Oxford Dendrochronology Laboratory
Report 2019/29

The Tree-Ring Dating of 14A Friday Street, Henley-on-Thames, Oxfordshire

Dr D W H Miles FSA

Summary:

HENLEY-ON-THAMES, 14A Friday Street (SU 76211 82504)

Felling dates: **Winter 1589/90** and **Spring 1590**

First floor girt 1589(41¼C); Principal post 1576(9); Transverse beam 1589(23C); Window jambs 1589(16¼C), 1586; Purlins 1589(33C, 27C); Rafter 1589(18C); Principal rafters 1589(24¼C, 20¼C). *Site Master* FSH 1413-1589 (*t* = 12.73 WHTOWR7; 11.95 SCENG; 11.88 NUFF).

14/14A Friday Street consists of about one-and-a-half bays of a probably four bay substantial house, the greater part (western end) of which was demolished in the 1880s to allow the construction of the present Queen Street. No. 14 consists of the truncated western end, and No. 14A the original eastern end of the house. The north-facing elevation is notable for the jettied construction, close studding, and a raised gable above an impressive first floor window. This window consists of a large three-light window with smaller flanking three-light windows either side, now blocked. There also remains a three-light window on each of the three floors of the original eastern gable end, the upper ones being blocked, as well as the smaller flanking windows of the front elevation. The window mullions are ovolo moulded. The jetty joists are narrow, with moulded ends, and internally the main beams are chamfered with lamb's tongue stops. The roof structure consists of clasped purlins.

Date sampled: 23rd September 2019

Owner & Commissioner: Caroline Lawrence

Historical Research: Ruth Gibson

Summary published: Miles, D H, and Bridge, M C, 2020 Tree-ring dates, *Vernacular Architecture* **51**, (forthcoming)

Oxford Dendrochronology Laboratory
Mill Farm, Mapledurham, South Oxfordshire, RG4 7TX
daniel.miles@rlaha.ox.ac.uk
www.Oxford-DendroLab.com

September 2019

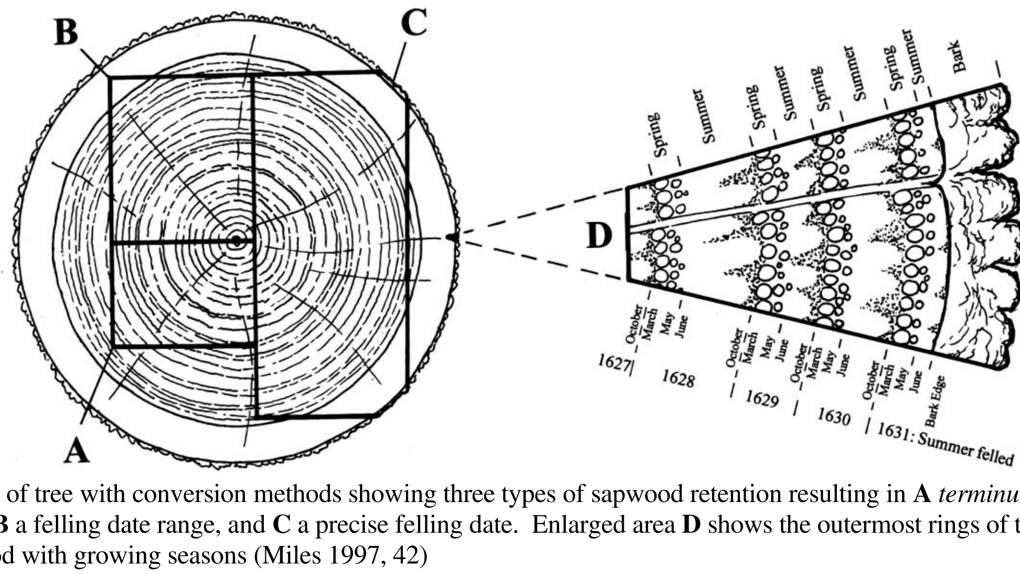
How Dendrochronology Works

Dendrochronology has over the past 30 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 which has shared a common period of growth with the sample being dated. 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 have been 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 consideration in dendrochronological studies is the presence (or absence) 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* spp), 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, a variant of the 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 Baillie-Pilcher *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 samples 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 straightforward. 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.

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 to eighteen 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 borne 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, a publication reference and the years covered by the reference chronology. The number of 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

14/14A Friday Street consists of about one-and-a-half bays of a probably four bay substantial house, the greater part (western end) of which was demolished in the 1880s to allow the construction of the present Queen Street (Gibson 2008). No. 14 consists of the truncated western end, and No. 14A the original eastern end of the house. The north-facing elevation is notable for the jettied construction, close studding, and a raised gable above an impressive first floor window. This window consists of a large three-light window with smaller flanking three-light windows either side, now blocked. There also remains a three-light window on each of the three floors of the original eastern gable end, the upper ones being blocked, as well as the smaller flanking windows of the front elevation. The window mullions are ovolo moulded. The jetty joists are narrow, with moulded ends, and internally the main beams are chamfered with lamb's tongue stops. The roof structure consists of clasped purlins.

Ten timbers were sampled throughout the house, ranging from the ground floor up to the second floor or attic. All samples were given the prefix **fsh**. Timbers with complete sapwood were selected with the exception of **fsh1** which had a long ring sequence and some sapwood.

Two samples were taken from two timbers to obtain bark edge. Timber **fsh3a** was found to be missing the outer rings of sapwood, and a second core, **fsh3b** was taken from a small area with certain bark edge below a mortice, resulting in a short sequence. However, the two matched exceptionally well (Table 2) and were combined to form the same-timber mean **fsh3**.

Two samples were also taken from a rafter, the first sample taken, **fsh8b**, had bark edge but hit a section of rot 10 rings in, so this was not continued. A second core was taken lower down the rafter, with fewer rings, but was intact, the area of rot not present at this point. The sapwood was intact, but the core only 48 years long. The two were compared visually, and whilst there was some correlation and alignment of bark edge, an area of distorted rings in **fsh8b** prevented it being combined with **fsh8a**, apart from **fhs8b** only having 10 rings.

Mean sample **fsh3** was then compared with the other nine timber samples and three pairs of timbers were found to match exceptionally well. Indeed, the degree of correlation is so high that they can be consider to have originated from the same parent tree, which is confirmed that they are from the same timber types.

Thus, two window jambs **fsh4** and **fsh5** were found to have come from the same parent tree and were combined to form the mean **fsh45**. Two purlins, **fsh6** and **fsh7** were also found to match, and were combined to form the same-tree mean **fsh67**. And similarly, principal rafters **fsh9** and **fsh10** were combined to form the same-tree mean **fsh910**. All three of these mean sequences were therefore taken through to the next stage of analysis.

A total of 9 timbers representing six trees were therefore found to match together well, and were combined to form the 177-ring site master **FSH**. This was compared with the reference chronologies and found to match exceptionally well, spanning the years 1413-1589 (Table 3). Particularly good matches were found with well replicated chronologies all across the south of England.

Sample **fsh8a** did match with two of the other individual timbers: t = 4.40 with **fsh910**, t = 5.12 with **fsh67**, and t = 4.77 with **FSH**. It also matched independently with the reference chronologies **NUFF** with a t = 4.68 and a t = 5.65 with **COTTESMR**, chronologies from Nuffield and Roke in South Oxfordshire. However, given the matches were not exceptional, and the length of the sequence short, it was decided not to include this in the site master.

Of the ten timbers sampled, all apart from **fsh1** appeared to have complete sapwood up to the bark edge. However, several timbers, particularly on the second or attic floor, had been scraped and sanded, and sample **fsh4** at 1586 was found to have lost several rings beneath the bark edge, as evidenced by the same-tree comparison with **fsh5**, which finished in 1589. As this timber retained the early spring growth of the following year, a felling date of spring 1590 was determined. This of course can be applied to **fsh4** as well, having originated from the same parent tree.

A total of four timbers: **fsh3**, **fsh6**, **fsh7**, **fsh8a**, all were found to have been felled in the winter of 1589/90. Five additional timbers: **fsh2**, (**fsh4**), **fsh5**, **fsh9**, and **fsh10** were found to have been felled in the spring of 1590, one (**fsh2**) being felled in the very early spring. Given this extremely tight spread of felling dates from **winter 1589/90** to **spring 1590** would strongly suggest that the house was constructed during 1590. Only one timber without complete sapwood (**fsh1**) produced a felling date range of 1577-1608, and is clearly coeval with the precise felling dates derived.

The presumed stylistic dating of 1550 – 1650 (Gibson 2008) has been securely determined to be 1590, which dates not only 14A Friday Street but the much larger four-bay structure the has now mainly become lost.

Acknowledgements

The dating was commissioned by the owner, Mrs Caroline Lawrence. The work was arranged by Ruth Gibson from the Henley Archaeological and Historical Society (HA&HG) who made a contribution to the costs. She also provided the photograph used in the report. Dr Martin Bridge provided the bar diagram and commented on an early draft of the report.

References

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

Bridge, M C, 1998 Compilation of master chronologies from the South, unpubl computer file SENG98, University College London Dendrochronology Laboratory

Bronk Ramsey, C, 1995 Radiocarbon calibration and stratigraphy: the OxCal program, *Radiocarbon*, **37**, 425-30

Gibson, R, 2008 14/14A Friday Street, Henley-on-Thames, unpubl report, Henley Archaeological and Historical Group

Haddon-Reece, D, and Miles, D H, 1993 Working compilation of 190 British reference chronologies supplied by various researchers, unpubl computer file MASTERAL, Oxford Dendrochronology Laboratory

Haddon-Reece, D, Miles, D H, and Munby, J T, 1989 List 32 - Tree-ring dates, Vernacular Architect, **20**, 46-9

Haddon-Reece, D, Miles, D H, Munby, J T, and the late Fletcher, J M , 1993 Oxfordshire Mean Curve - a compilation of master chronologies from Oxfordshire, unpubl computer file OXON93, Oxford Dendrochronology Laboratory

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

Miles, D, 2003 Dating Buildings and Dendrochronology in Hampshire, in Hampshire Houses 1250 - 1700: Their Dating and Development (ed E Roberts), 220-6, Southampton (Hampshire County Council)

Miles, D H, 2005 *New Developments in the Interpretation of Dendrochronology as Applied to Oak Building Timbers*, Unpubl DPhil thesis, Hertford College, Oxford Univ

Miles, D H, 2006 Refinements in the Interpretation of Tree-Ring Dates for Oak Building Timbers in England and Wales, *Vernacular Architecture*, **37**, 84-96

Miles, D, 2007 The Tree-Ring dating of the White Tower, HM Tower of London (TOL99 and TOL100), London Borough of Tower Hamlets, English Heritage Res Dept Rep Ser, **35/2007**

Millard, A, 2002 A Bayesian approach to sapwood estimates and felling dates in dendrochronology, *Archaeometry*, **44** (1), 137-143

Munro, M A R, 1984 An Improved Algorithm for Crossdating Tree-Ring Series, *Tree Ring Bulletin*, **44**, 17-27

Wilson, R, Miles, D, Loader, N J, Melvin, T, Cunningham, L, Cooper, R, and Briffa, K, 2012 A millennial long March-July precipitation reconstruction for southern-central England, Climate Dynamics, **40**, 997-1017

Table 1: Summary of Tree-Ring Dating

14A FRIDAY 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)**
* **fsh1**	c	Principal post centre truss	1460-1576	1567	9	117	2.16	0.72	0.188	1577-1608
* **fsh2**	c	Rear first floor girt	1488-1589	1548	41¼C	102	1.83	1.14	0.186	Spring 1590
fsh3a	c	Transverse beam centre truss	1489-1585	1565	20	97	2.23	0.86	0.194	(Winter 1589/90)
fsh3b	c	ditto	1539-1589	1566	23C	51	1.74	0.34	0.180	Winter 1589/90
* **fsh3**		Mean of **fsh3a** + **fsh3b**	1489-1589	1566	23C	101	2.20	0.86	0.196	Winter 1589/90
fsh4	c	Front (north) attic window jamb	1523-1586	1571	15	64	2.25	0.85	0.224	(Spring 1590)
fsh5	c	Rear (south) attic window jamb	1534-1589	1573	16¼C	56	2.60	1.21	0.285	Spring 1590
* **fsh45**		Same-tree mean of **fsh4** + **fsh5**	1523-1589	1572	17¼C	67	2.37	0.98	0.253	Spring 1590
fsh6	c	Front (north) purlin	1413-1589	1562	27C	177	0.91	0.25	0.222	Winter 1589/90
fsh7	c	Rear (south) purlin over stairs	1415-1589	1556	33C	175	0.79	0.27	0.266	Winter 1589/90
* **fsh67**		Same-tree mean of **fsh6** + **fsh7**	1413-1589	1559	30C	177	0.86	0.23	0.220	Winter 1589/90
fsh8a	c	3rd rafter from centre truss rear (south) roof	1542-1589	1571	18C	48	1.73	0.50	0.198	Winter 1589/90
fsh8b	c	ditto	1580-1589		+10C	10	3.06	2.21	0.483	Winter 1589/90
fsh9	c	Rear (south) principal rafter centre truss	1504-1589	1565	24¼C	86	1.47	0.45	0.201	Spring 1590
fsh10	c	Front (north) principal rafter centre truss	1496-1589	1569	20¼C	94	1.42	0.43	0.238	Spring 1590
* **fsh910**		Same-tree mean of **fsh9**+ **fsh10**	1496-1589	1567	22¼C	94	1.45	0.42	0.213	Spring 1590
*** = FSH Site Master**			**1413-1589**			**177**	**1.57**	**0.53**	**0.178**	**1590**

Key: * = sample included in site-master; c = core; ¼C, C = bark edge present, partial or complete ring: ¼C = spring (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 **fsh3**

Sample:	**fsh3b**
Last ring date AD:	1589
fsh3a	14.47 / 47

Components of same-tree mean **fsh45**

Sample:	**fsh5**
Last ring date AD:	1589
fsh4	11.11 / 53

Components of same-tree mean **fsh67**

Sample:	**fsh7**
Last ring date AD:	1589
fsh6	13.97 / 175

Components of same-tree mean **fsh910**

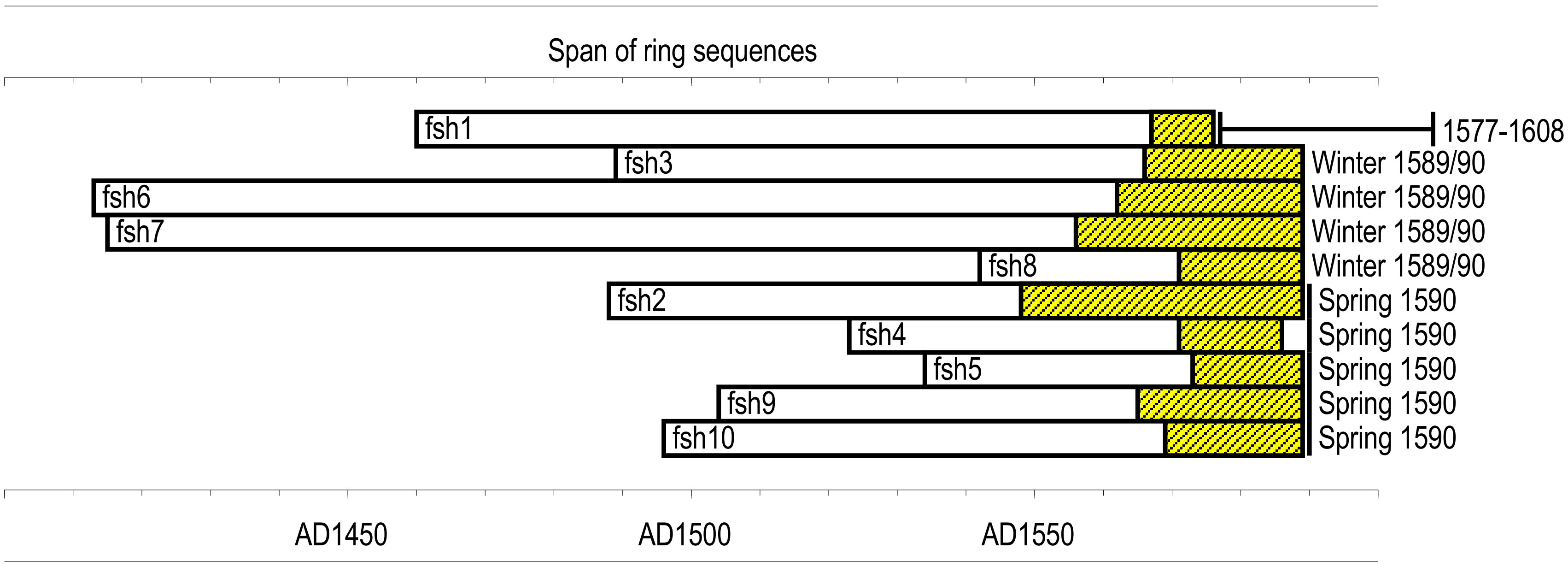
Sample:	**fsh10**
Last ring date AD:	1589
fsh9	12.80 / 86

Components of site master **FSH**

Sample:	**fsh2**	**fsh3**	**fsh45**	**fsh67**	**fsh910**
Last ring date AD:	1589	1589	1589	1589	1589
fsh1	3.40 / 89	4.40 / 88	6.40 / 54	5.03 / 117	9.54 / 81
	fsh2	4.27 / 101	1.86 / 67	3.62 / 102	4.83 / 94
		fsh3	5.61 / 67	5.92 / 101	5.50 / 94
			fsh45	5.10 / 67	7.97 / 67
				fsh67	6.72 / 94

Table 3: Dating of site master **FSH** (1413-1589) against reference chronologies at 1589

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	*t-value:*
Oxfordshire	Oxfordshire Master Chronology	(Haddon-Reece *et al* 1993)	**OXON93**	632-1987	177	9.74
Hampshire	Hampshire Master Chronology	(Miles 2003)	**HANTS02**	443-1972	177	10.11
Great Britain	British Isles Master Chronology	(Haddon-Reece and Miles 1993)	**MASTERAL**	404-1987	177	10.57
Southern England	Southern England Master	(Bridge 1998)	**SENG98**	944-1790	177	10.64
London	London Master Chronology	(Tyers *pers comm*)	**LONDON**	413-1728	177	11.17
Oxfordshire	Upper House Farm, Nuffield	(Haddon-Reece *et al* 1989)	NUFF	1404-1627	177	11.88
S Central England	South Central England	(Wilson *et al* 2012)	**SCENG**	663-2009	177	11.95
London	White Tower, Tower of London	(Miles 2007)	WHTOWR7	1463-1616	127	12.73



Bar diagram showing dated timbers in chronological position