Oxford Dendrochronology Laboratory
Report 2016/12

THE TREE-RING DATING OF THE ROOF AND OTHER TIMBERS AT BRACKLEY TOWN HALL, BRACKLEY, NORTHAMPTONSHIRE (SP 584 368)

Summary

A large transverse beam, and a re-set joist in the mezzanine floor area were shown to be from the original build, the beam being from a tree felled in summer 1699, and the joist in spring 1703. Timbers from the length of the original four-bay roof area, including those supporting the clock tower, were from trees felled over a period from spring 1881 to late summer/autumn 1882, showing that the whole of this roof was rebuilt when the building itself was extended north by one bay in the 1880s.

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BACKGROUND TO DENDROCHRONOLOGY

The basis of dendrochronological dating is that trees of the same species, growing at the same time, in similar habitats, produce similar ring-width patterns. These patterns of varying ring-widths are unique to the period of growth. Each tree naturally has its own pattern superimposed on the basic 'signal', resulting from genetic variations in the response to external stimuli, the changing competitive regime between trees, damage, disease, management etc.

In much of Britain the major influence on the growth of a species like oak is, however, the weather conditions experienced from season to season. By taking several contemporaneous samples from a building or other timber structure, it is often possible to cross-match the ring-width patterns, and by averaging the values for the sequences, maximise the common signal between trees. The resulting 'site chronology' may then be compared with existing 'master' or 'reference' chronologies. These include chronologies made by colleagues in other countries, most notably areas such as modern Poland, which have proved to be the source of many boards used in the construction of doors and chests, and for oil paintings before the widespread use of canvas.

This process can be done by a trained dendrochronologist using plots of the ring-widths and comparing them visually, which also serves as a check on measuring procedures. It is essentially a statistical process, and therefore requires sufficiently long sequences for one to be confident in the results. There is no defined minimum length of a tree-ring series that can be confidently cross-matched, but as a working hypothesis most dendrochronologists use series longer than at least fifty years.

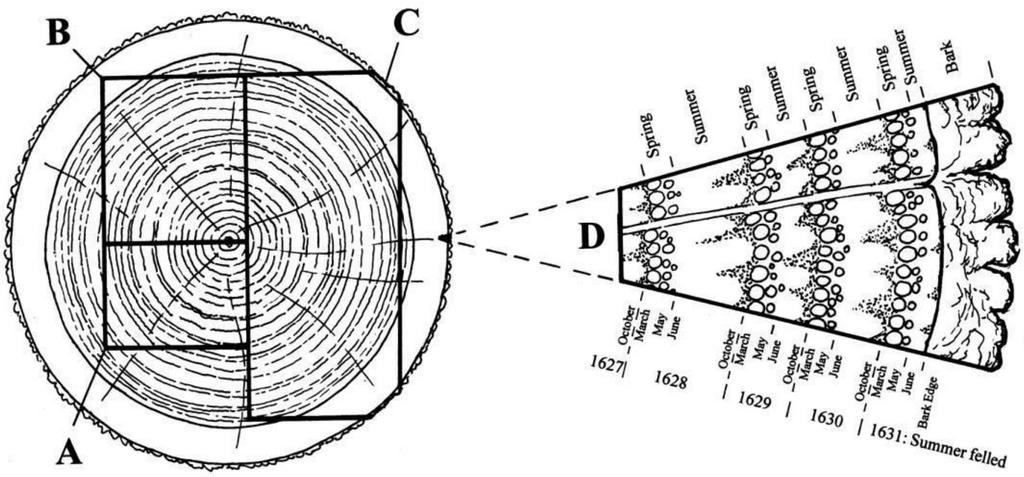
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation to the variation in the data, and is an established statistical technique for looking at the significance of matching between two datasets that has been adopted by dendrochronologists. The values of '*t*' which give an acceptable match have been the subject of some debate; originally values above 3.5 being regarded as acceptable (given at least 100 years of overlapping rings) but now 4.0 is often taken as the base value in oak studies. Higher values are usually found with matching pine sequences. It is possible for a random set of numbers to give an apparently acceptable statistical match against a single reference curve – although the visual analysis of plots of the two series usually shows the trained eye the reality of this match. When a series of ring-widths gives strong statistical matches in the same position against a number of independent chronologies the series becomes dated with an extremely high level of confidence.

One can develop long reference chronologies by cross-matching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence of unknown date to this reference material.

It follows from what has been stated above that the chances of matching a single sequence are not as great as for matching a tree-ring series derived from many individuals, since the process of aggregating individual series will remove variation unique to an individual tree, and reinforce the common signal resulting from widespread influences such as the weather. However, a single sequence can be successfully dated, particularly if it has a long ring sequence.

Growth characteristics vary over space and time, trees in south-eastern England generally growing comparatively quickly and with less year-to-year variation than in many other regions (Bridge, 1988). This means that even comparatively large timbers in this region often exhibit few annual rings and are less useful for dating by this technique.

When interpreting the information derived from the dating exercise it is important to take into account such factors as the presence or absence of sapwood on the sample(s), which indicates the outer margins of the tree. Where no sapwood is present it may not be possible to determine how much wood has been removed, and one can therefore only give a date after which the original tree must have been felled. Where the bark is still present on the timber, the year, and even the time of year of felling can be determined. In the case of incomplete sapwood, one can estimate the number of rings likely to have been on the timber by relating it to populations of living and historical timbers to give a statistically valid range of years within which the tree was felled. For this region the estimate used is that 95% of oaks will have a sapwood ring number in the range 9 – 41 (Miles 1997).



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)

BRACKLEY TOWN HALL
(from Conservation Plan by Rena Pitsilli-Graham, and associated documents).

The original building contract for a four-bay town hall is dated 19th September 1704, naming a local building contractor, but not confirming any association with an architect. There has been speculation that Wren or Hawksmoor may have worked on the building, and it is similar in style to those at Abingdon and Aylesbury. Original the four-bay arcade was open at ground level, with stairs at the south end going up into the room above. When extended in the late-nineteenth century, an extra bay was made to the north end and the ground floor became enclosed. The original roof was hipped at both ends, and the clock tower was central. The clock tower was moved to be central when the whole building was extended. The roof is a raised-tiebeam and queen-post roof, creating a coved ceiling below. The primary structure (trusses and purlins) are of oak and a recent survey by David Yeomans suggested the use of 'cotter and wedge' connections between the tiebeam and the queen posts, and the use of stitch bolts between the posts and the principal rafters, made this an entirely nineteenth-century roof. There are no empty mortices in the north end posts showing where a hip would have sat.

SAMPLING

Samples were taken in March 2016. The locations of the samples are described in Table 1, with some illustrated in Fig 1. Core samples were extracted using a 15mm diameter borer attached to an electric drill. They were labelled (prefix **brth**) and were polished with progressively finer grits down to 400 to allow the measurement of ring-widths to the nearest 0.01 mm. The samples were measured under a binocular microscope on a purpose-built moving stage with a linear transducer, attached to a desktop computer. Measurements and subsequent analysis were carried out using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004).

RESULTS AND DISCUSSION

Details of the samples are given in Table 1, the timbers being illustrated in Figs 1 and 2. The three timbers in the mezzanine area were thought to represent one of the primary beams supporting the first floor from the original build, and two re-set joists. One joist could not be dated, but the ring series from the other joist matched that from the beam (t = 4.3, 76 years overlap) and the two were combined into a site sequence, **BRACKLY1**, which dated to the period 1550–1702, the strongest matches being shown in Table 3a. The large transverse beam was from a tree felled in summer 1699, and the joist was from a tree felled in late spring 1703. These are both felled before the building contract made in September 1704 (the building being finished in 1707) – so indicate that the timbers were probably sourced from a timber merchant, rather than being felled specifically for this construction, but were probably from the local region.

Table 2 shows the internal matches between all the timbers sampled in the original four-bay roof area. The very strong match between samples **01** and **04** indicate a probably same tree origin for these two timbers (both principal rafters, but on different trusses), and the two series were combined for further analysis. The other tree-ring series match reasonable well, except for **09**, which gives consistently non-significant matches to the other series (highlighted in Table 2). This series was re-measured to check for any errors, but none were found. It does however date independently (e.g. t = 6.2 with Hayley Wood, 4.1 against Oxford, both with 84 years overlap), so it would seem it perhaps just came from a different source. Two site masters were made, one without **09**, and one with, and it was found that its incorporation led to consistently higher matches with the reference data (Table 3b). Again the timber appears to be of regional origin, but again, the small range of felling dates, from spring 1881, to late summer/autumn 1882 (Fig 3), all before the construction work started in 1883, may indicate that these timbers were sourced from a timber merchant.

This work confirms the presence of the original timbers in the first-floor floor area, and the total rebuilding of the roof to the main body of the building, as suggested by David Yeomans. It also provides very valuable tree-ring information for a period overlapping the early parts of chronologies made from living trees, and those from later buildings, which tend to be dendrochronologically investigated less frequently than medieval and immediately post-medieval ones.

ACKNOWLEDGEMENTS

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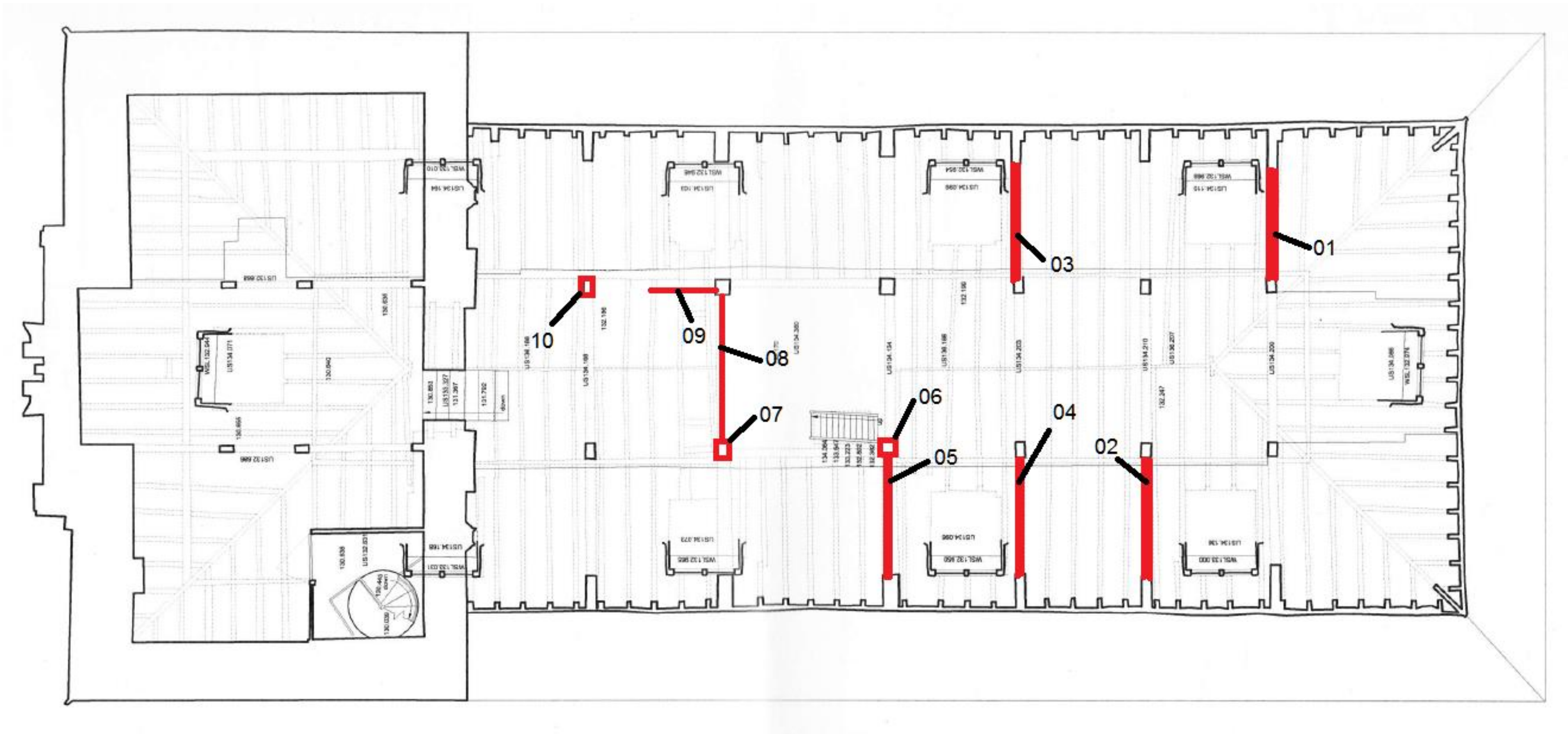

Figure 1: Drawing of the roof timbers of Brackley Town Hall, showing timbers sampled for dendrochronology, adapted from a drawing supplied by Haverstock LLP.

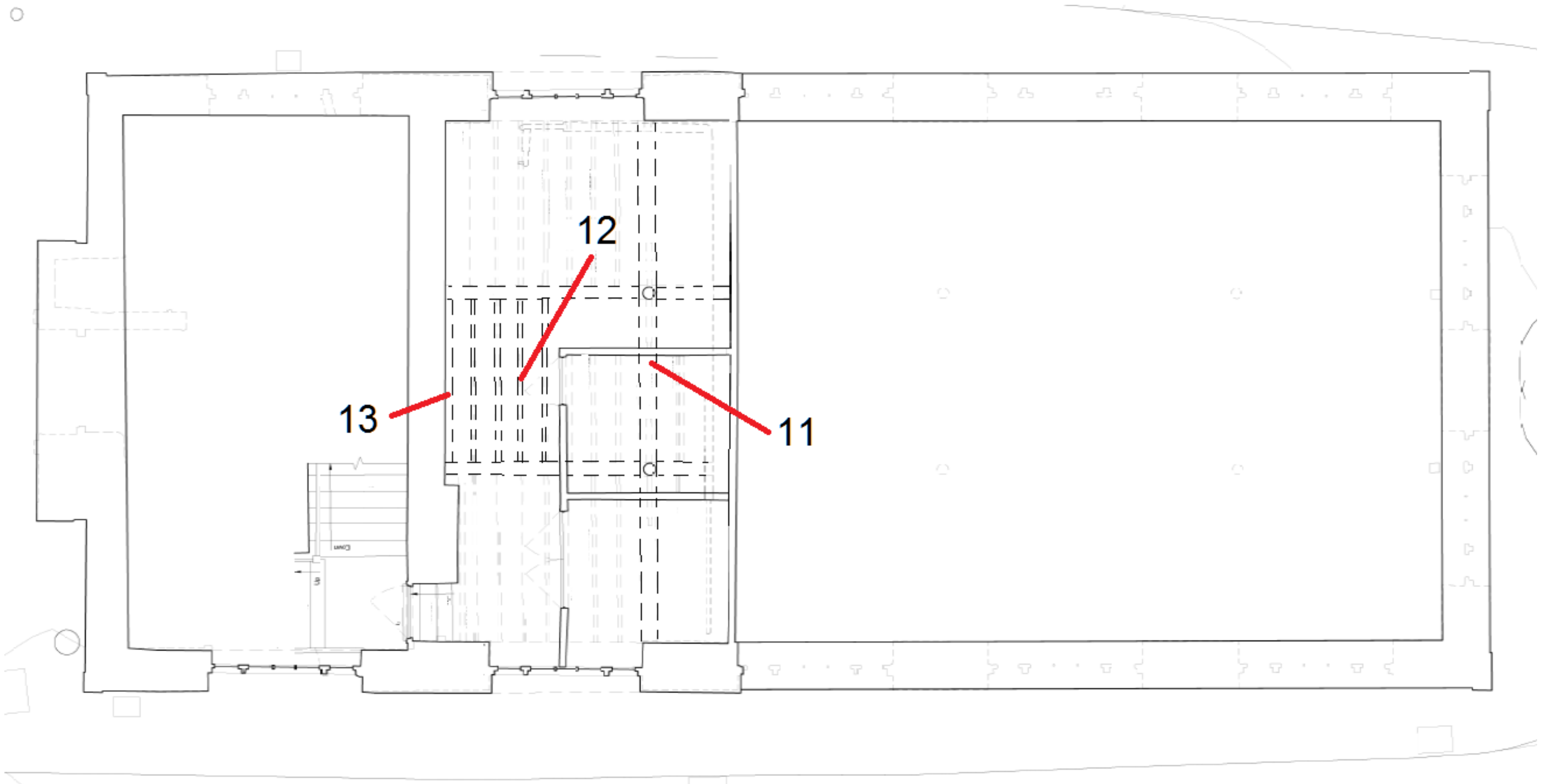

Figure 2: Drawing of the Mezzanine Floor of Brackley Town Hall, with timbers sampled for dendrochronology highlighted, adapted from a drawing supplied by Haverstock LLP

Table 1: Details of samples taken from Brackley Town Hall (trusses numbered from the south end).

Sample number	Timber and position	Date of series	H/S boundary date	Sapwood complement	No of rings	Mean width (mm)	Std devn (mm)	Mean sens	Felling date range
Roof area									
brth01	East principal rafter, truss 1	1761-1881	1861	20½C	121	1.30	0.51	0.21	Late summer 1882
*** brth02**	East principal rafter, truss 2	1774-1881	1864	17½C	108	1.58	0.68	0.18	Late summer 1882
*** brth03**	East principal rafter, truss 3	1760-1881	1866	15½C	122	1.66	0.67	0.23	Summer 1882
brth04	West principal rafter, truss 3	1776-1879	1864	15	104	1.52	0.47	0.19	(late summer 1882)
*** brth41m**	Mean of **01** and **04** (same tree)	*1761-1881*	*1863*	*18½C*	*121*	*1.41*	*0.49*	*0.20*	
*** brth05**	West principal rafter, truss 4	1748-1877	1852	25 (+3NM)	130	1.38	0.71	0.22	1880–93
*** brth06i**	West post, truss 4, in cupola	1798-1829	-	-	32	0.94	0.23	0.21	-
*** brth06ii**	*ditto* - outer section	1832-1877	1865	12	46	1.49	0.39	0.23	1877–1906
*** brth07**	West post, truss 5	1774-1880	1859	21¼C	107	1.86	0.76	0.25	Spring 1881
*** brth08**	Collar, truss 5	1808-1881	1860	21½C	74	1.32	0.59	0.29	Summer 1882
*** brth09**	North diagonal brace to T5 post	1798-1881	1863	17½C	84	0.91	0.32	0.20	Summer 1882
*** brth10**	East post, truss 6	1806-1871	1862	9 (+6NM)	66	2.42	0.62	0.19	1877–1903
* = included in site master **BRACKLY2**		**1748-1881**			**134**	**1.54**	**0.44**	**0.17**	
ʃ brth11	Transverse beam	1550-1698	1676	22½C	149	1.39	0.60	0.21	Summer 1699
brth12	Reset centre joist, 4th from north	-	-	34¼C	99	1.01	0.38	0.18	-
ʃ brth13	Reset centre joist, 1st from north	1623-1702	1685	17¼C	80	1.50	0.57	0.31	Late spring 1703
ʃ = included in site master **BRACKLY1**		**1550-1702**			**153**	**1.50**	**0.56**	**0.22**	

Key: H/S bdry = heartwood/sapwood boundary - last heartwood ring date; C = complete sapwood, winter felled; ¼ C = complete sapwood, felled the following spring; ½ C = complete sapwood, felled the following summer; std devn = standard deviation; mean sens = mean sensitivity; NM = not measured.

Table 2: Cross-matching between the individual dated timbers in **BRACKLY2** (values of *t* in excess of 3.5 are statistically significant)

Sample	**brth02**	**brth03**	**brth04**	**brth05**	**brth06i**	**brth06ii**	**brth07**	**brth08**	**brth09**	**brth10**
brth01	6.9	10.1	14.0	6.8	4.2	3.8	3.8	3.5	2.4	4.2
brth02		6.4	7.7	7.6	5.4	3.7	4.5	5.9	2.5	4.7
brth03			8.6	6.8	5.5	5.1	4.1	2.9	2.0	4.0
brth04				7.5	3.7	4.2	3.8	3.6	1.9	4.7
brth05					5.8	5.7	6.1	2.9	1.4	3.5
brth06i						*	1.9	3.6	2.7	2.3
brth06ii							2.9	5.4	1.6	3.2
brth07								3.2	2.8	2.6
brth08									2.3	6.6
brth09										2.0

* = overlap too short to calculate meaningful statistic

The grey hatched values (**brth09**) are consistently low, this tree is however dated, and its inclusion in the site master improves overall matching, the brown shaded cell highlights a probable same tree origin between two timbers.

Table 3a: Dating evidence for the site sequence **BRACKLY1** **AD 1550–1702** against dated reference chronologies

County or region	*Chronology name*	*Reference*	*File name*	*Spanning*	*Overlap (yrs)*	*t-value*
Regional Chronologies						
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663–2009	153	6.7
East Midlands	East Midlands Master	(Laxton and Litton 1988)	**EASTMID**	882–1981	153	6.7
Site Chronologies						
Derbyshire	Bolsover Castle	(Arnold *et al* 2005a)	BLSASQ01	1494–1744	153	7.6
Oxfordshire	Wardington Manor, Wardington	(Miles et al 2006)	WRD-B	1547–1738	153	7.1
Oxfordshire	Old Clarendon Building, Oxford	(Worthington and Miles 2006)	CLRNDNOX	1539–1711	153	6.7
Nottinghamshire	Pitchforks, Norwell	(Hurford *et al* 2010)	NRWASQ01	1624–1747	79	6.3
Derbyshire	Bretby Hall	(Howard *et al* 1999)	BRTASQ01	1497–1718	153	6.2
Buckinghamshire	Corinthian Arch, Stowe	(Miles *et al* 2004)	STOWE8	1653–1765	50	6.2
Somerset	Farfield House, Stogursey	(Arnold and Howard 2013)	FRFDSQ02	1525–1713	153	6.1
Buckinghamshire	Claydon House	(Tyers 1995)	CLAYDON	1613–1756	90	6.0
Bedfordshire	De Grey Mausoleum, Flitton	(Howard *et al* 2003)	FLTASQ01	1510–1726	153	6.0
Oxfordshire	Fellow's Quad, Merton College	(Miles and Worthington 2006)	mer16	1553–1693	141	6.0

Table 3b: Dating evidence for the site sequence **BRACKLY2** **AD 1738–1881** against dated reference chronologies

County or region	*Chronology name*	*Reference*	*File name*	*Spanning*	*Overlap (yrs)*	*t-value*
Regional Chronologies						
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663–2009	134	10.6
Hampshire	Hampshire Master Chronology	(Miles 2003)	**HANTS02**	443–1972	134	7.1
Site Chronologies						
Buckinghamshire	Mill Pond planks, Stowe	(Miles *et al* 2003)	STOWE5	1712–1891	134	9.1
Kent	Hatch Park	(Arnold *et al* 2005b)	HATCHPK	1819–1993	63	6.8
Oxfordshire	Oxford Living Trees	(Pilcher and Baillie 1980)	OXFORD	1787–1978	101	6.1
Gloucestershire	Yanworth Woods	(Melvin and Briffa ITRDB*)	YANWORTH	1738–1979	134	6.0
Cambridgeshire	Hayley Wood	(Bridge 1983)	HAYLEY	1777–1981	105	5.9
Oxfordshire	St Margaret's Church, Mapledurham	(Miles *et al* 2006)	MDMCH15	1755–1861	107	5.8
Wiltshire	Savenake Forest	(Briffa *et al* 1986)	SAVENAKE	1651–1982	134	5.8
Suffolk	Sotterley Park	(Briffa *et al* 1986)	SOTTERLY	1586–1981	134	5.1
Cambridgeshire	Great Gransden Windmill	(Bridge 2015)	GRANSDEN	1703–1836	89	5.0
North Yorkshire	Hovingham Woods	(Tyers 2002)	HOVWOOD	1804–2000	78	4.9
Buckinghamshire	Pitstone Windmill	(Miles *et al* 2004)	PITSTN1	1729–1823	76	4.9

* = International Tree-Ring Databank, maintained by NOAA.

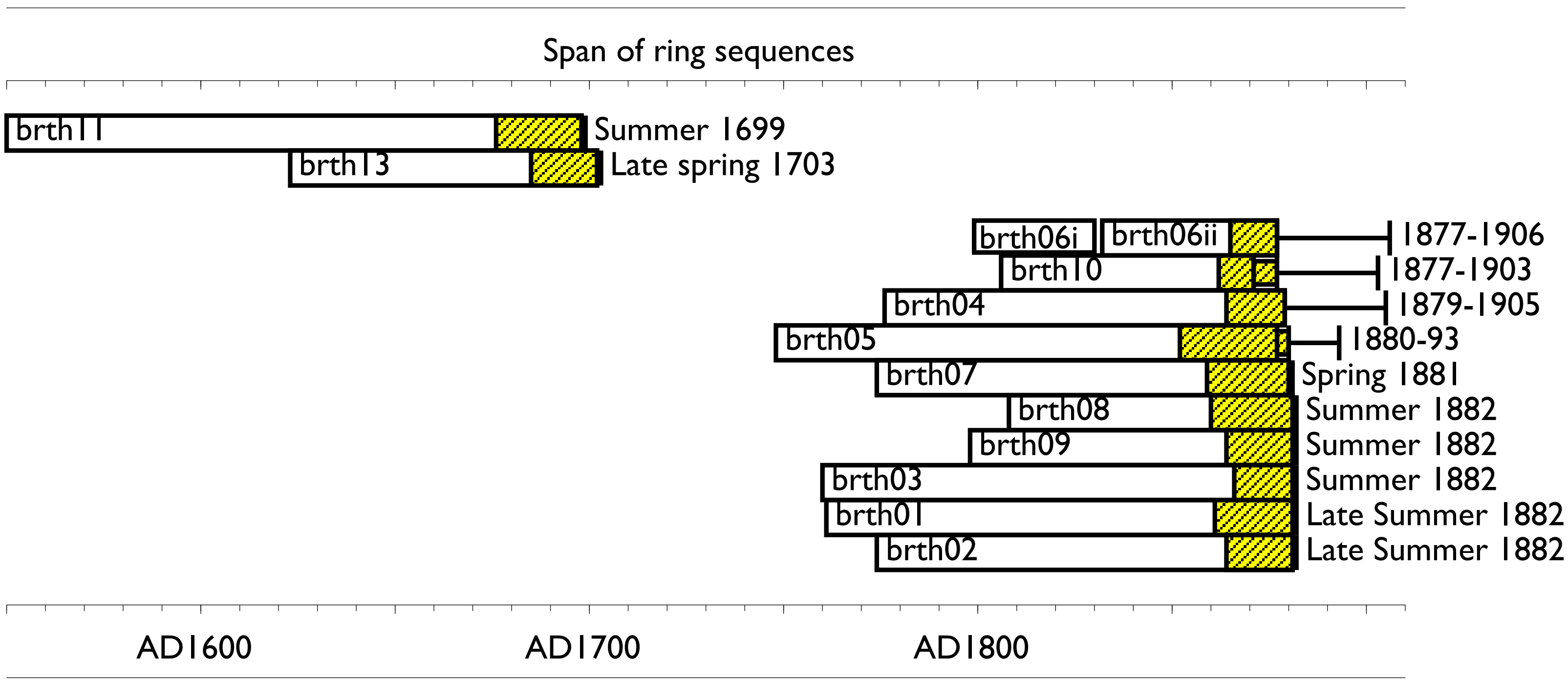

Figure 3: Bar diagram showing the relative positions of overlap of the dated samples, with their actual or likely felling dates / date ranges. White sections represent heartwood rings and yellow hatched sections represent sapwood; narrow sections represent additional unmeasured rings.