Oxford Dendrochronology Laboratory
Report 201732

The Tree-Ring Dating of 93-95 Bell Street, Henley-on-Thames, Oxfordshire

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Summary:

HENLEY-ON-THAMES, 93-95 Bell Street (SU 7606 8295)

(a) Main range *Felling date range (OxCal Modelled):* **1436-44** (Unrefined 1434-59)
(b) Repair phase (No. 93) *Felling dates:* **Spring 1567**
(c) Rear wing (No. 95) *Felling dates:* **Winter 1758/9**

(a) Collar 1416(H/S); Purlin 1416(H/S); Principal rafters (2/3) 1423(H/S), 1412(2); Staves (1/2) 1431(1); Queen struts (1/2) 1414(H/S); Spandrel brace 1338; Rafters (0/3); Posts (0/2); Braces (0/1); (b) Rafters 1566(24¼C, 23¼C); (c) Tiebeams 1758(23C, 22C). *Site Masters* (a) 1361-1431 HENLEY9 ($t = 7.0$ LUDLOW9; 6.9 MASTERAL; 6.9 PRINCES2); 1282-1338 bsh20b ($t = 7.3$ HANTS04; 7.2 APTASQ01; 7.1 TYTHRLY1); (b) 1516-1566 HENLEY10 ($t = 6.3$ WALES97; 5.8 NORTH; 5.7 gm7); (c) 1668-1758 HENLEY2 ($t = 7.7$ GREYSCT4; 7.3 MDM24; 5.9 MASTERAL).

Located at the northern entrance to the town, this was originally a rather grand house consisting of 4 unequal bays, aligned along the street, built for a wealthy owner. The two southern bays represent either a hall or a solar with an arch braced truss, of which the principal rafters remain as well as moulded purlins and wind braces. The two northern bays, which form one large room on each floor, retain richly moulded ceiling beams, wall plates, posts, knee braces and also cusped wind braces. The double hollow chamfer mouldings indicate a building date between 1450 and 1500. Although dendrochronology was previously attempted (Miles *et al* 2008) additional samples taken in 2016 has resulted in the first phase dating to 1436-44 (a), as well as identifying a secondary date of 1567 for the repair or alteration to the rear roof slope of no. 93 (b). A three-bay rear range (c) produced a date of 1758/9; this was very likely built when the house had gone down the social scale and had become a bakery, for which there is documentary evidence in 1777 from of the 'beating of the bounds'. The fact that the building straddled the Henley and Bensington boundaries meant that the instructions were to go 'through the window and through the oven' of Mr. Toomer, baker. Dating partly commissioned by the owners. This entry supersedes that from 2008.

Date sampled:	2007 and 14th July 2016
Owner & Commissioner:	Mr Alan Gaynor (No. 95)
Historical Research:	Ruth Gibson
Summary published:	Miles, D H, Worthington, M J and Bridge, M C 2008 Tree-ring dates, *Vernacular Architecture*, **39**, 135-146; and Miles, D H, and Bridge, M C, 2017 Tree-ring dates, *Vernacular Architecture* **48**, (forthcoming)

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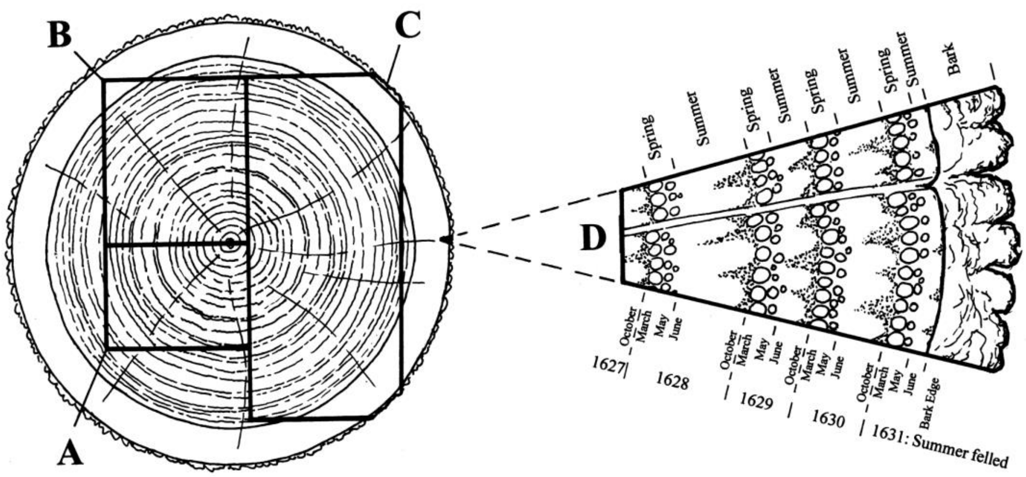
How Dendrochronology Works

Dendrochronology has over the past 20 years become one of the leading and most accurate scientific dating methods. Whilst not always successful, when it does work, it is precise, often to the season of the year. Tree-ring dating is well known for its use in dating historic buildings and archaeological timbers to this degree of precision. However more ancillary objects such as doors, furniture, panel paintings, and wooden boards in medieval book-bindings can sometimes be successfully dated.

The science of dendrochronology is based on a combination of biology and statistics. Fundamental to understanding how dendrochronology works is the phenomenon of tree growth. Essentially, trees grow through the addition of both elongation and radial increments. The elongation takes place at the terminal portions of the shoots, branches, and roots, while the radial increment is added by the cambium, the zone of living cells between the wood and the bark. In general terms, a tree can be best simplified by describing it as a cone, with a new layer being added to the outside each year in temperate zones, making it wider and taller.

An annual ring is composed of the growth which takes place during the spring and summer until about November when the leaves are shed and the tree becomes dormant for the winter period. For the European oak (*Quercus robur* and *Q. petraea*), as well as many other species, the annual ring is composed of two distinct parts - the spring growth or early wood, and the summer growth, or late wood. Early wood is composed of large vessels formed during the period of shoot growth which takes place between March and May, which is before the establishment of any significant leaf growth, and is produced by using most of the energy and raw materials laid down the previous year. Then, there is an abrupt change at the time of leaf expansion around May or June when hormonal activity dictates a change in the quality of the xylem and the summer, or late wood is formed. Here the wood becomes increasingly fibrous and contains much smaller vessels. Trees with this type of growth pattern are known as ring-porous, and are distinguished by the contrast between the open, light-coloured early wood vessels and the dense, darker-coloured late wood.

Dendrochronology utilises the variation in the width of the annual rings as influenced by climatic conditions common to a large area, as opposed to other more local factors such as woodland competition and insect attack. It is these climate-induced variations in ring widths that allow calendar dates to be ascribed to an undated timber when compared to a firmly-dated sequence. If a tree section is complete to the bark edge, then when dated a precise date of felling can be determined. The felling date will be precise to the season of the year, depending on the degree of formation of the outermost ring. Therefore, a tree with bark which has the spring vessels formed but no summer growth can be said to be felled in the spring, although it is not possible to say in which particular month the tree was felled.



Section of tree with conversion methods showing three types of sapwood retention resulting in **A** *terminus post quem*, **B** a felling date range, and **C** a precise felling date. Enlarged area **D** shows the outermost rings of the sapwood with growing seasons (Miles 1997, 42)

Another important dimension to dendrochronological studies is the presence of sapwood. This is the band of growth rings immediately beneath the bark and comprises the living growth rings which transport the sap from the roots to the leaves. This sapwood band is distinguished from the heartwood by the prominent features of colour change and the blocking of the spring vessels with tyloses, the waste products of the tree's growth. The heartwood is generally darker in colour, and the spring vessels are blocked with tyloses. The heartwood is dead tissue, whereas the sapwood is living, although the only really living, growing, cells are in the cambium, immediately beneath the bark. In European oak (*Quercus robur* sp), the difference in colour is generally matched by the change in the spring vessels. Generally the sapwood retains stored food and is therefore attractive to insect and fungal attack once the tree is felled and therefore is often removed during conversion.

Sapwood in European oaks tends to be of a relatively constant width and/or number of rings. By determining what this range is with an empirically or statistically-derived estimate is a valuable aspect in the interpretation of tree-ring dates where the bark edge is not present (Miles 1997). The narrower this range of sapwood rings, the more precise the estimated felling date range will be.

Methodology: The Dating Process

All timbers sampled were of oak (*Quercus* spp.) from what appeared to be primary first-use timbers, or any timbers which might have been re-used from an early phase. Those timbers which looked most suitable for dendrochronological purposes with complete sapwood or reasonably long ring sequences were selected. In situ timbers were sampled through coring, using a 16mm hollow auger. Details and locations of the samples are detailed in the summary table.

The dry samples were sanded on a linisher, or bench-mounted belt sander, using 60 to 1200 grit abrasive paper, and were cleaned with compressed air to allow the ring boundaries to be clearly distinguished. They were then measured under a x10/x30 microscope using a travelling stage electronically displaying displacement to a precision of 0.01mm. Thus each ring or year is represented by its measurement which is arranged as a series of ring-width indices within a data set, with the earliest ring being placed at the beginning of the series, and the latest or outermost ring concluding the data set.

The principle behind tree-ring dating is a simple one: the seasonal variations in climate-induced growth as reflected in the varying width of a series of measured annual rings is compared with other, previously dated ring sequences to allow precise dates to be ascribed to each ring. When an undated sample or site sequence is compared against a dated sequence, known as a reference chronology, an indication of how good the match is must be determined. Although it is almost impossible to define a visual match, computer comparisons can be accurately quantified. Whilst it may not be the best statistical indicator, Student's (a pseudonym for W S Gosset) *t*-value has been widely used amongst British dendrochronologists. The cross-correlation algorithms most commonly used and published are derived from Baillie and Pilcher's CROS programme (Baillie and Pilcher 1973), although a faster version (Munro 1984) giving slightly different t-values is sometimes used for indicative purposes.

Generally, *t*-values over 3.5 should be considered to be significant, although in reality it is common to find demonstrably spurious t-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some *t*-value ranges of 5, 6, or higher, and for these to be well replicated from different, independent chronologies with local and regional chronologies well represented. Users of dates also need to assess their validity critically. They should not have great faith in a date supported by a handful of *t*-values of 3's with one or two 4's, nor should they be entirely satisfied with a single high match of 5 or 6. Examples of spurious *t*-values in excess of 7 have been noted, so it is essential that matches with reference chronologies be well replicated, and that this is confirmed with visual matches between the two graphs. Matches with *t*-values of 10 or more between individual sequences usually signify having originated from the same parent tree.

In reality, the probability of a particular date being valid is itself a statistical measure depending on the *t*-values. Consideration must also be given to the length of the sequence being dated as well as those of the reference chronologies. A sample with 30 or 40 years growth is likely to match with high *t*-values at varying positions, whereas a sample with 100 consecutive rings is much more likely to match significantly at only one unique position. Samples with ring counts as low as 50 may occasionally be dated, but only if the matches are very strong, clear and well replicated, with no other significant matching positions. This is essential for intra-site matching when dealing with such short sequences.

Consideration should also be given to evaluating the reference chronology against which the samples have been matched: those with well-replicated components which are geographically near to the sampling site are given more weight than an individual site or sample from the opposite end of the country.

It is general practice to cross-match samples from within the same phase to each other first, combining them into a site master, before comparing with the reference chronologies. This has the advantage of averaging out the 'noise' of individual trees and is much more likely to obtain higher *t*-values and stronger visual matches. After measurement, the ring-width series for each sample is plotted as a graph of width against year on log-linear graph paper. The graphs of each of the samples in the phase under study are then compared visually at the positions indicated by the computer matching and, if found satisfactory and consistent, are averaged to form a mean curve for the site or phase. This mean curve and any unmatched individual sequences are compared against dated reference chronologies to obtain an absolute calendar date for each sequence. Sometimes, especially in urban situations, timbers may have come from different sources and fail to match each other, thus making the compilation of a site master difficult. In this situation samples must then be compared individually with the reference chronologies.

Therefore, when cross-matching samples with each other or against reference chronologies, a combination of both visual matching and a process of qualified statistical comparison by computer is used. The ring-width series were compared on an IBM compatible computer for statistical cross-matching using a variant of the Belfast CROS program (Baillie and Pilcher 1973). A version of this and other programmes were written in BASIC by D Haddon-Reece, and re-written in Microsoft Visual Basic by M R Allwright and P A Parker.

Ascribing and Interpreting Felling Dates

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. For samples which have sapwood complete to the underside of, or including bark, this process is relatively straight forward. Depending on the completeness of the final ring, i.e. if it has only the early wood formed, or the latewood, a *precise felling date and season* can be given. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an *estimated felling date range* can be given for each sample. The number of sapwood rings can be estimated by using a statistically derived sapwood estimate with a given confidence limit. A review of the geographical distribution of dated sapwood data from historic building timbers has shown that a 95% range of 9-41 rings is most appropriate for the southern counties of England (Miles 1997), which will be used here. If no sapwood or heartwood/sapwood boundary survives, then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* (*tpq*) or *felled after* date.

An alternative method of estimating felling date ranges has recently been developed (Miles 2005) which runs as a function under OxCal (Bronk Ramsey 1995; Miles and Bronk Ramsey *in prep*). Instead of using a simple empirical estimate for a particular geographical location, one model was found to be suitable for the whole of England and Wales. With the methodology set out by Millard (2002), Bayesian statistical models are used to produce individual sapwood estimates for samples using the variables of number of heartwood rings present, the mean ring width of those heartwood rings, the heartwood/sapwood boundary date, and the number of any surviving sapwood rings or a count of those lost in sampling. Using the suite of calculation and graphical plotting functions in OxCalInput and OxCalPlot (Bronk Ramsey *in prep*), the area of highest probability density for each sample can be graphically displayed to any of three confidence levels. The addition of surviving sapwood to the equation narrows the felling date range for each sample, although the outer end of the range shifts slightly later, more noticeably on those samples with higher sapwood counts. An empirically-derived stock-piling factor added to the ranges produced also helps to make the estimated felling date ranges more representative for the actual latest common felling date, from which a construction date can then be extrapolated.

This new method of predicting sapwood ranges has resulted in over 94% of the samples tested producing felling date ranges narrower than the 36-year empirical estimate currently used. About a quarter of the samples tested showed an improvement with a range of 24 years or less. Conversely, some 4.5% of the samples tested produced a range larger than the empirical range, but again these ranges are more representative of the actual sapwood found.

However, it has been found that some unusual samples do not fit the model well. These include samples which have exceptional or sudden variation in mean ring width, such as might be found in pollarded or managed timber. Sometimes a tree will exhibit a sudden drop in mean ring width toward the end of its life, resulting in more sapwood rings being present then might be suggested in the faster-grown heartwood. Additionally, samples which have come from small timbers converted from larger, slow-grown trees would have a much larger number of heartwood rings then were actually present in the sample. Some examples of heartwood ring counts of 25 years or less with a narrow mean ring width are good indicators of this situation, as were observations made during sampling. Samples with these characteristics should be excluded from such analysis.

A particularly useful feature of OxCalPlot is the ability of producing combined felling date ranges for a group of samples comprising a single phase of building. Here, two samples combined can reduce the individual felling date ranges from about 30 to about 20 years. By including more samples within the combined phase, this 20-year range can be reduced to half or even less, depending on the number of samples in the phase. Thus felling date ranges for combined building phases have the potential to being reduced by as much as a two-thirds or even three-quarters of the individual empirically-derived felling date ranges (Miles 2005).

Some caution must be used in interpreting solitary precise felling dates. Many instances have been noted where timbers used in the same structural phase have been felled one, two, or more years apart. Whenever possible, a *group* of precise felling dates should be used as a more reliable indication of the *construction period*. It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure under study. However, it is common practice to build timber-framed structures with green or unseasoned timber and that construction usually took place within twelve months of felling (Miles 2006).

Details of Dendrochronological Analysis

The results of the dendrochronological analysis for the building under study are presented in a number of detailed tables. The most useful of these is the summary **Table 1**. This gives most of the salient results of the dendrochronological process, and includes details for each sample, its location, and its felling date or date range, if successfully tree-ring dated. This last column is of particular interest to the end user, as it gives the actual year and season when the tree was felled, if the final ring is present, or an estimated felling date range if the sapwood is incomplete. Occasionally it will be noted that the felling date ranges may not coincide with the precise felling dates. This is nothing to be overly concerned about so long as these are not too far apart. It must be remembered that the estimated felling date ranges are calculated at a 95% confidence level, which means that statistically one sample in 20 will have felling dates which actually fall *outside* the predicted range.

It will also be noticed that often the precise felling dates will vary within several years of each other. Unless there is supporting archaeological evidence suggesting different phases, all this would indicate is either stockpiling of timber, or of trees which have been felled or died at varying times but not cut up until the commencement of the particular building operations in question. When presented with varying precise felling dates, one should always take the *latest* date for the structure under study, and it is likely that construction will have been completed for ordinary vernacular buildings within twelve or eighteen months from this latest felling date (Miles 1997).

Table 2 gives an indication of the statistical reliability of the match between one sequence and another. This shows the *t*-value over the number of years overlap for each combination of samples in a matrix table. It should be born in mind that *t*-values with less than 80 rings overlap may not truly reflect the same degree of match and that spurious matches may produce similar values.

First, multiple radii have been cross-matched with each other and combined to form same-timber means. These are then compared with other samples from the site and any which are found to have originated from the same parent tree are again similarly combined. Finally, all samples, including all same timber and same tree means are combined to form one or more site masters. Again, the cross-matching is shown as a matrix table of *t*-values over the number of years of overlap. Reference should always be made to **Table 1** to clearly identify which components have been combined.

Table 3 shows the degree of cross-matching between the site master(s) with a selection of reference chronologies. This shows the county or region from which the reference chronology originated, the common chronology name together with who compiled the chronology with publication reference and the years covered by the reference chronology. The years overlap of the reference chronology and the site master being compared are also shown together with the resulting *t*-value. It should be appreciated that well replicated regional reference chronologies, which are shown in **bold**, will often produce better matches than with individual site masters or indeed individual sample sequences.

Figures include a bar diagram which shows the chronological relationship between two or more dated samples from a phase of building. The site sample record sheets are also appended, together with any plans showing sample locations, if available.

Publication of dated sites are published in *Vernacular Architecture* annually, and the entry, if available, is shown on the summary page of the report. This does not give as much technical data for the samples dated, but does give the *t*-value matches against the relevant chronologies, provide a short descriptive paragraph for each building or phase dated, and gives a useful short summary of samples dated. These summaries are also listed on the web-site maintained by the Laboratory, which can be accessed at `www.Oxford-dendroLab.com`. The Oxford Dendrochronology Laboratory retains copyright of this report, but the commissioner of the report has the right to use the report for his/her own use so long as the authorship is quoted. Primary data and the resulting site master(s) used in the analysis are available from the Laboratory on request by the commissioner and bona fide researchers. The samples form part of the Laboratory archives.

Summary of Dating

A total of 20 samples were taken from both No. 93 and 95 Bell Street, which comprise the original core of the house (Table 1). The first ten were taken during the first phase of investigations (Miles *et al* 2008), and the second 10 timbers were sampled in 2016. The samples were given the code **bsh**, and sampled timbers **bsh1** and **bsh2**, **bsh4** – **bsh8**, **bsh11** – **bsh16**, and **bsh18** – **bsh20** were all taken from the primary phase, whilst samples **bsh3** and **bsh17** were taken from the rear roof slope of No. 93, and samples **bsh9** and **bsh10** were taken from the rear wing of No. 95. Trusses were numbered from the south, with Trusses 1 and 2 being in No 93, Truss 3 being the party wall with No 95, and Trusses 4 and 5 being in No. 95.

Multiple samples were taken from a number of timbers for either the retention of more rings or sapwood retention. Attempts were made to initially internally cross-match the multiple radii, but only those from the collar of Truss 1 were combined to form the mean **bsh1**, and the rear queen strut of Truss 3 were combined to form the mean **bsh12** (Table 2) It was not possible to match the three radii of **bsh11** due to exceptionally narrow rings, nor the two radii of **bsh20** due to indeterminate or minimal overlap. Nevertheless, the means formed were taken through to the next stage of the analysis, as well as the individual unmatched radii.

First in the first phase of the analysis, the two samples from the rear wing of No. 95 were matched together. Samples from tiebeams **bsh9** and **bsh10** were therefore combined to form the 91-year site master **HENLEY2**. This dated conclusively, spanning the years 1668-1758 (Table 3d). As both samples retained bark edge, they were both dated to the winter of 1758/9.

Next the primary phase timbers were cross-matched, and due primarily to the additional samples taken during 2016, six were combined to form the 71-year site master **HENLEY9** (Table 2). This was then compared to the reference chronologies and was found to date conclusively, spanning the years 1361-1431 (Table 3b). One other sample, **bsh20b**, dated individually with the reference chronologies, spanning the years 1282-1338. This sample was too early to match with the other samples or to be combined into the site master.

Apart from sample **bsh20b**, which had no evidence of sapwood at all, all six dated components of the site master either retained the heartwood / sapwood transition, or one or two sapwood rings, but certainly none retained bark edge. Therefore felling date ranges were calculated for each sample as given in Table 1, and a conventionally calculated mean felling date range for the group of 1434-59. By employing the OxCal procedure, the individual felling date ranges were all reduced as shown in Table 1, and by employing the combined function of OxCal, the group felling date range was significantly reduced to **1436-44**.

Finally, samples **bsh3** and **bsh17** rafters to the rear slope of No. 93 matched together, most likely from the same parent tree, and were combined to form the 51-year third site master **HENLEY10**. This dated, spanning the years 1516-1566 (Table 3c). Both samples retained bark edge, and both were found to have been felled in the spring of 1567.

With additional sampling, the primary phase of component timbers from 93 – 95 Bell Street were dated, and by employing the OxCal combined procedure, a felling date of **1436-44** was produced, reduced by a third that produced by conventional methods. Two later phase dates of **Spring 1567** and **Winter 1758/9** were also produced.

Acknowledgements

The dating was commissioned by Ruth Gibson on behalf of the owners, Mr and Mrs Todd (No. 93) and Mrs Hogge, subsequently Alan Gaynor (No. 95). Indeed, it was only following the additional sampling commissioned by Alan Gaynor that the primary phase samples could be dates. Financial assistance was also provided for the 2007 work by the Marc Fitch Fund through the Henley Archaeological and Historical Society and the Oxford Architectural and Historical Society. Mr Ross Cook assisted with the samples on the return visit, and Dr Martin Bridge produced the bar diagram. Acknowledgements are also given to fellow dendrochronologists for the use of both published and unpublished chronologies.

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Table 1: Summary of Tree-Ring Dating: 93-95 BELL STREET, HENLEY-ON-THAMES

Sample number & type		Timber and position	Dates AD spanning	H/S bdry	Sapwood complement	No of rings	Mean width mm	Std devn mm	Mean sens mm	Felling seasons and dates/date ranges (AD)
Primary phase										
bsh1a	c	Collar T1	1374-1415		H/S	42	3.01	1.60	0.240	
bsh1b	c	ditto	1397-1416		H/S	20	2.05	0.60	0.263	
* **bsh1**		Mean of **bsh1a** + **bsh1b**	1374-1416	1416	H/S	43	3.04	1.56	0.237	1425-57 (OxCal 1424-48)
bsh2	c	4th rafter from T1 rear side	-		H/S?	45	1.13	0.50	0.228	
* **bsh4**	c	Rear purlin Bay 2	1377-1416	1416	H/S	40	2.81	1.04	0.148	1425-57 (OxCal 1424-48)
bsh5	c	Rear RH corner post	-		H/S?	43	4.16	1.71	0.208	
bsh6	c	Rear RH brace to tiebeam T5	-		H/S	64	1.34	0.42	0.157	
* **bsh7**	c	Front principal rafter T4	1367-1412	1410	2	46	3.03	0.87	0.174	1419-51 (OxCal 1418-42)
bsh8	c	Rear principal post T4	-		H/S?	17	5.19	1.04	0.178	
bsh11a	c	Rear (W) stave T3	-			43	0.95	0.32	0.144	
bsh11b	c	ditto	-		H/S	51	0.85	0.21	0.170	
bsh11c	c	ditto	-		40C	60	0.54	0.28	0.198	
bsh12a	c	Rear (W) queen strut T3	-		H/S	50	2.44	0.48	0.125	
bsh12b	c	ditto	-		H/S	39	2.39	0.62	0.147	
bsh12		Mean of **bsh12a** + **bsh12b**	-		H/S	50	2.40	0.50	0.125	
* **bsh13**	c	Front (E) queen strut T3	1361-1414	1414	H/S	54	2.62	1.02	0.196	1423-55 (OxCal 1423-46)
* **bsh14**	c	Front (E) stave T3	1395-1431	1430	1	37	2.37	1.26	0.292	1439-71 (OxCal 1439-63)
bsh15	c	Front (E) principal rafter T3	-		H/S	41	2.19	1.18	0.159	
bsh16	s	3rd rear rafter N of Truss T2	-			44	2.39	0.69	0.110	
bsh18	c	2nd front rafter S of Truss T2	-		H/S	52	1.13	0.47	0.208	
* **bsh19**	c	Front (E) principal rafter of T1	1361-1423	1423	H/S	63	2.33	0.94	0.201	1432-64 (OxCal 1432-58)
bsh20a	c	Lower front (E) spandrel brace T4	-			65	3.33	0.94	0.281	
bsh20b	c	ditto	1282-1338			57	1.76	0.93	0.214	After 1347
*** = HENLEY9 Site Master**			**1361-1431**	**(1418)**		**71**	**2.60**	**0.79**	**0.179**	**1434-59 (OxCal 1436-44)**
Repair Phase, No. 93										
† **bsh3**	c	5th rafter N from T1 rear side	1516-1566	1542	24¼C	51	1.38	0.67	0.179	Spring 1567
† **bsh17**	s	1st rear rafter S of T2	1516-1566	1543	23¼C	51	1.51	0.69	0.184	Spring 1567
† = HENLEY10 Site Master			**1516-1566**			**51**	**1.45**	**0.67**	**0.171**	**Spring 1567**
Rear Wing, No. 95										
* **bsh9**	c	Front tiebeam	1668-1758	1735	23C	91	1.80	0.49	0.206	Winter 1758/9
* **bsh10**	c	Rear tiebeam	1671-1758	1736	22C	88	1.94	0.50	0.187	Winter 1758/9
*** = HENLEY2 Site Master**			**1668-1758**	**1735**	**23C**	**91**	**1.88**	**0.43**	**0.180**	**Winter 1758/9**

Key: *, †, § = sample included in site-master; c = core; mc = micro-core; s = slice/section; g = graticule; p = photograph; ¼C, ½C, C = bark edge present, partial or complete ring: ¼C = spring (last partial ring not measured), ½C = summer/autumn (last partial ring not measured), or C = winter felling (ring measured); H/S bdry = heartwood/sapwood boundary - last heartwood ring date; std devn = standard deviation; mean sens = mean sensitivity

Explanation of terms used in Table 1

The summary table gives most of the salient results of the dendrochronological process. For ease in quickly referring to various types of information, these have all been presented in Table 1. The information includes the following categories:

Sample number: Generally, each site is given a two or three letter identifying prefix code, after which each timber is given an individual number. If a timber is sampled twice, or if two timbers were noted at time of sampling as having clearly originated from the same tree, then they are given suffixes '**a**', '**b**', etc. Where a core sample has broken, with no clear overlap between segments, these are differentiated by a further suffix '**1**', '**2**', etc.

Type shows whether the sample was from a core 'c', or a section or slice from a timber's'. Sometimes photographs are used 'p', or timbers measured *in situ* with a graticule 'g'.

Timber and position column details each timber sampled along with a location reference. This will usually refer to a bay or truss number, or relate to compass points or to a reference drawing.

Dates AD spanning gives the first and last measured ring dates of the sequence (if dated),

H/S bdry is the date of the heartwood/sapwood transition or boundary (if present). This date is critical in determining an estimated felling date range if the sapwood is not complete to the bark edge.

Sapwood complement gives the number of sapwood rings. The tree starts growing in the spring during which time the earlywood is produced, also known also as spring growth. This consists of between one and three decreasing spring vessels and is noted as *Spring* felling and is indicated by a ¼ C after the number of sapwood ring count. Sometimes this can be more accurately pin-pointed to very early spring when just a few spring vessels are visible. After the spring growing season, the latewood or summer growth commences, and is differentiated from the proceeding spring growth by the dense band of tissue. This summer growth continues until just before the leaves drop, in about October. Trees felled during this period are noted as *summer* felled (½ C), but it is difficult to be too precise, as the width of the latewood can be variable, and it can be difficult to distinguish whether a tree stopped growing in autumn or *winter*. When the summer growth band is clearly complete, then the tree would have been felled during the dormant winter period, as shown by a single C. Sometimes a sample will clearly have complete sapwood, but due either to slight abrasion at the point of coring, or extremely narrow growth rings, it is impossible to determine the season of felling.

Number of rings: The total number of measured rings present on the samples analysed.

Mean ring width: This, simply put, is the sum total of all the individual ring widths, divided by the number of rings, giving an average ring width for the series.

Mean sensitivity: A statistic measuring the mean percentage, or relative, change from each measured yearly ring value to the next; that is, the average relative difference from one ring width to the next, calculated by dividing the absolute value of the differences between each pair of measurements by the average of the paired measurements, then averaging the quotients for all pairs in the tree-ring series (Fritts 1976). Sensitivity is a dendrochronological term referring to the presence of ring-width variability in the radial direction within a tree which indicates the growth response of a particular tree is "sensitive" to variations in climate, as opposed to complacency.

Standard deviation: The mean scatter of a population of numbers from the population mean. The square root of the variance, which is itself the square of the mean scatter of a statistical population of numbers from the population mean. (Fritts 1976).

Felling seasons and dates/date ranges is probably the most important column of the summary table. Here the actual felling dates and seasons are given for each dated sample (if complete sapwood is present). Sometimes it will be noticed that often the precise felling dates will vary within several years of each other. Unless there is supporting archaeological evidence suggesting different phases, all this would indicate is either stockpiling of timber, or of trees which have been felled or died at varying times but not cut up until the commencement of the particular building operations in question. When presented with varying precise felling dates, one should always take the *latest* date for the structure under study, and it is likely that construction will have been completed for ordinary vernacular buildings within twelve or eighteen months from this latest felling date (Miles 2006).

Felling date ranges are produced using an empirical estimates using the appropriate estimate (Miles 1997). However, these can sometimes be reduced using a new sapwood estimation methodology which uses the mean ring width, number of heartwood rings, known H/S boundary date, and the number of surviving sapwood rings, if present (Miles 2006). These are used after the empirical range and are shown in brackets (OxCal followed by date range). Combined felling date ranges for a phase of building is shown at the end of the phase to which it relates.

Table 2: Matrix of *t*-values and overlaps for same-timber means and site masters

Components of timber **bsh1**

Sample:	**bsh1b**
Last ring date AD:	1416
bsh1a	8.45 19

Components of timber **bsh12**

Sample:	**bsh12b**
Last ring date AD:	50
bsh12a	5.44 39

Components of site master **HENLEY9**

Sample:	**bsh4**	**bsh7**	**bsh13**	**bsh14**	**bsh19**
Last ring date AD:	1416	1412	1414	1431	1423
bsh1	3.50 40	4.23 39	4.54 41	0.08 22	1.97 43
	bsh4	2.48 36	4.01 38	1.94 22	2.78 40
		bsh7	4.98 46	0.00 18	2.88 46
			bsh13	0.70 20	5.03 54
				bsh14	5.20 29

Components of site master **HENLEY2**

Sample:	**bsh10**
Last ring date AD:	1758
bsh9	9.10 88

Table 3a: Dating of site master **HENLEY9** (1361-1431) against reference chronologies at 1431

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
Worcestershire	The Commandery, Worcester	(Arnold *et al* 2006)	WORDSQ01	1284-1473	71	6.43
Oxfordshire	Dower House, West Hanney	(Miles *et al* 2005)	WHANNEY	1390-1517	42	6.61
Gloucestershire	Ashleworth Tithe Barn	(Bridge 2002)	ASHLEWTH	1319-1475	71	6.79
Oxfordshire	Russetts, Roke	(Miles and Bridge 2015)	RUSSETS1	1392-1548	40	6.79
Oxfordshire	Princes Manor, Harwell	(Miles *et al* 2006)	PRINCES2	1355-1497	71	6.87
Great Britain	British Isles Master Chronology	(Haddon-Reece and Miles 1993)	**MASTERAL**	404-1987	71	6.88
Shropshire	Bodenhams, Ludlow	(Miles *et al* 2003)	LUDLOW9	1358-1459	71	7.00

Table 3b: Dating of site master **bsh20b** (1282-1338) against reference chronologies at 1338

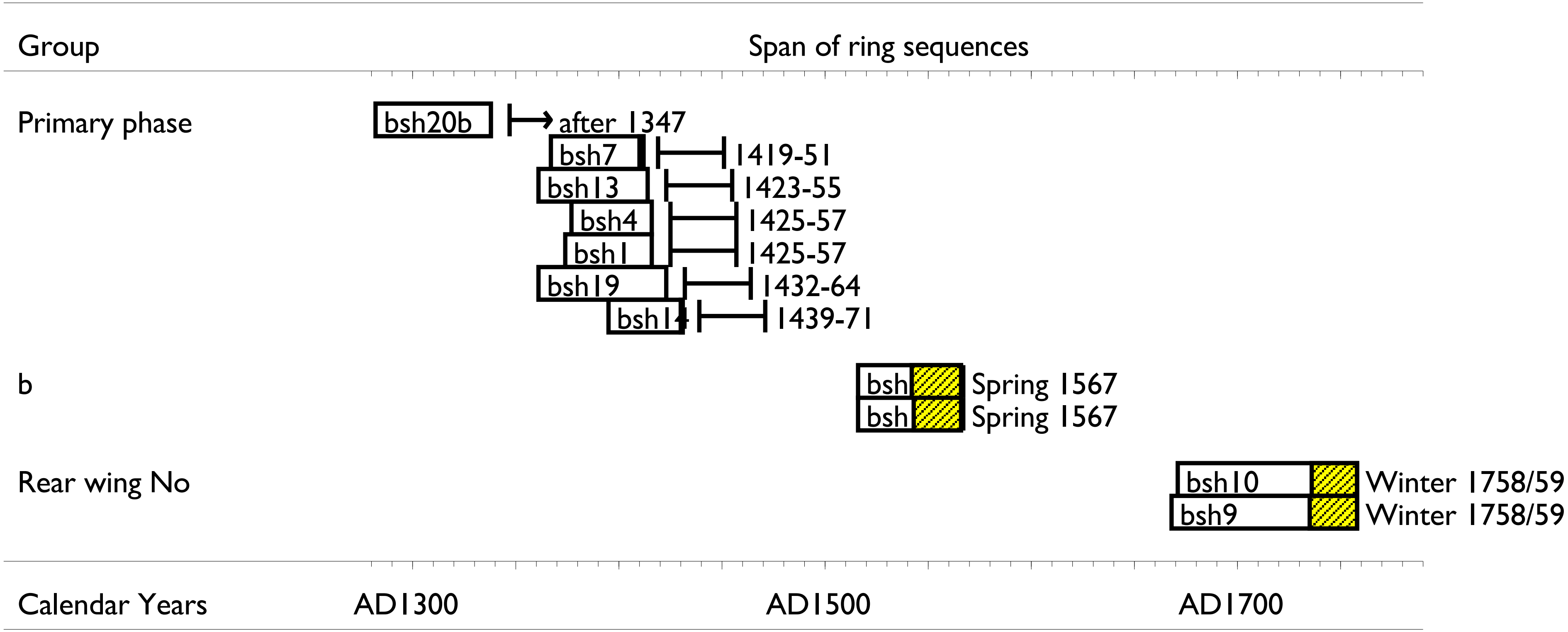
County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
Oxfordshire	Queens Head, Crowmarsh Gifford	(Haddon-Reece *et al* 1989)	QUEEN1	1203-1341	57	6.66
Oxfordshire	Oxfordshire Master Chronology	(Haddon-Reece *et al* 1993)	**OXON93**	632-1987	57	6.81
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663-2009	57	6.89
Hampshire	Rookley Farmhouse	(Miles and Worthington 1997)	ROOKLEY	1154-1387	57	6.96
Hampshire	Church Farm, West Tytherly	(Miles *et al* 2006)	TYTHRLY1	1242-1334	57	7.12
Northants	Apethorpe Hall, Apethorpe	(Arnold *et al* 2008)	APTASQ01	1292-1639	57	7.24
Hampshire	Hampshire Master Chronology	(Miles 2003)	**HANTS02**	443-1972	57	7.33

Table 3c: Dating of site master **HENLEY10** (1516-1566) against reference chronologies at 1566

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
Oxfordshire	The Red Lion and Thatch End Brightwell-cum-Sotwell	(Miles *et al* 2003)	REDLION	1424-1555	40	5.26
Warwickshire	Halls Croft, Stratford-upon-Avon	(Miles and Worthington 1999)	HLSCRFT2	1457-1613	51	5.39
England	England Master Chronology	(Baillie & Pilcher *pers comm)*	**ENGLAND**	404-1981	51	5.43
Worcestershire	Bailiff's House, Bewdley	(Fletcher 1980)	BEWDLEY2	1430-1600	51	5.55
Hampshire	Goleigh Manor	(Miles and Worthington 1997)	gm7	1494-1645	51	5.65
Northern England	Northern England Master	(Hillam and Groves 1994)	**NORTH**	440-1742	51	5.81
Wales	Welsh Master Chronology	(Miles 1997b)	**WALES97**	404-1981	51	6.29

Table 3d: Dating of site master **HENLEY2** (1668-1758) against reference chronologies at 1758

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
Oxfordshire	Step Cottage, Mapledurham	(Miles and Worthington 1998)	STEPCOTT	1688-1809	71	5.31
Hampshire	H.M.S. Victory	(Barefoot 1975)	VICTORY	1640-1800	91	5.48
Hampshire	Hampshire Master Chronology	(Miles 2003)	**HANTS02**	443-1972	91	5.64
Oxfordshire	Low Barn, Mapledurham	(Haddon-Reece *et al* 1987)	BARN	1658-1739	72	5.77
Great Britain	British Isles Master Chronology	(Haddon-Reece and Miles 1993)	**MASTERAL**	404-1987	91	5.88
Oxfordshire	Greys Court, Rotherfield Greys	(Miles *et al* 2009)	GREYSCTB	1640-1758	91	7.25
Shropshire	Bodenhams, Ludlow	(Miles *et al* 2003)	LUDLOW9	1358-1459	91	7.66



Bar diagram showing dated timbers in chronological position