Oxford Dendrochronology Laboratory
Report 2011/5

THE TREE-RING DATING OF PLAS Y DDUALLT, TAN Y BWLCH, MAENTWROG, GWYNEDD (NGR SH 673 417)

Summary

A total of 17 timbers were sampled at Plas y Dduallt – twelve from the west range and five from the east range. A total of fifteen timbers including the two same-tree means were found to match together consistently to be averaged together. These were combined to form the 250-year site master which was found to match exceptionally well with local chronologies from Bedgellart, spanning the years 1355-1604. The west range was found to be the earlier of the two parts of the house, as expected. However, the felling dates for this section were widely ranging from **winter 1559/60 to the spring of 1565**, with a further timber dating to **1567-92**. As to the East Range, many of the timbers were fast grown with insufficient rings for successful cross-dating. Of those slow-grown timbers that were accessible, the majority were defrassed, removing the sapwood and bark. Of the four out of five timbers dated from this range, only two retained complete sapwood. These were the first floor tiebeams, one of which was found to have been felled in the spring of 1600, whilst the other was felled in the winter of 1604/5. One purlin without sapwood dated with a last measured ring of 1546, giving a *terminus post quem* of after 1557, whilst a principal rafter gave a felling date range of 1563-93. Given the small mean ring width for this sample of 0.83, it is likely that there would have been more sapwood rings than normal and the felling date range probably extended to encompass one or both of the felling dates. Therefore, it is most likely that this range would have been constructed in or shortly after **1605**.

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 Plas y Ddualtt, Tan y Bwlch, Maentwrog, Gwynedd (NGR SH 673 417)

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.

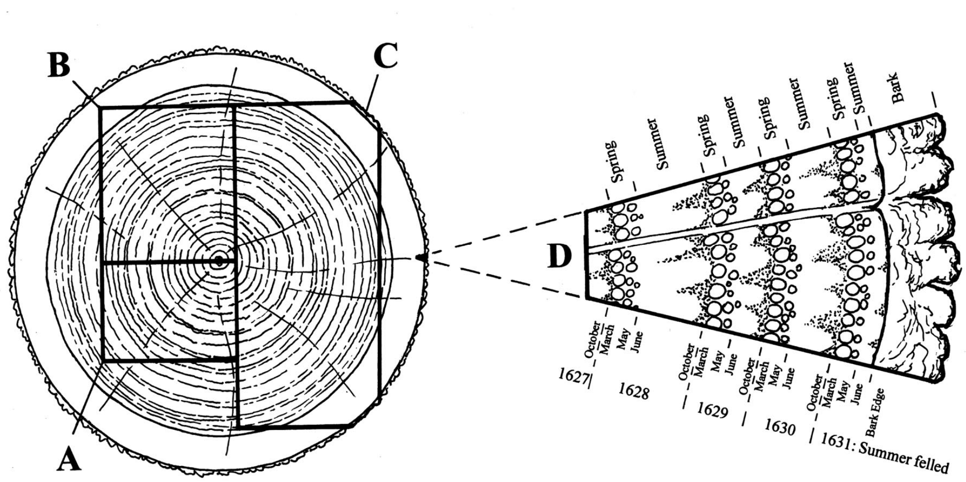
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation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

PLAS Y DDUALLT

Dduallt is an unusual example of the 'unit-system' of linked dwellings, in which two parallel ranges are linked by a storeyed lobby giving independent access to each. The precise relationship between the two ranges is uncertain, but the rear range of Snowdonian type is likely to be the earlier of the two on architectural grounds. The front range probably served as a parlour, but the layout suggests that it might also have been, on occasions, as a small separate dwelling. A barn or byre attached to the rear range is a later addition. The house was restored by Colonel Campbell in the 1960s when it was extensively renovated. See the discussion of the unit system in *Vernacular Architecture* 38 (2007), pp. 19-34. Plan and perspective sketch published in *Houses of the Welsh Countryside* (RCAHMW, 1975), fig. 85. (RFS/RCAHMW/APRIL 2011).

SAMPLING

Sampling took place in November 2010. 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 **gwyh**. 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. Measurements and subsequent analysis were carried out using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004) and other programmes written in BASIC by D Haddon-Reece, and re-written in Microsoft Visual Basic by M R Allwright and P A Parker.

RESULTS AND DISCUSSION

A total of 17 timbers were sampled at Plas y Dduallt – twelve from the west range and five from the east range. The sampling strategy was to (a) obtain a date for the west range, (b) obtain a date for the first floor structure of the west range and confirm that it was contemporary with the roof above, and (c) date the east range which was thought to be basically coeval, although the east range might be slightly later than the west range on stylistic evidence. For that reason fewer samples were taken from the east range than the west. Sampling was somewhat hindered by the lack of sapwood due to the previous owners rather overzealous cleaning of the timbers, resulting in the loss of many of the outermost rings of sapwood.

The various ring sequences were first compared with each other and two pairs of timbers were found to match so well that they were considered to have originated from the same parent tree. Thus samples **gwyh1** and **gwyh6** matched together with a *t*-value of 12.3 and an overlap of 58 years were combined to form the same-tree mean **gwyh16**, and **gwyh9** and **gwyh10** matched together with a *t*-value of 21.3 and an overlap of 187 years were combined to form the same-tree mean **gwyh910**. These two means were then compared with the other individual samples.

Thus a total of fifteen timbers including the two same-tree means were found to match together consistently to be averaged together. These were combined to form the 250-year site master **GWYNEDD5**. This was compared with the available reference chronologies and was found to match exceptionally well with local chronologies from Bedgellart, spanning the years 1355-1604.

The west range was found to be the earlier of the two parts of the house, as expected. However, the felling dates for this section were widely ranging from winter 1559/60 to the spring of 1565, with a further timber dating to 1567-92. The lintel over the west door was found to have the earliest felling date of the group, having been felled in the winter of 1559/60. Although the 1st transverse beam was missing some of the outermost sapwood rings, finishing at 1552, it was found to have been from the same parent tree as the door lintel, therefore it too would have been felled in the winter of 1559/60. The east V-strut to Truss 2 was also felled in the winter of 1559/60. The east principal rafter to truss 2 was felled one year later, in the winter of 1560/61. Similarly, as the west principal rafter to the same truss with its outermost rings detached was from the same tree, it too was felled in the same year.

The mantelbeam was sampled, but the sapwood was in a very soft state on the outside of the beam and would have been lost in coring. Therefore a core was taken from the top inside of the beam where a possible waney edge was visible under the soot. This core hit a shake, therefore it was treated as two samples. The earlier section of the core dated, finishing in 1506. The outer section of the core had 58 rings including 32 sapwood rings. Unfortunately this section did not date individually and did not have sufficient overlap to be able to cross-match with the earlier part of the core. Given this difficulty, a felling date range of *circa* 1550-75 is the best that can be given for this timber.

Four ceiling joists were sampled to try and confirm whether they were contemporary with the roof. The results here are slightly inconsistent, in that the earliest joist was felled about five years later, in the spring of 1565, and three others with almost complete sapwood produced felling date ranges of 1564-7, 1564-79, and 1567-92. This latter joist had a last measured ring date of 1566, so the earliest it could have been felled would be in 1567, but it could well be some years later. Thus the dating has shown that the joists were felled at least five or more years after the frame. However, given that the transverse beam was felled in the winter of 1559/60, the most logical interpretation is that the house was under construction for an extended period of time, with the timbers for the floor beams and roof trusses felled, and possibly jointed, in or shortly after 1561, and that they were either not put into place until the latter part of the 1560s after the floor joists were felled, or they built into the building as the stonework was progressing, with the joists being laid in later. Much depends on the method of supports for the joists, whether they are lodged or morticed, and some further investigation is need to determine this. Nevertheless, the west range was probably completed in its present form by the late 1560s.

As to the East Range, here samples were much less suitable. Many of the timbers were fast grown with insufficient rings for successful cross-dating. Of those slow-grown timbers that were accessible, the majority were defrassed, removing the sapwood and bark. Of the four out of five timbers dated from this range, only two retained complete sapwood. These were the first floor tiebeams, one of which was found to have been felled in the spring of 1600, whilst the other was felled in the winter of 1604/5. One purlin without sapwood dated with a last measured ring of 1546, giving a *terminus post quem* of after 1557, whilst a principal rafter gave a felling date range of 1563-93. Given the small mean ring width for this sample of 0.83, it is likely that there would have been more sapwood rings than normal and the felling date range probably extended to encompass one or both of the felling dates. Therefore, it is most likely that this range would have been constructed in or shortly after 1605.

Table 1: Details of samples taken from Plas y Dduallt.

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
West Range									
gwyh1	Transverse beam	1436-1552	1530	22	117	1.52	0.74	0.39	(Winter 1559/60)
* **gwyh2**	7th ceiling joist from E, S bay GF	1437-1563	1526	37	127	0.80	0.33	0.19	1564-7
* **gwyh3**	5th ceiling joist from E, S bay GF	1432-1564	1520	44¼C	133	0.86	0.29	0.21	Spring 1565
* **gwyh4**	3rd ceiling joist from E, middle bay GF	1500-1563	1538	25	64	1.81	0.69	0.24	1564-79
* **gwyh5**	4th ceiling joist from E, N bay GF	1474-1566	1551	15	93	1.37	0.55	0.25	1567-92
gwyh6	Lintel over east door GF	1495-1559	1532	27C	65	1.23	0.34	0.24	Winter 1559/60
* **gwyh7a1**	GF mantelbeam	1413-1506	-		94	1.78	1.31	0.27	-
gwyh7a2	ditto	undated	-	32	58	0.74	0.45	0.24	*c.*1550-75
* **gwyh8**	E principal rafter T1	1405-1550	1532	18	146	1.18	0.34	0.21	1551-73
gwyh9	W principal rafter T2	1355-1544	1524	20+14C NM	190	1.02	0.54	0.40	(Winter 1560/61)
gwyh10	E principal rafter T2	1358-1560	1527	33C	203	1.13	0.55	0.33	Winter 1560/61
gwyh11	W V-strut T2	undated	-	33¼C	98	1.21	0.57	0.22	unknown
* **gwyh12**	E V-strut T2	1460-1559	-	33C	100	1.18	0.35	0.21	Winter 1559/60
* **gwyh16**	Same-tree mean of **gwyh1** + **gwyh6**	1436-1559	1531	28C	124	1.44	0.67	0.34	Winter 1559/60
* **gwyh910**	Same-tree mean of **gwyh9** + **gwyh10**	1355-1560	1526	34C	206	1.07	0.52	0.34	Winter 1560/61
East Range									
* **gwyh21**	N tiebeam T1	1481-1599	-	39¼C	119	0.76	0.31	0.22	Spring 1600
* **gwyh22**	S tiebeam T2	1497-1604	-	45C	108	0.95	0.50	0.21	Winter 1604/5
gwyh23	3rd rafter from S, W roof slope	undated	-	H/S	87	0.85	0.28	0.22	unknown
* **gwyh24**	E principal rafter T2	1414-1552	1552	H/S	139	0.83	0.33	0.20	1563-93
* **gwyh25**	SE lower purlin	1426-1546	-	-	121	0.99	0.58	0.24	After 1557
* = included in Site Master **GWYNEDD5**		**1355-1604**			**250**	**1.11**	**0.45**	**0.23**	

Key: H/S bdry = heartwood/sapwood boundary - last heartwood ring date; std devn = standard deviation; mean sens = mean sensitivity; NM = not measured; ¼C, ½C, C = bark edge present, partial or complete ring: ¼C = spring (last partial ring not measured), ½C = summer/autumn (last partial ring not measured), or C = winter felling (ring measured).

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Table 2: Cross-matching between the dated samples

	t-values											
Sample	**gwyh3**	**gwyh4**	**gwyh5**	**gwyh7a1**	**gwyh8**	**gwyh910**	**gwyh12**	**gwyh16**	**gwyh21**	**gwyh22**	**gwyh24**	**gwyh25**
gwyh2	6.3	2.4	6.0	3.8	6.5	4.8	7.3	6.6	3.9	4.1	7.2	6.7
gwyh3		3.4	6.3	5.3	4.7	8.6	7.5	9.1	7.1	5.1	5.7	8.6
gwyh4			5.3	-	4.8	4.5	4.4	3.5	4.2	4.3	3.5	3.8
gwyh5				3.5	7.1	5.3	7.8	8.7	5.5	3.4	5.9	5.6
gwyh7a1					3.3	3.9	3.1	3.3	1.9	-	3.7	5.5
gwyh8						7.4	5.5	7.9	4.1	3.3	7.2	4.9
gwyh910							5.3	8.3	8.2	6.5	7.8	7.1
gwyh12								7.2	4.3	3.3	5.6	5.8
gwyh16									6.1	3.3	6.0	7.8
gwyh21										6.4	5.9	4.3
gwyh22											4.2	2.7
gwyh24												5.7

- = less than 15 years overlap

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Table 3: Dating evidence for the site master **GWYNEDD5 AD 1355–1604** against dated reference chronologies, regional chronologies in **bold**

County or region:	***Chronology name:***	***Short publication reference:***	***File name:***	***Spanning:***	***Overlap (yrs):***	***t-value:***
Wales	Parc Llanfrothen, Merioneth	(Miles *et al* 2006)	BDGLRT22	1396-1669	219	13.8
Wales	Clenennau, Dolbenmaen	(Miles *et al* 2006)	BDGLRT10	1406-1570	165	11.8
Wales	Llanfrothen	(Miles *et al* 2006)	BDGLRT7	1386-1547	162	10.4
Wales	Cae'nycoed-uchaf, Maentwrog	(Miles *et al* 2006)	BDGLRT17	1407-1592	186	10.3
Wales	Pant-glas-uchaf, Clynnog	(Miles *et al* 2006)	BDGLRT14	1413-1573	161	10.2
Wales	Gelli, Llanfrothen	(Miles *et al* 2006)	BDGLRT8	1391-1662	214	9.6
Wales	Derwyn-bach, Dobenmaen	(Miles *et al* 2006)	BDGLRT15	1385-1548	164	9.6
Wales	Y Gesail Gyfarch, Dolbenmaen	(Miles *et al* 2006)	BDGLRT6	1384-1609	221	9.2
Wales	Pengwern Old Hall	(Miles *et al* 2003)	PENGWERN	1353-1521	167	9.2
Wales	Bryn yr Odyn, Maentwrog	(Miles *et al* 2010)	BRYNRDYN	1388-1586	199	8.9
Wales	Plas Tan-y-Bwlch, Maentwrog	(Miles *et al* 2006)	BDGLRT23	1411-1535	125	8.5
Wales	Beddgelert	(Nayling pers comm)	BEDD_T6	1302-1529	175	8.3
Lancashire	Worden Old Hall, Chorley	(Bridge 2003)	OLDWORD2	1415-1531	117	8.2

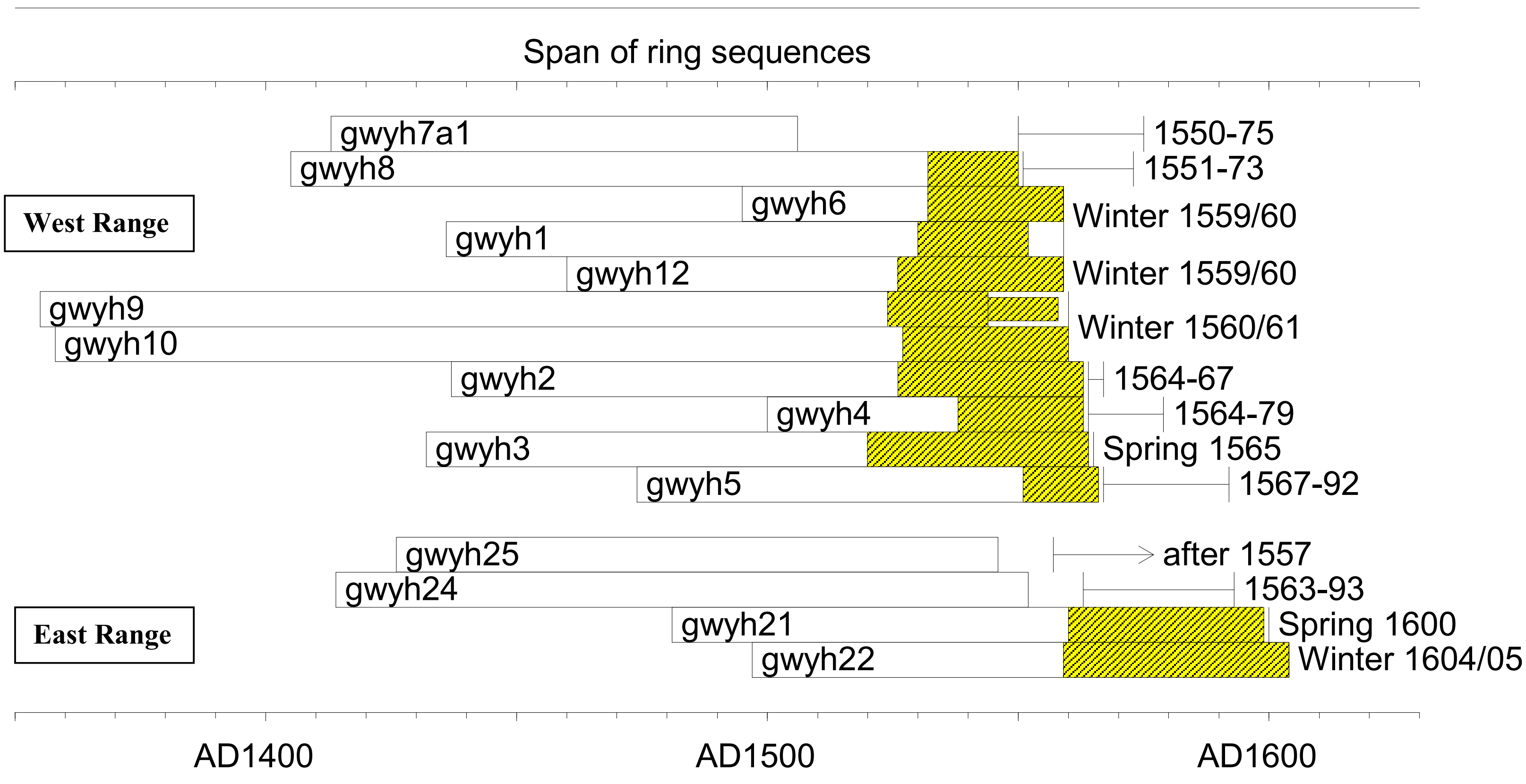

Figure 2: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings

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