Oxford Dendrochronology Laboratory
Report 2012/16

THE TREE-RING DATING OF BENNAR, PENMACHNO, BETWS-Y-COED CONWY (NGR SH 794 518)

Summary

Five timbers from this site dated. One was from a truss in a bedroom, three from joists in the entrance passage, and an axial beam in the kitchen. They all appear to form a single group of timbers felled at around the same time, but careful analysis shows that felling of the trees used took place over a few seasons. One timber lost the outermost rings of sapwood, and allowing for any lost, was judged to have come from a tree most likely felled in the period 1561-64. Two timbers retained complete sapwood and were found to have come from trees felled in spring 1563, and winter 1563/64 respectively, making the most likely date of construction **1564**, or within a year or two after this date.

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(NGR SH 794 518)

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.

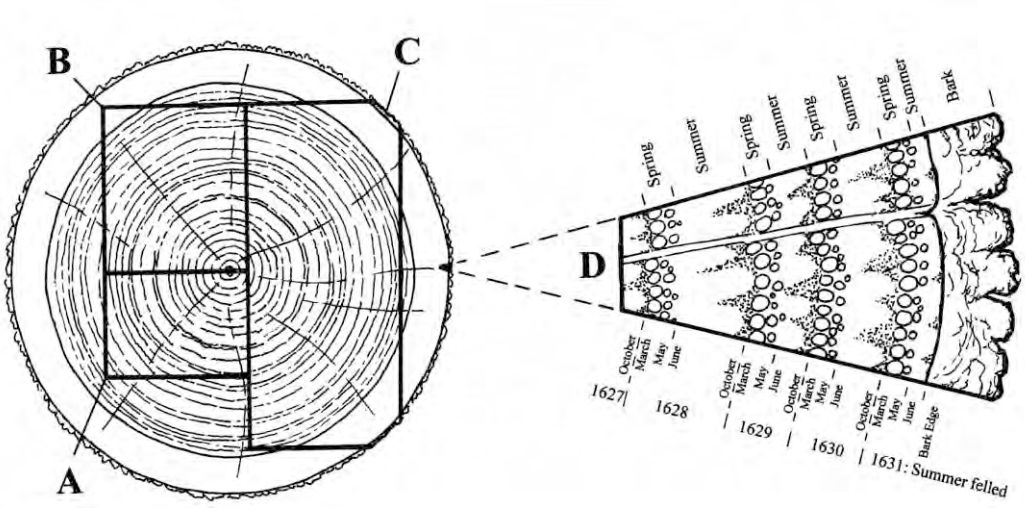
One can develop long reference chronologies by cross-matching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence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

BENAR

Bennar is a multi-period T-plan farmhouse. The old house was refronted in the late C17th (a hinge is dated 1693), becoming the back kitchen for the new range. The earlier house was of Snowdonian type and retains substantial stop-chamfered beams, post-and-panel partitions on ground (removed) and first floors. Bennar did not have a fireplace stair and the site of a ladder-stair is indicated by a trimmer near the hall fireplace. Other Snowdonian houses without fireplace stairs include Coedyffynnon (1537). Plan

and description in RCAHMW, *An Inventory of . . . Caernarvonshire, Volume I: East* (1956), pp. 169-70, fig. 160. NPRN 26006.

SAMPLING

Sampling took place in January 2012. 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 **bnr**. 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.

RESULTS AND DISCUSSION

Basic information about the samples and their origins are shown in Table 1, with Figure 1 giving more information on the position of the samples. The series from samples **bnr01** and **bnr03** both showed very abrupt changes in growth rate in their ring patterns, and neither could be dated. The remaining series cross-matched with each other (Table 2), and were combined into a 123-year long site master sequence, **BENNAR**. This was subsequently dated to the period 1441–1563, the strongest matches being shown in Table 3. The relative positions of overlap of the dated series are shown, along with their actual or interpreted felling dates in Figure 2. Two timbers retained complete sapwood, one having been felled in spring 1563, the other in the following winter (1563/64). One other timber had the outermost rings of sapwood detached, and allowing for loss of rings between the core and this outer portion of rings, is given a likely felling date range of 1561–64. The other two dated timbers have likely felling date ranges that broadly agree with these timbers, suggesting that they were all felled over a short period. The most likely date of construction of the building is therefore **1564**, or within a year or two after this date.

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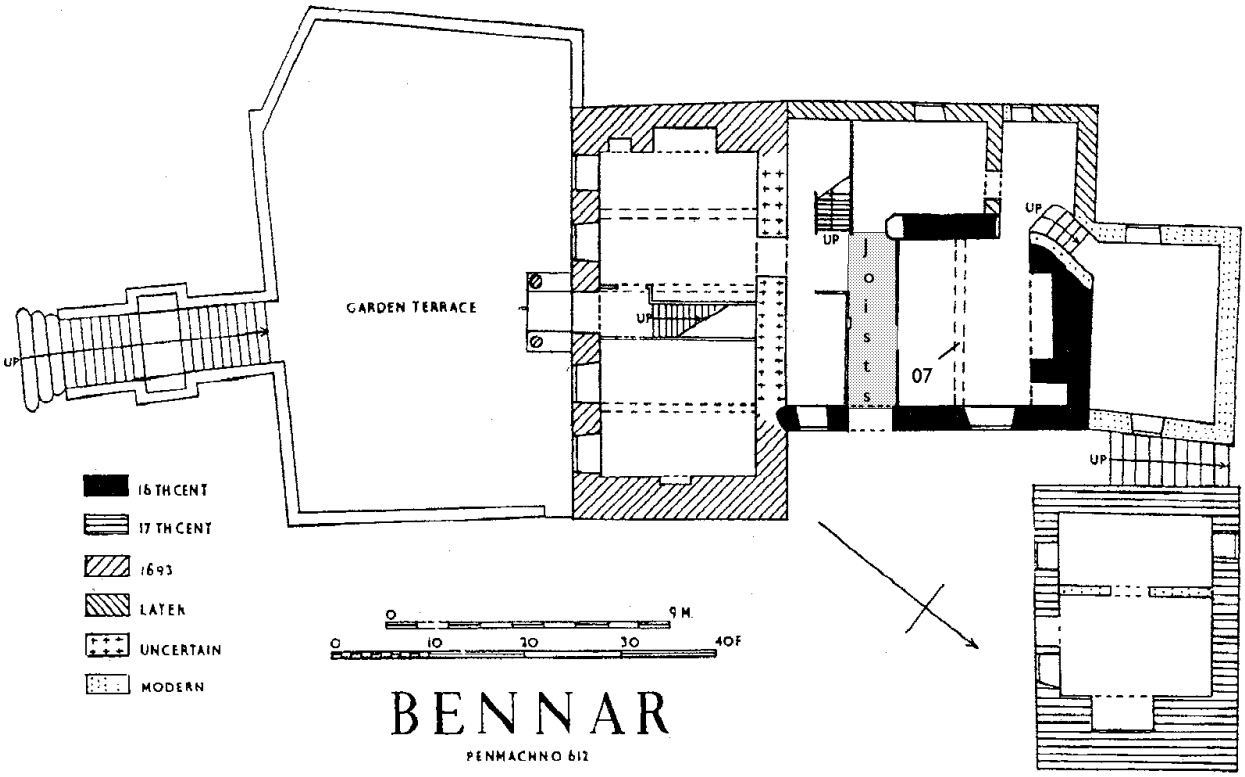

Figure 1: Plan showing the various parts of the building and the areas from which samples were taken for dendrochronology. Samples **03-06** came from the shaded area marked 'Joists' and the axial beam in the kitchen is shown as sample **07**. The truss sampled was above this axial beam. Adapted from an original in RCAHMW *An Inventory of . . . Caernarvonshire, Volume I: East* (1956).

Table 1: Details of samples taken from Bennar, Penmachno, Betws-y-Coed Conwy.

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
bnr01	Collar to truss in bedroom	undated	-	h/s + 17NM	99	2.03	1.00	0.20	-
*** bnr02**	West principal rafter, truss in bedroom	1441–1516	1516	h/s	76	2.00	0.87	0.23	1527–57
bnr03	4th joist from door, entrance hall	undated	-	25½C	97	1.09	0.62	0.23	-
*** bnr04**	6th joist from door, entrance hall	1443–1556	1523	33 + *c*5NM	114	1.08	0.69	0.20	1561–64
*** bnr05**	11th joist from door, entrance hall	1460–1536	1536	h/s	77	1.09	0.28	0.20	1547–77
*** bnr06**	13th joist from door, entrance hall	1474–1563	1536	27C	90	1.40	0.59	0.25	Winter 1563/64
*** bnr07**	Axial beam in kitchen	1449–1562	1529	33¼C	114	1.43	0.67	0.19	Spring 1563
*** =** included in Site Master **BENNAR**		**1441–1563**			**123**	**1.41**	**0.60**	**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

Table 2: Cross-matching between the dated samples

	***t*-values**			
Sample	**bnr04**	**bnr05**	**bnr06**	**bnr07**
bnr02	5.7	2.8	2.1	5.9
bnr04		2.8	4.1	6.2
bnr05			5.6	5.5
bnr06				4.0

Table 3: Dating evidence for the site master **BENNAR** **AD 1441–1563** against dated reference chronologies.
Regional multi-site chronologies are shown in **bold**

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap (yrs):*	*t-value:*
Wales	Dylasau Isaf, Caernarfonshire	(Miles *et al* 2011)	DYLASAU1	1412-1592	123	10.1
Wales	Dugoed, Penmachno	(Miles *et al* 2011)	DUGOED	1397-1593	123	8.1
Wales	Welsh Master Chronology	(Miles 1997b)	**WALES97**	404-1981	123	8.0
Wales	Lower Cill, Berriew, Montgomyshire	(Miles *et al* 2006)	BERRIEW	1428-1583	123	7.8
Wales	Neuadd Cynhinfa Pontrobert	(Miles and Haddon-Reece 1996)	neu1	1438-1506	66	7.4
Shropshire	Shropshire Master Chronology	(Miles 1995)	**SALOP95**	881-1745	123	7.3
Wales	Llwyn Llandrinio, Montgomeryshire	(Miles *et al* 2003)	LLWYN	1413-1551	111	7.0
Shropshire	Fulway Cottage	(Miles and Haddon-Reece 1994)	FULWAY	1397-1639	123	6.9
Wales	St Idloes Church, Llanidloes	(Miles *et al* 2003)	LNYDLOS2	1384-1593	123	6.9
Wales	Bryndrynaenog Beguildy	(Miles and Haddon-Reece 1996)	bry2	1414-1614	123	6.8
Shropshire	Lydbury North mean	(Miles *et al* 2007)	LYDBURY	1363-1658	123	6.8
Wales	Tyn Celyn	(Miles *et al* 2004)	TYNCELYN	1375-1524	84	6.8
Northumberland	Blanchland Abbey Gatehouse	(Arnold *et al* 2009)	BAGBSQ01	1326-1532	92	6.6
Wales	Gwernfyda Llanllugan	(Miles and Haddon-Reece 1996)	GWRNFYDA	1410-1551	111	6.6
Wales	Rose and Crown, Gwydwn	(Miles and Worthington 2000)	GWYDWN	1411-1571	123	6.6

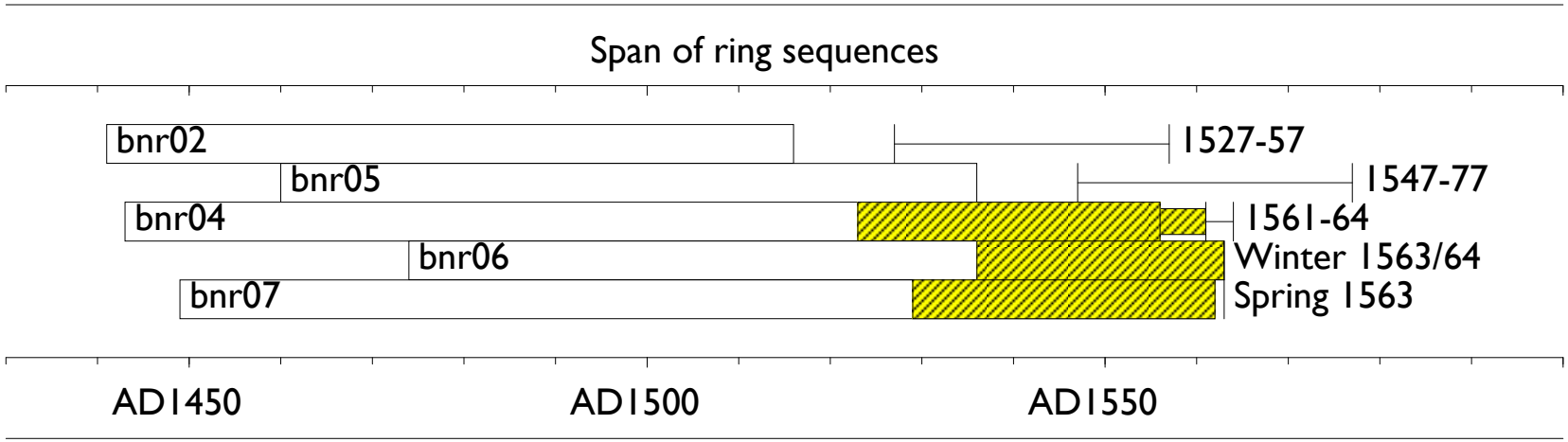

Figure 2: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings