Oxford Dendrochronology Laboratory
Report 2016/27

THE DENDROCHRONOLOGICAL DATING OF TIMBERS FROM THECELLARS, REBOW HOUSE, 58-62 HEAD STREET COLCHESTER, ESSEX (TL 994 250)

Photo: Leigh Alston

Summary

The large timbers in the cellar area below this building, itself largely dating from *c*1700, have been the object of some speculation as to their age. Six timbers were sampled, but one yielded a core with fewer than 40 rings, which was excluded from further analysis. The five tree-ring series were combined into a 143-year site chronology, covering the period 1217–1359. One timber had a significantly earlier heartwood-sapwood boundary date than the others. If included, and considered as a single batch of timbers felled at the same time, the empirically derived felling date range for all five timbers is **1371–94.** Bayesian modelling of the sapwood for each individual timber suggests that the earliest one should be excluded, leaving a 95% probability range for the likely felling of the remaining four timbers of ***1370–80***. Either way, this study shows the timbers to be of late fourteenth-century origin, and slightly earlier, by a decade or two, than large timbers in the cellar of the George Hotel in the High Street.

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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.

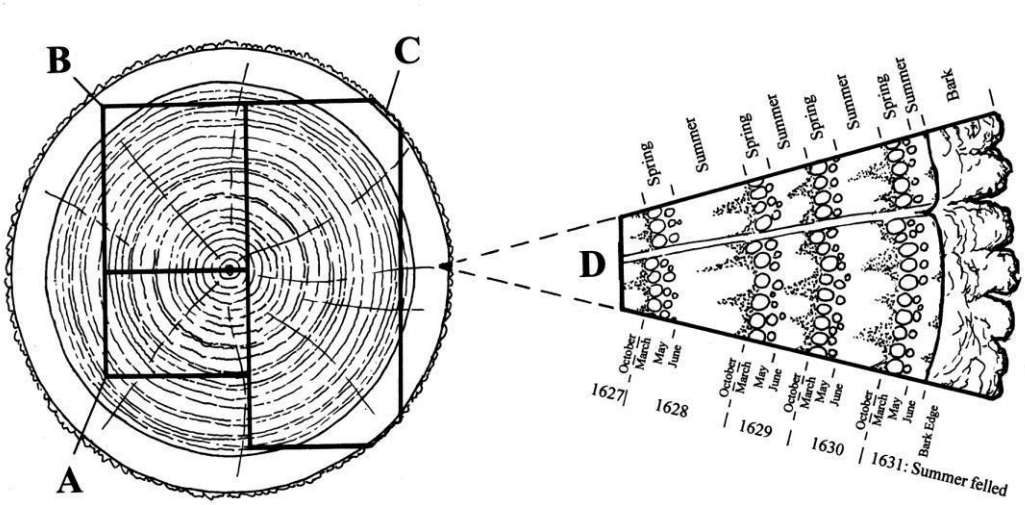
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation 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)

An alternative method of estimating felling date ranges has recently been developed (Miles 2006) which runs as a function under OxCal (Bronk Ramsey 2009). 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. When carried out within OxCal, this uses a sapwood model that has to be defined. Miles (2005) suggested several such models, of which the one that has been deemed appropriate to apply to the timbers in this case is that for 'England and Wales AD'. This model is based on timbers from throughout England and Wales, with a bias to those in the most densely-dated counties of Shropshire, Somerset, Hampshire, Oxfordshire, and Kent. 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 32-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.

Rebow House (based on notes in Alston 2016)

Rebow House is listed at grade II* and described in the Schedule of Listed Buildings as a 'large late-17th century house with a medieval cellar and an 18th century front' (Images of England no. 116989).

An impressive medieval cellar, possibly of unusually early origin, lies beneath the front part of the house. It extends to nearly 19' (5.75m) from front to rear with flint-rubble walls and a ceiling of largely concealed flat-sectioned joists lodged on massive binding joists of approximately 16" in width by 15" depth. These binding joists are supported by equally massive 9" thick braces that appear to have been tenoned to wall pieces resting on stone corbels projecting from the walls. The main timbers are hollow-chamfered and the manner of the ceiling's construction, with its common joists resting on top of the binding joists rather than tenoned to their sides, is usually found only in the 13th century and before. Cellars with identical ceilings survive beneath the George Hotel in the High Street, however, and it is possible that this archaic technique continued into the 14th or 15th centuries in positions such as this, where strength was paramount.

The best preserved section of cellar is reached by a modern stair from the St Helena Hospice charity shop which occupies the right-hand wing of the building. This section consists of three equal bays of 9.25' (2.8 m) and is divided from the rest of the cellar by a 19th century red-brick partition beneath the central print shop.

SAMPLING

Samples were taken in July 2016. The locations of the samples are described in Table 1, and illustrated in Fig 1. Core samples were extracted using a 15mm diameter borer attached to an electric drill. They were labelled (prefix **rebow**) 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

One sample, that from the wall post to truss 2 was fast-grown, and contained too few rings for further analysis. The remaining samples cross-matched (Table 2) and were combined into a 143-year long site chronology, **REBOW**, which was subsequently dated to the period 1217–1359, the strongest matches being shown in Table 3. These suggest that the timber was of local origin.

Matching was also found with timbers from the cellars at the George Hotel, High Street (t = 3.5 with 57 years overlap) and a single timber from 7 Trinity Street (t = 5.1 with 70 years overlap).

The question of interpretation is a little more difficult. The five matched timbers each retained the heartwood-sapwood boundary, with one timber (**02**) having a further 12 sapwood rings that were detached from the main core. The heartwood-sapwood (H/S) boundary date for sample **05** was much earlier than in the other dated timbers. The mean H/S date for all five dated timbers is 1353, and if the early outlier is removed, is 1354, giving an empirical likely felling date range of 1362–94, or 1363-95. This range can be modified in view of the unmeasured sapwood rings to be **1371–94/95**. If one applies Bayesian modelling of the sapwood ranges through OxCal, the early H/S date does not show good agreement with the other four timbers. When this is removed, the combined likely felling date range (95% probability) is ***1370–1380***. The empirical ranges and matching positions are shown in Figure 2, and the Bayesian modelled results in Figure 3.

Whichever interpretation one chooses to go with, it is clear that the trees used were felled in the late C14th, giving a clear date for these timbers, over which there has been some speculation in the past.

ACKNOWLEDGEMENTS

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Table 1: Details of samples taken from the cellars, Rebow House, Colchester.

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	Empirical felling date range	Oxcal-derived felling date distribution (95% probability)
*** rebow01**	West brace, truss 2	1285–1347	1347	H/S	63	1.81	1.06	0.24	1356–88	*1356–83*
*** rebow02**	Beam, truss 2	1256–1359	1359	H/S +12NM	104	1.82	0.57	0.25	1371–1400	*1370–95*
*** rebow03**	East brace, truss 2	1289–1353	1353	H/S	65	3.16	1.74	0.23	1362–94	*1361–83*
rebow04	East wall post, truss 2	-	-	?H/S	<40	NM	-	-	-	-
*** rebow05**	East brace, truss 1	1294–1339	1339	H/S	46	2.62	0.94	0.17	1348–80	-
*** rebow06**	Beam, truss 1	1217–1355	1355	H/S	139	1.72	1.04	0.24	1364–96	*1365–94*
***** = included in site master **REBOW**		**1217–1359**	**1353**		**143**	**2.21**	**0.84**	**0.22**	**1371–94**	***1370–80***

Key: H/S bdry = heartwood/sapwood boundary - last heartwood ring date; std devn = standard deviation; mean sens = mean sensitivity; NM = not measured.

Table 2: Cross-matching between the dated samples
(*t*-values above 3.5 are significant)

	***t*-values**			
Sample	**rebow02**	**rebow03**	**rebow05**	**rebow06**
rebow01	4.6	6.5	5.6	2.2
rebow02		2.1	4.3	5.1
rebow03			4.8	1.3
rebow05				1.3

Table 3: Dating evidence for the site series **REBOW AD 1217–1359** against dated reference chronologies

County or region:	*Chronology name:*	*Reference*	*File name:*	*Spanning*	*Overlap: (yrs)*	*t-value:*
Regional Chronologies						
East Anglia	East Anglia Master Chronology	(Bridge 2003)	**ANGLIA03**	944–1789	143	9.8
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663–2009	143	9.8
London	London Master Chronology	(Tyers pers comm)	**LONDON**	413–1728	143	9.1
Site Chronologies						
Essex	Coggeshall Abbey	(Arnold and Howard 2015)	COGASQ01	1225–1354	130	11.8
Hampshire	The Priory, Odiham	(Miles and Worthington 2000)	ODIHMPRY	1207–1448	143	9.9
Bedfordshire	St George's Church	(Bridge 2001)	TODDNGTN	1226–1392	134	9.8
Berkshire	Reading Waterfront	(Groves *et al* 1999)	READING	1160–1407	143	9.4
Bedfordshire	Chicksands Priory	(Howard *et al* 1998)	CHKSPQ01	1200–1541	143	9.0
Cambridgeshire	SW Portico Roof, Peterborough Cathedral	(Tyers 2008)	PTBSWP	1225–1370	135	9.0
Hertfordshire	Wymondleybury	(Groves *et al* 2005)	WYMNDBRY	1184–1379	143	8.8
Kent	Boxley Abbey Barn	(Bridge 2005)	BOXLEY	1200–1382	143	8.2

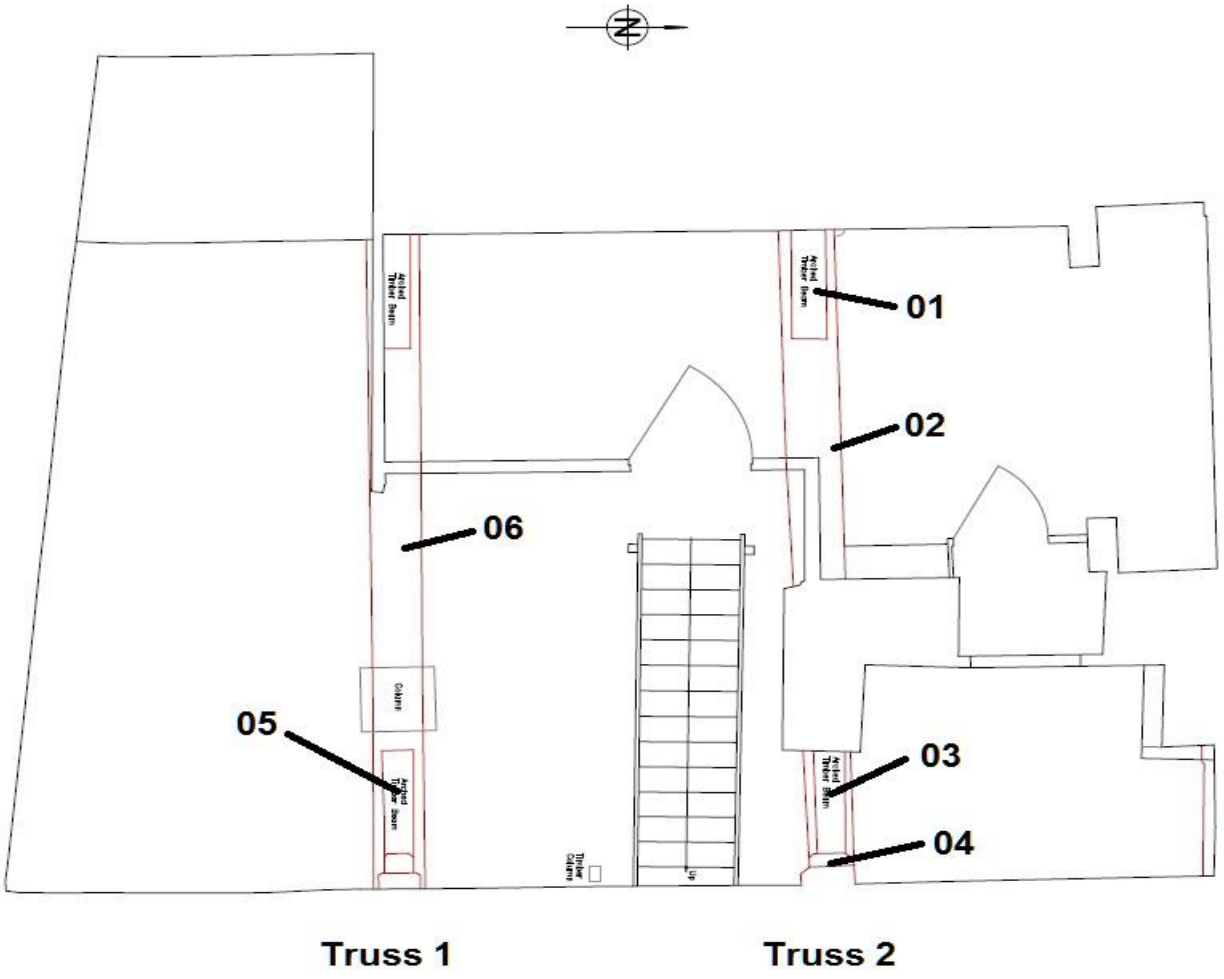

Figure 1: Drawing of the cellar layout, showing the timbers sampled, adapted from an original drawing by the Tollgate Partnership

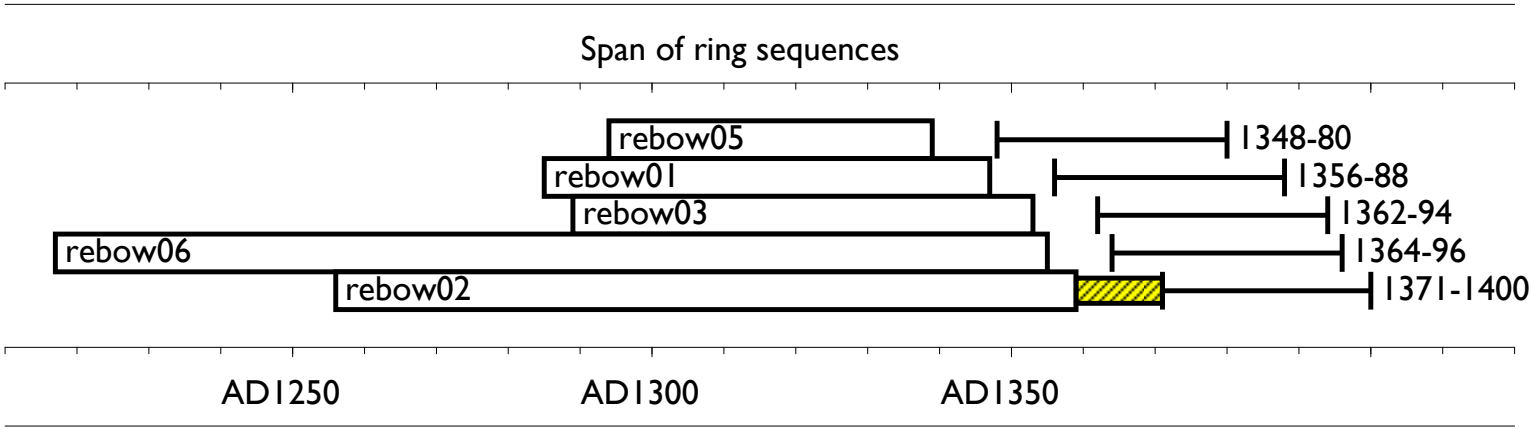

Figure 2: Bar diagram showing the relative positions of overlap of the dated samples, with their likely felling date ranges.
White sections represent heartwood rings and yellow hatched sections represent sapwood, narrow sections representing unmeasured additional rings.

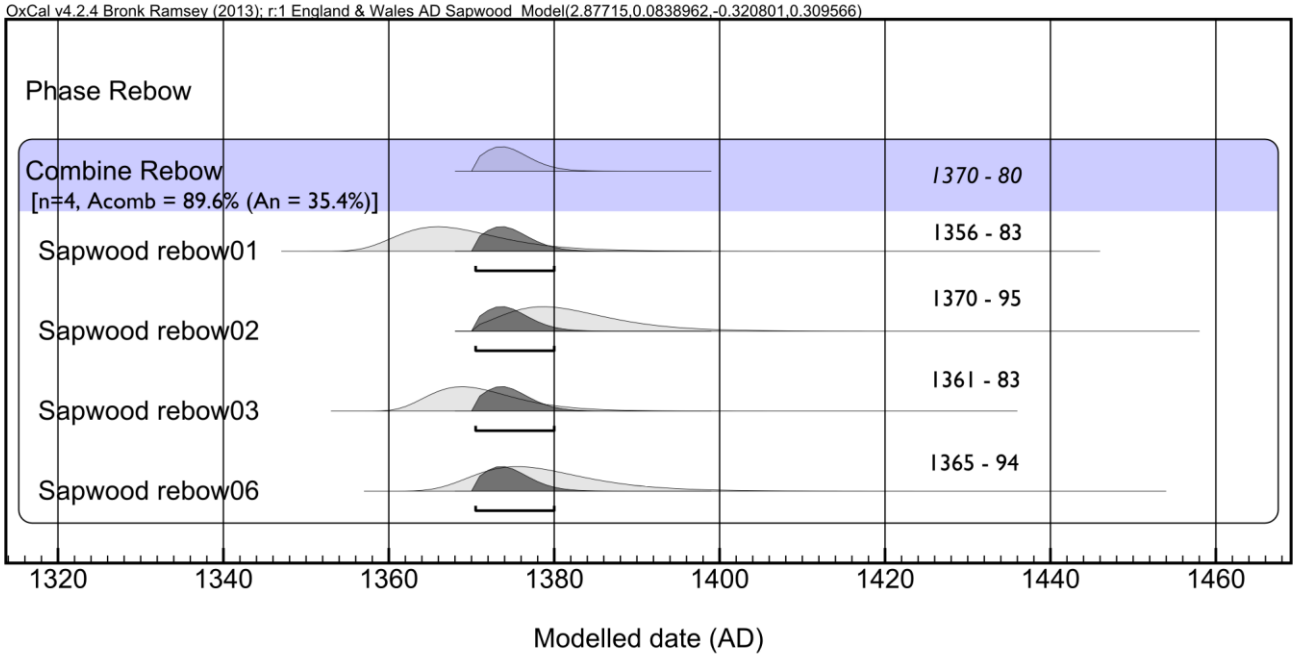

Figure 3: Rebow House, cellar timbers: combined felling date range and individual felling date distributions for four of the timbers from the cellar included in site chronology **REBOW**. Individual felling date distributions are shown in outline and the 95% probability individual felling date ranges are listed. The 95% probability combined felling date range is shown in italic text

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