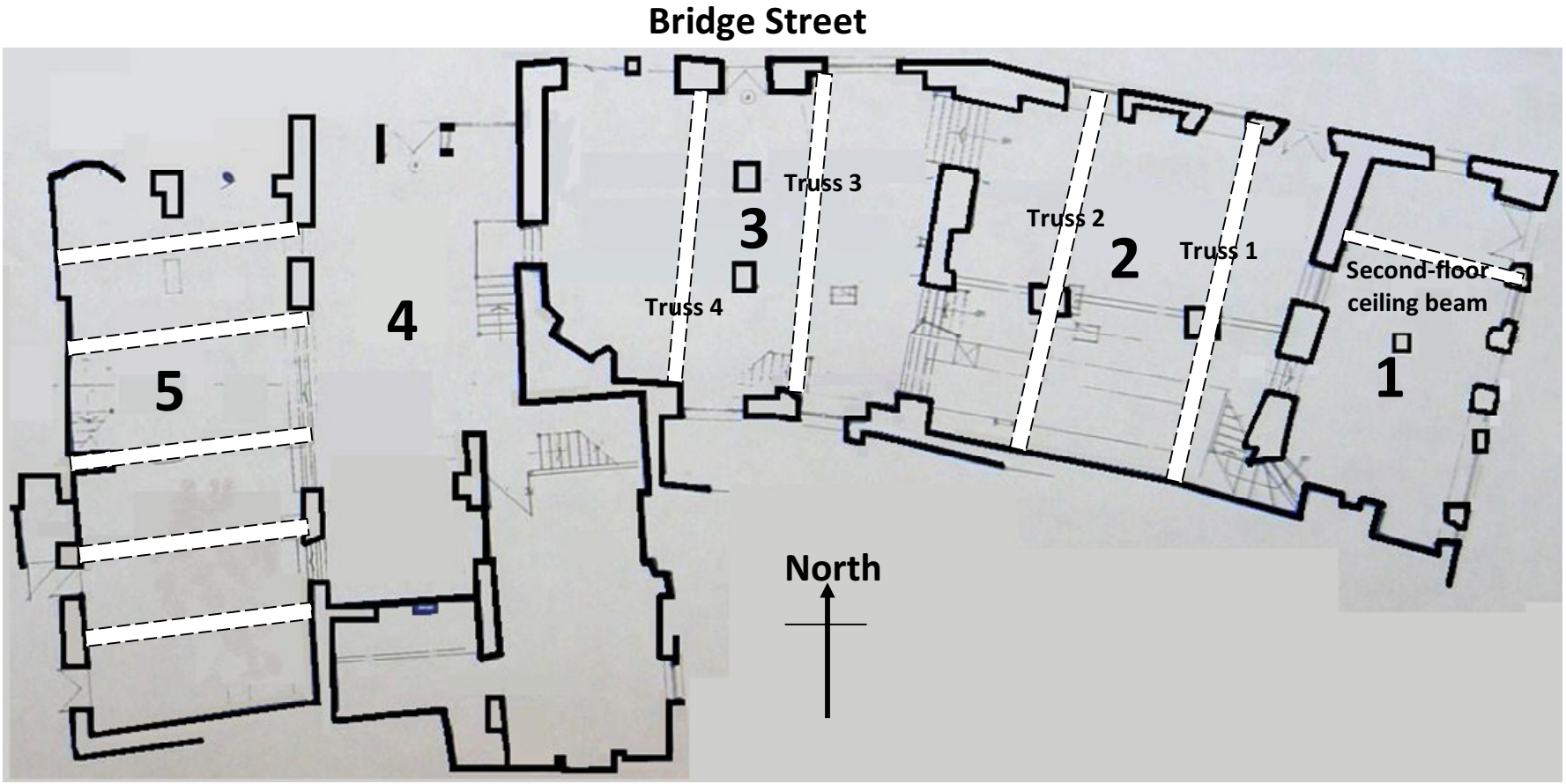
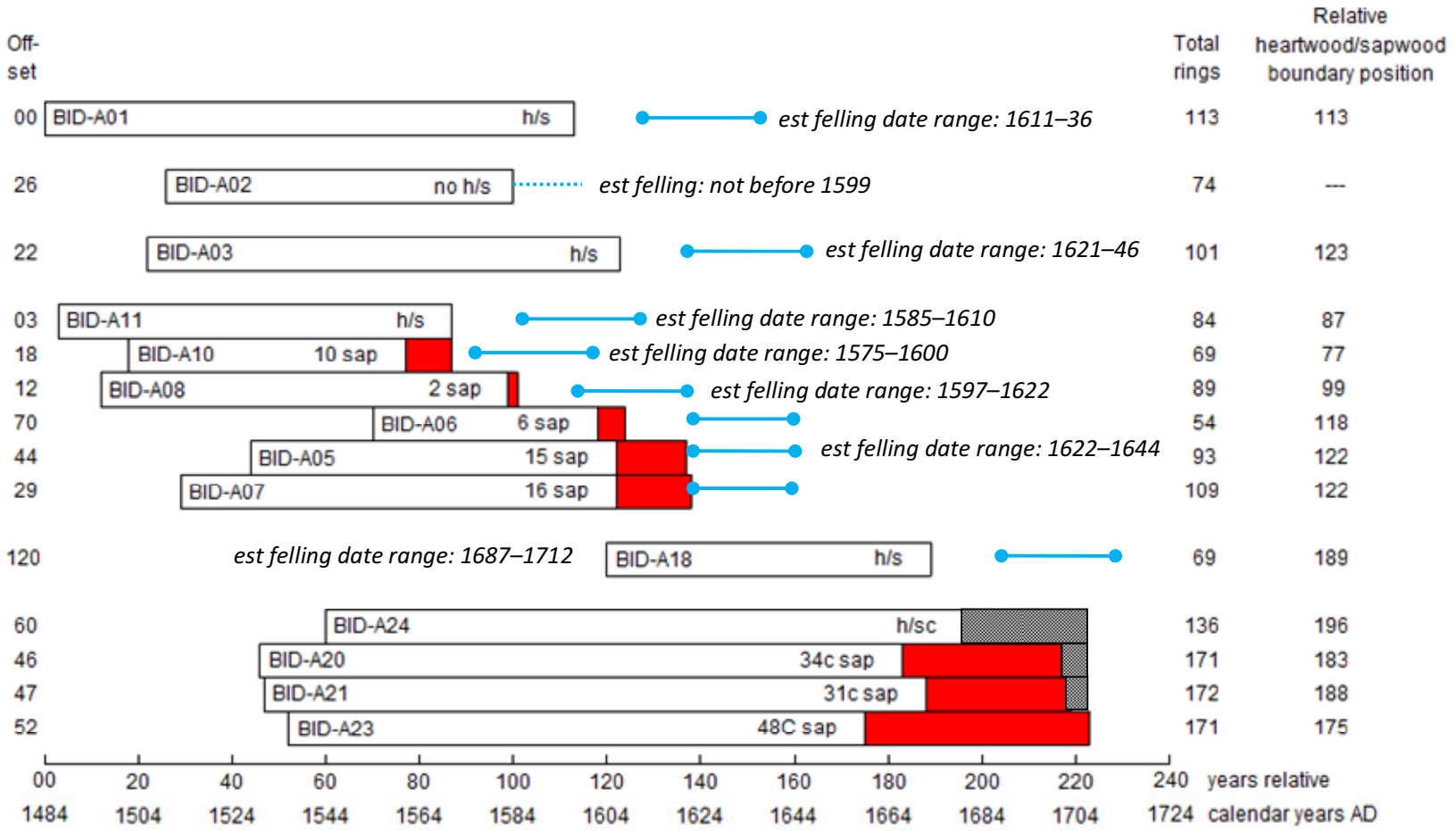


Figure 3: Ground-floor plan to show the layout and arrangement of 1–5 Bridge Street. The approximate position of the second-floor ceiling beam to 1 Bridge Street, the roof trusses to 2 and 3 Bridge Street, and ground-floor ceiling beams to 5 Bridge Street, are also shown

Figure 4a–c: View of the second-floor ceiling beam, (top) and first- and ground-floor fireplace lintels (middle and bottom) to 1 Bridge Street (respectively samples BID-A01–A03)

Figure 4d/e: View of the ground-floor pine ceiling beams to 2 Bridge Street (top), sampled as BID-P25–P27 and the ground-floor ceiling beams to 5 Bridge Street (bottom), sampled as BID-A20–A24

Figure 4f/g: View of the roofs to 2 Bridge Street (top) sampled as BID-A04–A11, and 3 Bridge Street (bottom), sampled as BID-A12–A19



Blank bars = heartwood rings. Filled bars = sapwood rings. Hatched bars = sapwood rings estimated from lost core portion.
Extended lines = estimated felling date range based on 15–40 sapwood rings. h/s = heartwood/sapwood boundary
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber
c = complete sapwood is found on the timber, but part or all has been lost from the sample in coring
Figure 5: Bar diagram of the samples in site chronology BIDASQ01

The 14 samples of site chronology BIDASQ01 are shown here in the form of a bar diagram (sorted by sample location and in last measured ring date order) at positions where the ring variations of each sample cross-match with each other. This similarity is produced by the trees represented sharing periods of growth in common (ie, where the bars overlap). The samples are combined at these offsets to form a 'site chronology' (BIDASQ01) which is compared with a large database of reference chronologies for all time periods for all parts of England, cross-matching only with a date span of 1484–1706 (see Table 2).

Although many of the samples have periods of growth in common, and cross-match with each other, interpretation of the sapwood on the individual cores suggests that some of the trees represented were felled at different times. Sample BID-A01, for example, from the main second-floor ceiling beam of 1 Bridge Street, has the heartwood/sapwood boundary ring (meaning that the outer sapwood rings are missing, but *only* the sapwood rings are missing), this boundary ring being dated to 1596. Given that the 95% confidence limit for the amount of sapwood that oaks trees have lies between 15 and 40 rings, it can be calculated that the tree has an estimated felling date of between 1611 at the earliest (1596+15) to 1636 at the latest (1596+40). This calculation has been done for a number of other timbers, as shown in the figure above.

It may be seen from these calculations that some timbers share overlapping estimated felling date ranges during which time it is possible that they were cut as part of the same episode of felling. The timber represented by BID-A01, for example, shares a possible felling date range with sample BID-A03 between 1621 (the earliest that sample A03 could have been cut) and 1636 (the latest likely felling for sample A01), and that these two share a common possible single felling date with samples BID-A05, A06, and A07, between 1622 and 1636.

Indeed, for these last three samples, it is so probable that the three trees represented were felled at the same time as each other, that they have been treated as a group, and their estimated felling date range calculated from an average of their heartwood/sapwood boundary date, here being 1604. Allowing that the latest dated ring on any of these three samples is 1621 (on BID-A07), the 95% sapwood probability gives an estimated felling date range of 1622–44 for this group. The interpretation that they were cut at the same time as each other is supported by the high degree of cross-matching between the three samples which suggests that the three trees were originally growing close to each other in the same copse or stand of woodland. As such it would perhaps be very unlikely that the trees, if they had been felled at different times, would come to be used in the same roof as each other. The trees represented by samples BID-A10 and A11 also share a possible common felling date with each other, along with, to a much lesser extent, sample BID-A08.

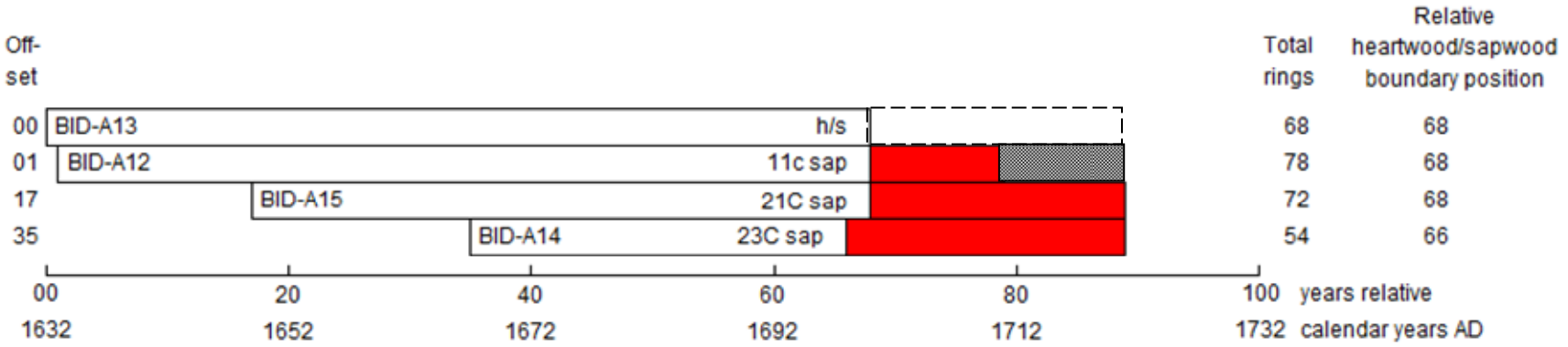
It should be remembered, however, that the 95% figure is a degree of *probability* and that there is a 5% possibility of some trees having fewer than 15 sapwood rings or more than 40. In a group of 20 or so samples, as here, this would translate to the number of sapwood rings being

outside the 15-40 range on one or possibly two samples. It may be seen from the above Figure and Table 1 that sample BID-A23 for example has 48 sapwood rings. There is thus some flexibility in the estimated felling date ranges.

The latest certain felling is represented by samples BID-A20, A21, A23, and A24, from the ground-floor ceiling beams of 5 Bridge Street. One of these samples, BID-A23, retains complete sapwood, that is, it has the last ring produced by the source tree before it was cut down (this is denoted by upper case 'C' in Table 1 and the bar diagram). This last, complete, sapwood ring, and thus the felling of the tree, is dated to 1706.
The three other samples of this group are also from timbers which have complete sapwood on them, but from which, due to the soft and fragile nature of this part of the wood, small portions of the sapwood were lost during in coring (this denoted by lower case 'c' in Table 1 and the bar diagram). Under such circumstances, having noted at the time of sampling the amount of core lost, it is possible to estimate the likely number of sapwood rings the lost portions might have contained. In this instance the lost sapwood portions all suggest that these trees were felled in 1706 as well. Such an interpretation is again supported by the high degree of cross-matching between all four samples which suggests that these trees were also growing close to each other, and that it would again be unlikely, if they had been felled at different times, they would come to be used in the same part of the building as each other.

It will be noted that the estimated felling date range, 1687–1712, for the timber represented by sample BID-A18, spans the know felling date, 1706, of the timbers from which samples BID-A20, A21, A23, and A24 were taken. It is thus *possible* that this timber was felled in 1706 as well. It will be further noted that an estimated felling date range cannot be given for the timber represented by sample BID-A02, from the ground-floor fireplace lintel of 1 Bridge Street. This sample does not retain the heartwood/sapwood boundary and thus not only are all the sapwood rings missing, but an unknown number of heartwood rings also. However, given that samples BID-A02 has a last extant, heartwood, ring date of 1583, and allowing for the possibility that the next (missing) ring could have been at the heartwood/sapwood boundary, and allowing for a minimum of 15 sapwood rings, it is unlikely to have been felled before 1599.

Taken overall, it would appear most likely that a number of timbers, probably those represented by samples BID-A01 and A03 from 1 Bridge Street (and possibly BID-A02, though this cannot be proven by dendrochronology), and BID-A05, A06, and A07 from 2 Bridge Street, were felled in the 1620s or early 1630s and used in conjunction with a few other timbers (represented by BID-A08, 10,and A11), also from 2 Bridge Street, which had been felled earlier in the late sixteenth century or early seventeenth century. Further timbers, felled in 1706, were used for the main ground-floor ceiling beams of 5 Bridge Street.

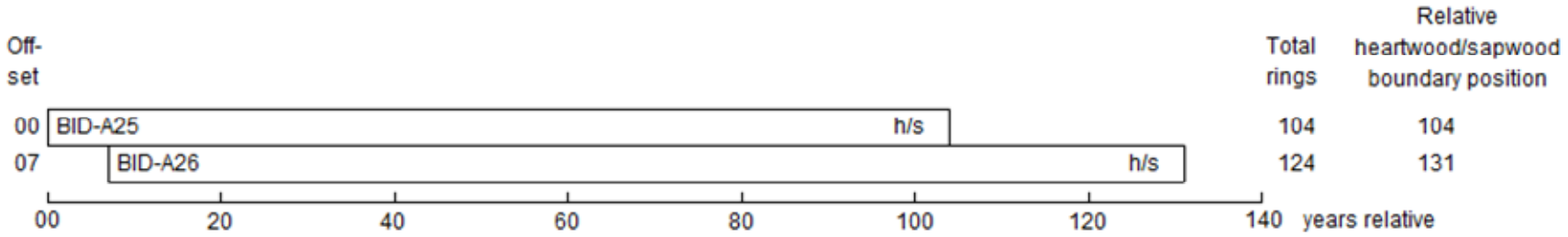


Blank bars = heartwood rings. Filled bars = sapwood rings. Hatched bars = sapwood rings estimated from lost core portion.
Broken bars = illustration of likely sapwood rings, assuming same felling date as other samples in the group
h/s = heartwood/sapwood boundary
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber
c = complete sapwood is found on the timber, but part or all has been lost from the sample in coring

Figure 6: Bar diagram of the sample in site chronology BIDASQ02

The four samples of site chronology BIDASQ02 (all of them from the roof of 3 Bridge Street) are also shown in the form of a bar diagram. The samples are again combined at these offsets to form a second site chronology which is likewise compared with a large database of reference chronologies for oak, in this instance cross-matching only with a date span of 1632–1720 (see Table 3).

Two of these samples, BID-A14 and A15, retain complete sapwood, the last ring produced by the tree before it was cut down. This last, complete, sapwood ring, and thus the felling of the two trees, is the same, being dated to 1720. One other sample of this group, BID-A12, is also from timbers which have complete sapwood on them, but from which a small portion of the sapwood has been lost during in coring. In this instance the lost sapwood portion suggests that the source tree was also felled in 1720. Given the heartwood/sapwood boundary on the fourth sample, BID-A13, is at an identical relative position and date to that on other samples in this group, there is little reason to suppose that the tree this represents was not felled in 1720 as well.



Blank bars [ ] = heartwood rings
h/s = heartwood/sapwood boundary

Figure 7: Bar diagram of the sample in site chronology BIDPSQ03

The two pine samples of site chronology BIDPSQ03 are shown in the form of a bar diagram. The samples are again combined at these offsets to form a third site chronology which has been compared with a large database of reference chronologies for pine. Unfortunately, in this instance, there is no satisfactory cross-matching and both samples must remain undated.