Oxford Dendrochronology Laboratory
Report 2014/28

THE TREE-RING DATING OF GWERCLAS, CYNWYD, RHUG MERIONETH (NGR SJ 053 421)

Summary
Five timbers from the lattice-braced truss and its associated purlin were dated. Two retained complete sapwood and were found to have come from trees felled in summer 1652 and the following winter, **1652/53** – making this the likely date of construction, or within a year or two after this date. Two principal rafters from a second truss, both re-used or reset in their current positions, could not be dated.

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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.

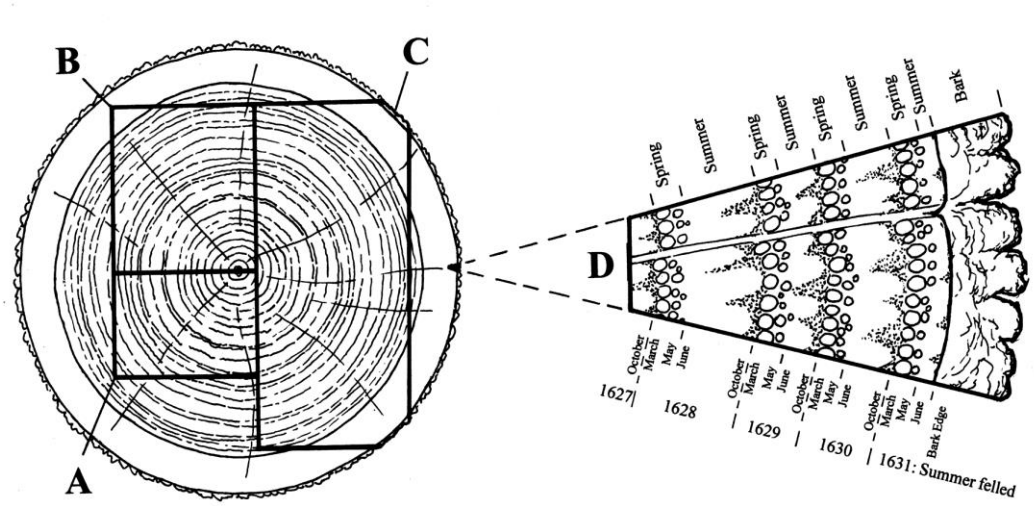
One can develop long reference chronologies by cross-matching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence 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 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 1997a, 42)

GWERCLAS (notes by Richard Suggett)

Gwerclas is a country-house associated from the sixteenth century with the Hughes family, descendants of one of the 'baronial' families of Edeyrnion. The house was rebuilt in 1767, the date displayed on the front of the present three-storey brick-built house in Palladian style. Traces of the older house remain: the 1767 house may incorporate fragments of its predecessor at basement level and a substantial four-bay service range to the west was certainly associated with the old house. This storeyed, stone-built range was originally built without fireplaces but has a relatively high ceiling of chamfered beams. It is

best interpreted as stable – the indispensable adjunct of a gentry house. A re-set post-and-panel partition on the first floor probably derives from the old house. The end truss (now within the range) originally had a decorative gable of lattice (criss-cross) framing, fashionable in the seventeenth century, and this was presumably intended to be visible from the old house.

RCAHMW's *Merioneth Inventory* (1921), p. 125 (mon. 398) emphasizes the antiquity of the site. See Richard Haslam et al., *The Buildings of Wales: Gwynedd* (2009), p. 580-1, for a description of Gwerclas. Coflein (RCAHMW's on-line database) entry: NPRN 28455. R.F.Suggett/RCAHMW/November 2014.

SAMPLING

Sampling took place in June 2014. 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 **grcs**. Locations of samples 1 – 6 are shown in Fig. 1. 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 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. 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. Subsequent analyses were carried out using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004).

Figure 1: Photograph of the lattice truss (DM) showing the timbers sampled for dendrochronology, the samples were taken from the other face of this truss.

RESULTS AND DISCUSSION

Basic information about the samples and their origins are shown in Table 1. Table 2 shows the cross-matching between sequences, and it is clear that series 1, 2a and 4 match together reasonably well. Series 5 has very short overlaps with the others, and series 6 has poor cross-matching statistics, even though the visual matches between plots were acceptable. For this reason, samples 5 and 6 were run independently against the dated reference material to confirm the matching positions, and this independent dating is shown in Table 3a. Series 3 of just 38 rings could not be satisfactorily matched to the other series, and the additional information from the sapwood slice was useful, but the short 19 year sequence could not be matched with certainty.
Five series were matched together to form a 94-year long site master chronology, **GWRCLS1**. This was subsequently dated to the period 1559–1652, the strongest matches being shown in Table 3b.

The remaining two samples, 7 and 8 matched each other well (t = 5.6 with 52 years overlap). They did not match the dated series. They were combined into a second site master, **GWRCLS2**, of 70 years. This could not be dated.

The complete sapwood on two samples allowed two felling dates to be derived, Summer 1652, and Winter 1652/53, and the information from sample 2 allowed a narrow range of 1650–55 to be derived for this timber. The other two dated series have felling date ranges that agree well with these dates (Figure 2), suggesting that all the timbers in the lattice-braced truss were felled at around the same time, and that construction of the truss was likely in **winter 1652/53**, or within a year or two after this date. Thus, the tree-ring dating confirms that the stable range was built in the mid-seventeenth century.

The two principal rafters of the second truss investigated were noted at the time of sampling as likely to be re-used and/or reset in their present positions, and no further evidence of their dating was found.

ACKNOWLEDGEMENTS

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Table 1: Details of samples taken from Gwerclas, Cynwyd.

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
Lattice truss									
* **grcs1**	East principal rafter	1559-1634	-	-	76	2.71	0.78	0.19	after 1645
* **grcs2a**	West principal rafter	1589-1634	1631	3 +16NM	46	2.33	0.86	0.22	1650-55
grcs2b	*ditto* - slice of sapwood	-	-	19¼C	19	NM	-	-	-
grcs3	Diagonal lattice brace	-		-	38	4.12	1.99	0.25	-
* **grcs4**	Diagonal lattice brace	1572-1636	1635	1	65	1.97	0.98	0.27	1646–76
* **grcs5**	Diagonal lattice brace	1607-1651	1633	18½C	45	1.29	0.52	0.28	Summer 1652
* **grcs6**	East upper purlin	1560-1652	1626	26C	93	1.64	0.93	0.27	Winter 1652/53
* = included in site master **GWRCLS1**		**1559-1652**			**94**	**1.96**	**0.74**	**0.19**	
….truss									
§ **grcs7**	East principal rafter (re-used?)	-	-	1	70	2.66	1.37	0.22	-
§ **grcs8**	West principal rafter (re-set?)	-	-	4	52	1.72	0.48	0.20	-
§ = included in site master **GWRCLS2**		-			**70**	**2.16**	**0.80**	**0.20**	

Key: H/S bdry = heartwood/sapwood boundary - last heartwood ring date; C = complete sapwood, felled the following winter; ¼C = 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 samples (values over 3.5 are significant)

***t*-values**				
Sample	**grcs2a**	**grcs4**	**grcs5**	**grcs6**
grcs1	5.8	4.0	*	2.4
grcs2a		2.9	*	1.5
grcs4			*	2.3
grcs5				1.9

* = overlap too short for meaningful calculation

Table 3a. Independent dating evidence for samples **grcs5** and **grcs6**

Sample	**Strongest matches (*t*-values)**		
grcs5 1607-1651	5.5 PBT_C (Tyers 1999)	5.5 LYTHAM1 (Tyers 2013)	5.5 STOKE5 (Miles & Worthington 1997)
grcs6 1560-1652	5.7 HBNASQ01 (Arnold & Howard 2009)	5.4 STKASQ01 (Howard *et al* 2003)	5.2 TOWERM2o (Miles *et al* 2012)

Table 3b: Dating evidence for the site master **GWRCLS1** **AD 1559–1652** against dated reference chronologies, regional chronologies in **bold**

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap (yrs):*	*t-value:*
Regional chronologies						
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663–2009	94	6.3
Shropshire	Shropshire Master Chronology	(Miles 1995)	**SALOP95**	881–1745	94	5.9
Wales	Welsh Master Chronology	(Miles 1997b)	**WALES97**	404–1981	94	5.8
Individual site chronologies						
Derbyshire	Bentley Hall, Hungry Bentley	(Arnold and Howard 2009)	HBNASQ01	1444–1675	94	8.1
Derbyshire	Bolsover Castle	(Arnold *et al* 2005)	BLSASQ01	1494–1744	94	6.8
Gt Manchester	Staircase House, Stockport	(Howard *et al* 2003)	STKASQ01	1489–1658	94	6.2
Shropshire	Brookgate Farm	(Miles and Haddon-Reece 1993)	BROOKGT	1362–1611	53	6.2
Oxfordshire	Newington House	(Haddon-Reece *et al* 1987)	NEWING	1540–1678	94	6.1
Warwickshire	Middleton Hall	(Arnold *et al* 2006)	MIDHSQ01	1593–1718	74	5.9
Flintshire	Tower, Nercwys, Mold	(Miles *et al* 2012)	TOWERM2o	1573–1699	80	5.7
Lancashire	Turton Tower, Blackburn	(Arnold and Howard 2008)	TRTASQ01	1483–1665	94	5.6
Cheshire	Hulme Hall, nr Northwich	(Arnold *et al* 2003)	ALSASQ01	1574–1689	79	5.5
Lancashire	Buckshaw Hall, Chorley	(Bridge 2003)	BUCKSHAW	1517–1627	69	5.4
Warwickshire	Peggs Barn, Coleshill	(Miles and Worthington 2002)	PEGGS	1561–1668	92	5.4

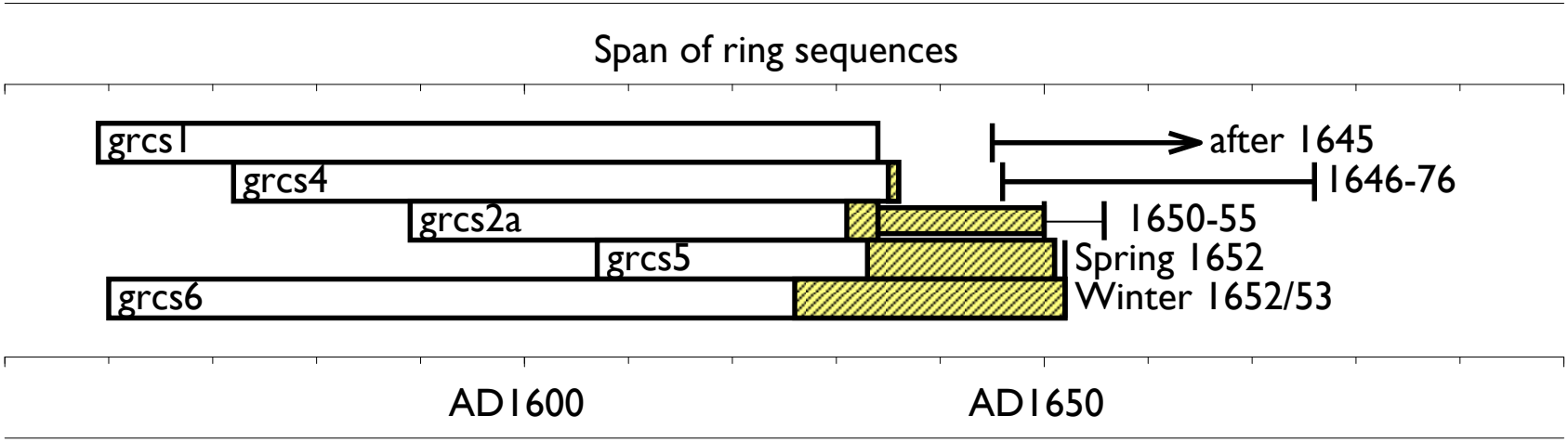

Figure 2: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely, or actual, felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings

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