

Oxford Dendrochronology Laboratory
Report 2012/27

**THE TREE-RING DATING OF
TOWER,
NERCWYS,
MOLD,
CLWYD
(NGR SJ 240 619)**



Summary

Dendrochronology has found that the roof was replaced with a cranked tiebeam truss ceiling in or shortly after 1564. The seventeenth-century dates obtained for the later house, possibly on the site of a medieval hall range, are consistent with the architectural detail. The 1671/72 date from a joist in the tank room is not consistent with the 1698 and 1699/1700 dates for the adjacent roofs. Caution must be used in interpreting this date for this section of the building, as it was from a single sample.

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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.

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. 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.

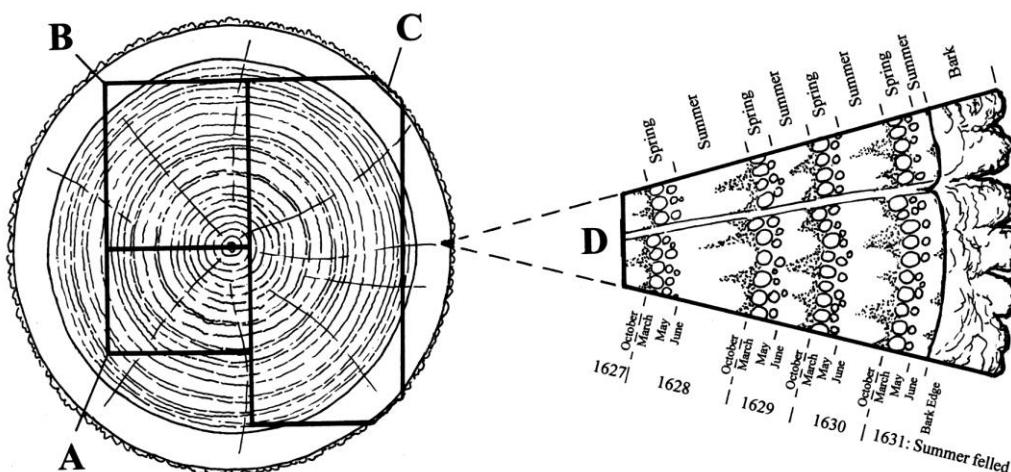
One can develop long reference chronologies by cross-matching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence 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 11 – 41 (Miles 1997a).



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 1997a, 42)

TOWER

The Tower (sometimes Broncoed or Rheinallt's Tower) is one of very few tower-houses in Wales. A vaulted tower or refuge with wall-walk has a substantial dwelling alongside. The tower has a vaulted undercroft and ground-floor with a tall first-floor chamber originally open to the roof. Ground and first-floor levels both have a small west projecting chamber secured by a draw-bar. A stair turret provided access to ground and first-floors and the wall-walk. Documentary and architectural evidence suggests that the tower has a mid-fifteenth-century building date although some of the most striking

detail belongs to a picturesque medievalising phase of *c.* 1800 when a later roof has been superimposed over the earlier roof. Plan and description in *Houses of the Welsh Countryside*, pp. 135, 139, fig. 74. NPRN 36266.

Sampling took place in July 2011. All the samples were of oak (*Quercus* spp.). Core samples were extracted using a 15mm diameter borer attached to an electric drill. They were numbered using the prefix **twr**. The samples were removed for further preparation and analysis. Cores were mounted on wooden laths and then these were polished using progressively finer grits down to 400. The samples were measured under a binocular microscope on a purpose-built moving stage with a linear transducer, attached to a desktop computer allowing the measurement of ring-widths to the nearest 0.01 mm using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004), which was also used for subsequent analysis, along with other programs written in BASIC by D Haddon-Reece, and re-written in Microsoft Visual Basic by M R Allwright and P A Parker.

One major problem in sampling the main roof was that only three sets of cranked tiebeams with principal rafters survived, the purlins and the middle axial beam had been removed. Other problems were that the vaulted ceiling below was very fragile and not capable of carrying any load so sampling had to be done balancing on a few scaffold boards. Little sapwood survived on the early roof structure, so what did survive was very friable.

In assessing the roof structure, it was not immediately evident if the principal rafters had been replaced, or reset, and therefore both the tiebeams as well as the principal rafters were sampled.

RESULTS AND DISCUSSION

Basic information about the samples and their origins are shown in Table 1.

Many of the ring series showed very abrupt changes in the rate of growth as illustrated in Figs 1 and 2. In some cases this meant that the series could not be dated, despite having long ring-width series, e.g. **twr2**, whilst in others, editing of some years meant that the remainder of the series could be dated, for example in the case of **twr9**, where the removal of the first five years dramatically improved the cross-matching of the remainder of the series. Tables 2a and 2b show the cross-matching between the dated series. It can be seen that some of the individuals did not at first date very well against the others, probably as a result of these sudden growth changes. However, when a few of the matched series were put together into a working site master, it was found that some of the less well matched individuals matched the combined series well, and chronology building in both phases therefore followed a step-wise progression.

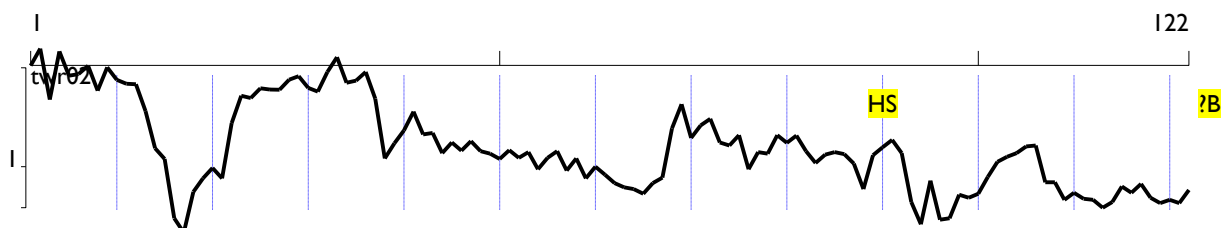


Figure 1: Semi-logarithmic plot of the ring series for **twr2**, showing a number of dramatic growth rate changes (y-axis, ring width in mm on a log scale)

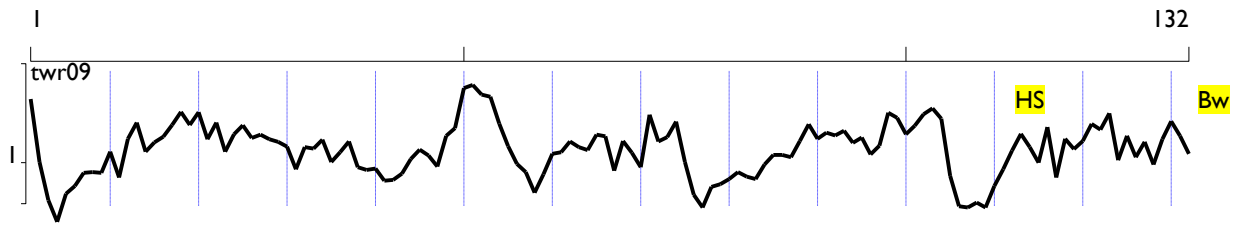


Figure 2: Semi-logarithmic plot of the ring series for **twr9**, showing a number of dramatic growth rate changes (y-axis, ring width in mm on a log scale)

The second site chronology **TOWERM2** gave some consistent statistical matches against the reference data (Table 3b) – but after editing the series by removing the first five growth rings from samples **twr7** and **twr9**, and the first ten rings from **twr14** (to produce new series **twr7o**, **9o** and **14o**), the new site master, **TOWERM2o** gave much more robust matches, dating it to the period 1573–1699.

The relative positions of overlap of the dated series from both phases of the building are shown, along with their felling date ranges, in Figure 3.

The felling dates obtained from the distinctive cranked tie-beam trusses showed (somewhat surprisingly) show that the tower was re-roofed during or shortly after 1564. Broadly consistent dates for both the principal rafters and the cranked tiebeams show that the trusses are in their original configuration, with just the axial ceiling beams and purlins having been removed.

The seventeenth-century dates obtained for the later house, possibly on the site of a medieval hall range, and are consistent with the architectural detail. The 1671/72 date from a joist in the tank room is not consistent with the 1698 and 1699/1700 dates for the adjacent roofs. Caution must be used in interpreting this date for this section of the building, as it was from a single sample and it is possible that the joist had been reused from another phase of the building, or a completely different building. Only a small section of the joist was visible so it was not possible to judge conclusively whether this had been re-used previously.

ACKNOWLEDGEMENTS

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Table 1: Details of samples taken from Tower, Nercwys, Mold, Clwyd.

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
Tower – phase 1?									
* twr1	Tiebeam T1 (north)	1419-1514	c1516	+ c42C NM	96	2.57	0.93	0.24	c1556-60?
twr2	Tiebeam, central truss, T2	-	-	32C	122	1.76	1.39	0.23	-
* twr3	Tiebeam T3 (south)	1435-1546	1546	H/S	112	2.32	0.85	0.17	1557–87
Tower – phase 2?									
* twr4	East principal rafter, T1	1475-1561	-	-	87	1.78	1.01	0.21	Winter 1561/62
* twr5	East principal rafter, T3	1453-1544	1532	12 +18CNM	92	1.31	0.56	0.21	1562-65
* twr6	West principal rafter, T3	1461-1563	1531	32½C	103	0.94	0.37	0.19	Summer 1564
* = included in site master TOWERM1		1419-1563			145	1.91	0.99	0.16	
South-West (front) Range									
Ω twr7	North-east lower purlin, east bay	1613-1694	1681	13	82	1.88	0.71	0.25	1695–1722
Ω twr8	North principal rafter, east truss	1592-1684	1683	1	93	1.63	0.85	0.25	1694–1724
Ω twr9	Collar, west truss	1568-1699	1681	18C	132	1.33	0.56	0.25	Winter 1699/1700
twr10ai	North principal rafter, west truss	1605-1670	-	-	66	2.21	1.08	0.24	
twr10aii	<i>ditto</i>	-	-	13	28	1.51	0.46	0.25	
twr10b	<i>ditto</i>	1633-1698	1686	12	66	1.53	0.56	0.27	
Ω twr10	Mean of twr10ai and twr10b	1605-1698	1685	13	94	1.78	0.65	0.24	1699–1726
North-West (rear) Wing									
Ω twr11	East principal rafter, west roof	1601-1697	1684	13¼C	97	2.32	1.14	0.29	Spring 1698
twr12	Severed beam on staircase, west roof	-	-	H/S	88	1.23	0.84	0.37	-
twr13	1 st joist adjacent to stairs, west roof	-	-	19¼C	66	2.03	0.57	0.22	-
Ω twr14	Valley beam between east & west roofs	1606-1679	1679	H/S + 18C NM	74	1.45	0.54	0.28	1698–1703
Ω twr15	1 st joist at door to tank room, east roof	1626-1671	1653	18C	46	2.07	1.18	0.28	Winter 1671/72
twr16	2 nd joist from door, east roof	-	-	2	75	1.66	0.50	0.22	-
Ω = included in site master TOWERM2		1568-1699		132	1.70	0.56	0.19		
Using edited files TOWERM2o		1573-1699		127	1.73	0.53	0.18		

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



A report commissioned by the Royal Commission on the Ancient and Historical Monuments in Wales (RCAHMW).

Table 2a: Cross-matching between the dated samples included in **TOWERM1**

<i>t</i> -values				
Sample	twr3	twr4	twr5	twr6
twr1	3.1	6.4	3.4	3.6
twr3		0.8	3.1	2.2
twr4			4.0	3.4
twr5				5.4

Table 2b: Cross-matching between the dated samples included in **TOWERM2o**

<i>t</i> -values						
Sample	twr8	twr9o	twr10	twr11	twr14o	twr15
twr7o	0.4	3.6	1.3	1.6	4.4	2.5
twr8		2.9	6.2	4.9	2.0	3.1
twr9o			2.4	4.2	3.5	3.1
twr10				8.4	6.0	3.9
twr11					7.2	3.6
twr14o						4.5

Table 3a: Dating evidence for the site master **TOWERM1 AD 1419–1563** against dated reference chronologies.
Regional multi-site chronologies are shown in **bold**

<i>County or region:</i>	<i>Chronology name:</i>	<i>Short publication reference:</i>	<i>File name:</i>	<i>Spanning:</i>	<i>Overlap (yrs):</i>	<i>t-value:</i>
Shropshire	Roseleigh, All Stretton	(Miles <i>et al</i> 2007)	ALLSTRET	1386-1509	91	9.8
Lancashire	Worden Old Hall, Chorley	(Bridge 2003)	OLDWORD2	1415-1531	113	7.4
Wales	Welsh Master Chronology	(Miles 1997b)	WALES97	404-1981	145	7.2
Shropshire	High Street, Whitchurch	(Miles and Worthington 2001)	WHGHWHIT	1416-1596	145	7.2
Wales	Rose and Crown, Gwydwn	(Miles and Worthington 2000)	GWYDWN	1411-1571	145	7.2
Wales	Plas Mawr House	(Miles 1997c)	PLASMAWR	1360-1578	145	7.2
N. England	Northern England Master	(Hillam and Groves 1994)	NORTH	440-1742	145	7.0
Warwickshire	Gorcott Hall	(Nayling 2006)	GORC_T17	1385-1531	113	6.9
Wales	Llwyn Llandrinio, Montgomeryshire	(Miles <i>et al</i> 2003)	LLWYN	1413-1551	133	6.8
Shropshire	Shropshire Master Chronology	(Miles 1995)	SALOP95	881-1745	145	6.7
Wales	Kerry Church	(Miles <i>et al</i> 2011)	KERRY	1402-1567	145	6.6
Yorkshire	Yorkshire Buildings Chronology	(Hillam pers comm)	YORKS1	1192-1648	145	6.6
Cheshire	Combermere Abbey, Whitchurch	(Howard <i>et al</i> 2003a)	CBMASQ01	1371-1564	145	6.5
Wales	Upper Wig, Dolfor	(Miles <i>et al</i> forthcoming)	UPPERWIG	1419-1571	145	6.5
Shropshire	Ightfield Hall barn, Whitchurch	(Groves 1997)	IGHTFELD	1341-1566	145	6.4

Table 3b: Dating evidence for the site master **TOWERM2o AD 1573–1699** against dated reference chronologies. Regional multi-site chronologies are shown in **bold**

<i>County or region:</i>	<i>Chronology name:</i>	<i>Short publication reference:</i>	<i>File name:</i>	<i>Spanning:</i>	<i>Overlap (yrs):</i>	<i>t-value unedited mean</i>	<i>t-value:</i>
Cheshire	Combermere Abbey, Whitchurch	(Howard <i>et al</i> 2003)	CBMASQ02	1595-1727	105	8.2	8.3
Derbyshire	Bolsover Castle	(Arnold <i>et al</i> 2005)	BLSASQ01	1494-1744	127	5.9	7.8
Wales	Nantclwyd House, Ruthin	(Miles <i>et al</i> 2005)	NHRE	1563-1662	90	4.6	7.7
Wales	Welsh Master Chronology	(Miles 1997b)	WALES97	404-1981	127	5.6	7.1
Herefordshire	St Mary's Church, Pembridge	(Tyers 1999)	PBT_C	1559-1668	96	5.2	6.9
East Midlands	East Midlands Master	(Laxton and Litton 1988)	EASTMID	882-1981	127	5.3	6.9
Derbyshire	Bentley Hall, Hungry Bentley	(Arnold and Howard 2009)	HBNASQ01	1444-1675	103	4.4	6.4
Shropshire	Stokesay Castle	(Miles and Worthington 1997)	STOKE5	1463-1662	90	4.2	6.0
Warwickshire	Middleton Hall	(Arnold <i>et al</i> 2006)	MIDHSQ01	1593-1718	107	6.0	5.9
Gt Manchester	Staircase House, Stockport	(Howard <i>et al</i> 2003b)	STKASQ01	1489-1658	84	4.5	5.8
Shropshire	Clungunford Master Chronology	(Miles 2002 unpubl)	CLNGNFRD	1273-1653	81	4.0	5.7
Oxfordshire	Wardington Manor, Wardington	(Miles <i>et al</i> 2006)	WRD-B	1547-1738	127	3.5	5.6
England	Ref3 Master Chronology	(Fletcher 1977)	REF3	1399-1687	115	5.0	5.6
Derbyshire	Bretby Hall	(Howard <i>et al</i> 1999)	BRTASQ01	1497-1718	127	4.6	5.6
Shropshire	Boscobel House, nr Brewood	(Tyers 2010)	BOSCOBL1	1609-1696	88	5.6	5.5

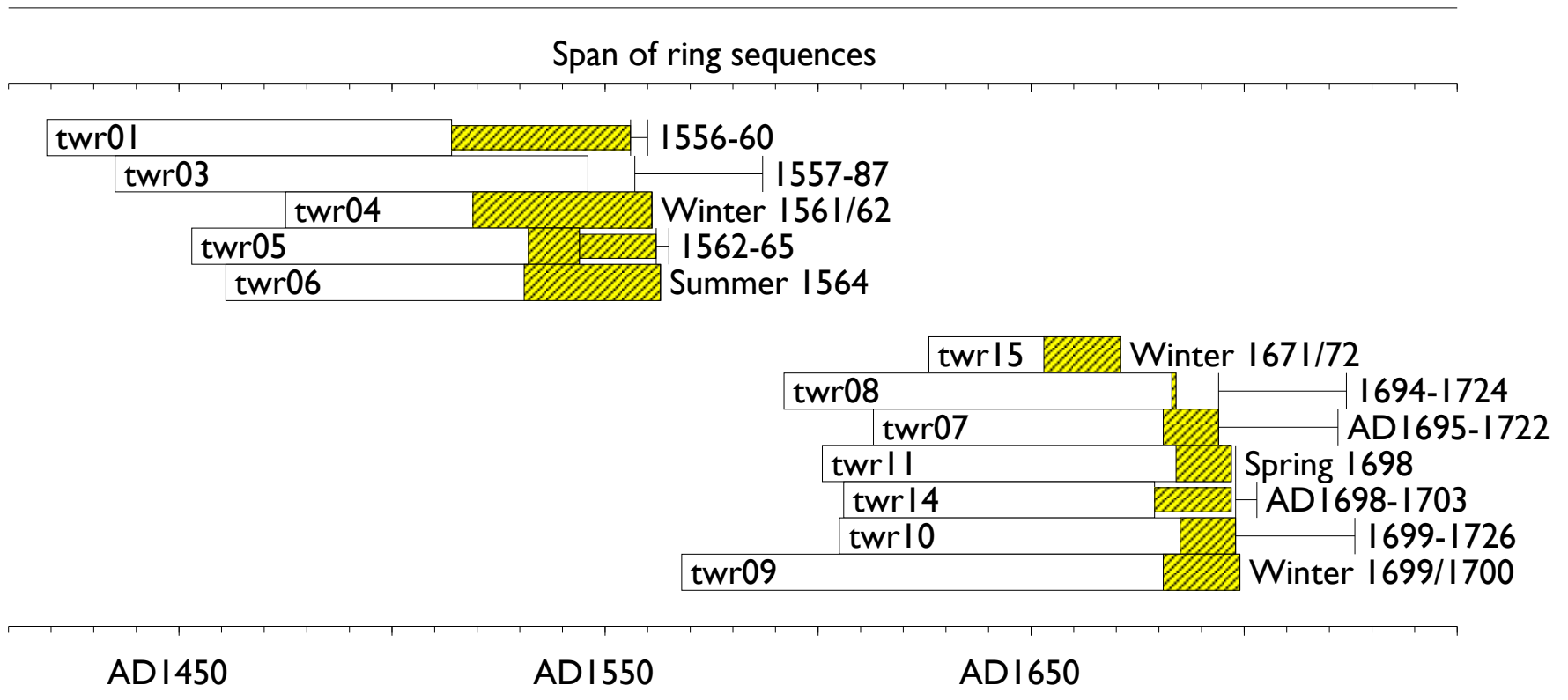


Figure 3: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings