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Oxford Dendrochronology Laboratory
Report 2011/21
Updated December 2014 with the results of the radiocarbon analysis

THE TREE-RING DATING OF TY MAWR, WYBRNANT PENMACHNO, BETWS-Y-COED, CONWY (CAERNARFONSHIRE) (NGR SH 7700 5240)

Summary

Tŷ-mawr is a large, three-unit, storeyed house of Snowdonian plan-type famous for its association with William Morgan (1545-1604), translator of the Bible into Welsh (1588). The stubs of cruck blades cut off flush with the walls suggest that Tŷ-mawr originated as a late-medieval hall-house. These cruck fragments failed to date but the collar-beam trusses of the Snowdonian house were successfully dated to 1565, showing that Tŷ-mawr was improved during the life-time of William Morgan. Plan and description in RCAHMW, *Caernarvonshire Inventory, Volume I: East* (1956), pp. 173-4. The mantel beam of the reconstructed guardian's cottage adjacent was sampled as it had evidence for reuse and was found to date from 1521-51. However, the provenance of this timber is unknown. Dating commissioned by The National Trust Wales in association with by the North West Wales Dendrochronology Project and RCAHMW. NPRN 16966. Inconclusive results were found for the radiocarbon analysis of an undated cruck blade, although it seems likely the tree was not felled before 1510. A third sample is being analysed by the Oxford Accelerator Unit in an attempt to resolve this issue.

Authors: Dr D. Miles FSA and Dr M. C. Bridge FSA
Oxford Dendrochronology Laboratory
Mill Farm
Mapledurham
Oxfordshire
RG4 7TX

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The Tree-Ring Dating of Ty Mawr, Wybrnant, Penmachno, Betws-y-Coed, Conwy (NGR SH 7700 5240)

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.

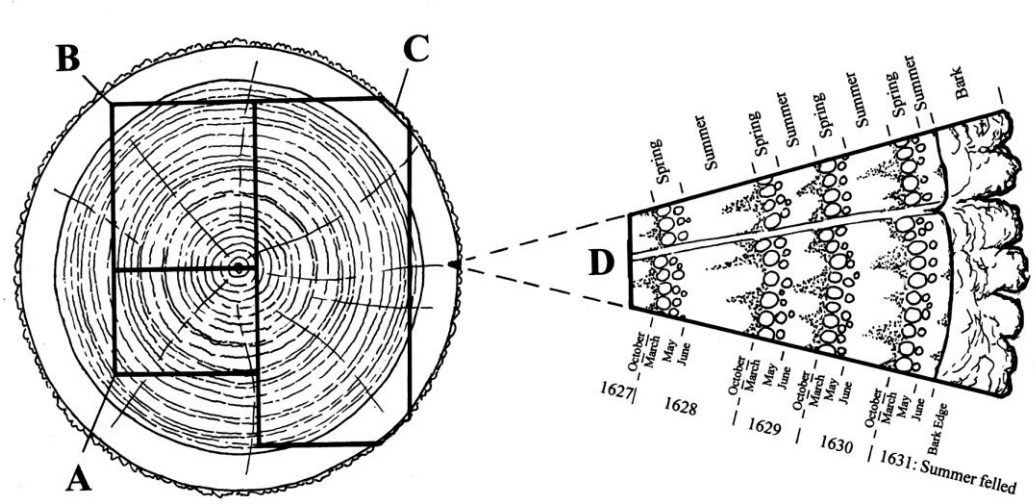
One can develop long reference chronologies by cross-matching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence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

TY MAWR, WYBRNANT

This is a large, three-unit, storeyed house of Snowdonian plan-type famous for its association with William Morgan (1545-1604), translator of the Bible into Welsh (1588). The stubs of cruck blades cut off flush with the walls suggest that Tŷ-mawr originated as a late-medieval hall-house. These cruck fragments failed to date but the collar-beam trusses of the Snowdonian house were successfully dated, showing that Tŷ-mawr was improved during the life-time of William Morgan. Plan and description in RCAHMW, *Caernarvonshire Inventory, Volume I: East* (1956), pp. 173-4. The mantel beam of the reconstructed guardian's cottage adjacent was sampled as it had evidence for re-use and was found to date from 1521-51. However, the provenance of this timber is unknown. NPRN 16966.

SAMPLING

Sampling was undertaken in two sessions, the first in February 2001 in which the two truncated crucks and the mantel beam were sampled, and the second took place in January 2011 when the second phase roof and floor timbers were sampled. 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 **dug**. 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).

RESULTS AND DISCUSSION

Details of the samples, and their locations, are given in Table 1. The two samples (**wyb1** and **wyb2**) from the cruck blades were compared together and were found to match, forming the site master **wyb12**. However, this had only 51 rings and failed to date. The mantel beam was sampled twice to obtain as many rings as possible and the two series were combined to form the 88-ring mean **wyb3**. However this too failed to date. However, four of the additional six samples taken in 2011 from the second phase did date. Samples **wyb4**, **wyb5**, **wyb6**, all from principal rafters, and **wyb9** from a floor joist matched each other (Table 2) and were combined to form the 128-ring site master **WYB**. This was successfully cross-matched to span the years 1437-1564 (Table 3a). Two of the principal rafters retained complete sapwood, giving two felling dates of spring 1559 and winter 1564/5. A third principal rafter with incomplete sapwood produced a felling date range of 1553-83, whilst a floor joist gave a *terminus post quem* or felled after date of 1504.

The felling dates are significant in that this shows the house was remodelled in 1565 or shortly afterwards, which coincides with the date of 1565 when he began his studies at St John's College, Cambridge. The date of 1553-83 and after 1504 for the other principal rafter and floor joist respectively show that they are all likely to date from the same phase of building.

A single sample (**wyb10**) was taken from the mantel beam in the reconstructed cottage adjacent. This beam was evidently a reused timber with a single mortice. This produced a sample with 74 rings which dated, spanning the years 1442-1515 (Table 3b). As the sample retained five rings of sapwood, a felling date range of 1521-51 was produced, suggesting that it did not originate from the primary house at Tŷ-Mawr. The best chronologies this sample matched with were from the Welsh borders around Shropshire, and as it was introduced into the cottage which was rebuilt in 1987, it could have come from anywhere.

Two samples were submitted for radiocarbon analysis, one from each end of the core from **wyb2**, a known number of years apart. It is clear from the results sent back from the Oxford Accelerator Unit that there has been a problem with these samples – as the results show a failure in the chi-squared test between the two samples. It seems most likely that it is the outer segment which has some contamination. The results from the inner part of the core suggest at this stage that the tree was not felled before 1510. However, because of the problems encountered, the radiocarbon laboratory has generously agreed to analyse a third sample, from the middle of the core, to attempt to resolve the problems encountered – these results are not expected before mid-2015.

Table 1: Details of samples taken from Ty Mawr, Wybrnant.

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
Cruck phase									
wyb1	LH (upper end) front cruck blade	undated	-	H/S	38	2.86	0.83	0.16	
wyb2	RH (lower end) front cruck blade	undated	-	H/S	51	2.61	0.90	0.23	
wyb12	Mean of **wyb1** + **wyb2**	undated	-	H/S	51	2.76	0.54	0.18	unknown
Re-roofing phase									
wyb3a	LH mantel beam (upper end)		-	H/S	62	2.19	1.18	0.26	
wyb3b	*ditto*		-	H/S	86	1.66	0.66	0.26	
wyb3	Mean of ***wyb3a*** + ***wyb3b***	undated	-	H/S	88	1.91	0.89	0.23	unknown
* **wyb4**	Middle rear principal rafter	1445-1558	1530	28¼C	114	1.50	0.99	0.24	Spring 1559
* **wyb5**	LH rear principal rafter	1459-1564	1544	20C	106	1.57	0.82	0.19	Winter 1564/65
* **wyb6**	LH front principal rafter	1442-1545	1542	3	104	1.95	0.79	0.18	1553–83
wyb7	LH floor beam against fire place	undated	-	14+1C NM	45	2.94	1.12	0.27	unknown
wyb8	7th joist from front, 2nd bay from left	undated	-	-	40	1.59	0.42	0.22	unknown
* **wyb9**	4th joist from front, 2nd bay from left	1437-1492	-		56+1 NM	1.79	0.72	0.25	After 1504
Re-used mantel beam in rebuilt cottage									
wyb10	Re-used timber with mortice	1442-1515	1510	5	74	1.97	0.70	0.21	1521–51
* = included in site mean **WYB**		**1437-1564**			**128**	**1.62**	**0.66**	**0.15**	

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

Table 2: Cross-matching between dated samples

	***t*-values**		
Sample	**wyb5**	**wyb6**	**wyb9**
wyb4	2.6	3.6	5.2
wyb5		5.4	1.9
wyb6			4.8

Table 3a: Dating evidence for the site master **WYB AD 1437–1564** against dated reference chronologies, regional chronologies in **bold**

County or region:	***Chronology name:***	***Short publication reference:***	***File name:***	***Spanning:***	***Overlap (yrs):***	***t-value:***
Ireland	Belfast Master Chronology	Baillie (1977)	**BELFAST**	1001-1970	128	7.0
Wales	Welsh Master Chronology	(Miles 1997b)	**WALES97**	404-1981	128	6.9
Wales	Brecon Cathedral	(Miles and Haddon-Reece 1996)	BRECON1	1420-1510	74	6.7
Herefordshire	White House, Vowchurch	(Nayling 2000)	WVT9	1364-1602	128	6.1
East Midlands	East Midlands Master	(Laxton and Litton 1988)	**EASTMID**	882-1981	128	6.1
Wales	Dulasau-uchaf, Penmachno	(Miles *et al* 2011)	dluc02	1450-1551	102	6.1
Shropshire	Stokesay Castle	(Miles and Worthington 1997)	STOKE4	1449-1640	116	6.0
Wales	Royal House, Machynlleth	(Miles *et al* 2004)	ROYALHS1	1363-1560	124	6.0
Gloucestershire	Odda's Chapel, Deerhurst	(Bridge 2001)	ODDA	1352-1593	128	6.0
Gloucestershire	Swan House, Blakeney	(Miles *et al* 2009)	SWANHS	1386-1628	128	6.0
Essex	Broadoaks Manor, Wimbish	(Miles *et al* 2003)	WIMBISH	1440-1563	124	5.9
Shropshire	Hyde Farm, Middleton Priors	(Miles *et al* 2004)	DITTON6	1442-1547	106	5.9
Herefordshire	Farmer's Club, Hereford	(Tyers 1996)	HEREFC	1313-1640	128	5.7
Shropshire	Shootrough Farm, collar	(Miles and Haddon-Reece 1996)	shu7	1455-1608	110	5.7

Table 3b: Dating evidence for the sequence **wyb10** **AD 1442–1515** against dated reference chronologies, regional chronologies in **bold**

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap (yrs):*	*t-value:*
Staffordshire	Hospital of St John	(Worthington and Miles 2002)	STJLICH	1356-1494	53	7.4
Shropshire	Habberley Hall	(Miles and Haddon-Reece 1995)	HABBERLY	1386-1554	74	6.9
Shropshire	60 High Street, Whitchurch	(Miles and Haddon-Reece 1995)	by3	1440-1552	74	6.8
Warwickshire	Gorcott Hall	(Nayling 2006)	GORC_T17	1385-1531	74	6.7
Somerset	Muchelney Abbey	(Bridge 2002)	MUCHNEY	1148-1498	57	6.5
Wales	Tyddyn Cynnar Llansilin	(Miles *et al* 2003)	TYDDYNC2	1459-1609	57	6.4
Shropshire	Old Hall Farm, All Stretton	(Miles and Haddon-Reece 1996)	OLDHLLFM	1379-1630	74	6.3
London	Westminster School	(Miles *et al* 2007)	LIDDELLS	1346-1540	74	6.3
Southern England	Southern England Master	(Bridge 1998)	**SENG98**	944-1790	74	6.3
Worcestershire	Crowle Abbey	(Hillam 1997)	CROWLE2	1412-1496	55	6.3
Yorkshire	Yorkshire Buildings Chronology	(Hillam pers comm)	YORKS2	1192-1663	74	6.2
Kent	Manor House, Fordwich	(Arnold and Litton 2003)	KMFASQ01	1264-1556	74	6.2
Shropshire	Alcaston Hall	(Miles and Worthington 1998)	ALCASTON	1389–1556	74	6.1
Yorkshire	Nostell Priory	(Tyers 1998)	NOSTELL1	1263-1536	74	6.1

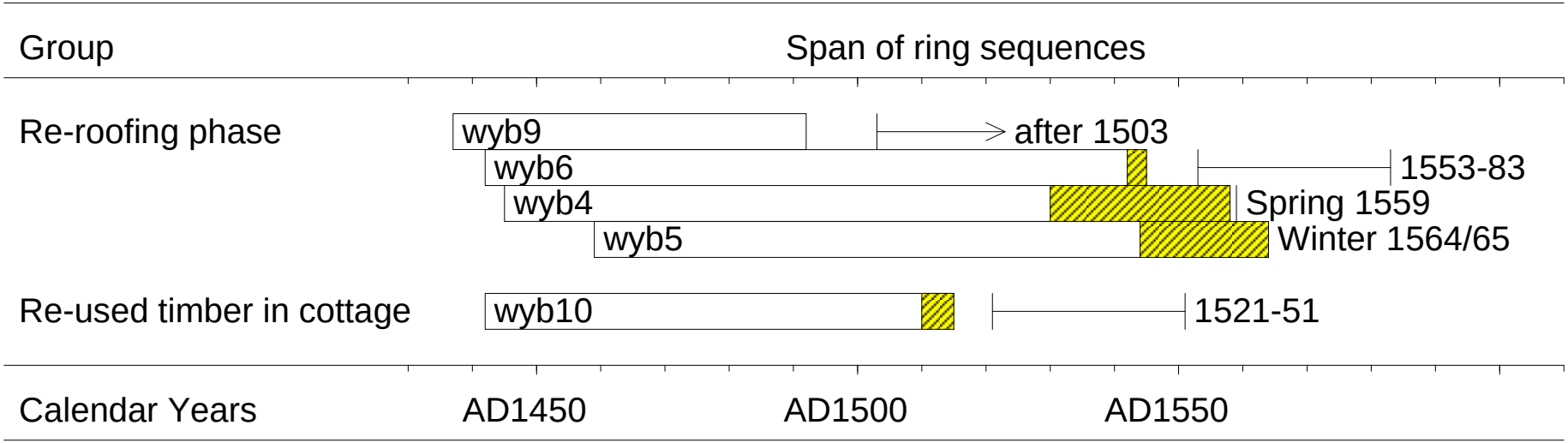


Figure 1: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely, or actual, felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings

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