Tree Ring Dating

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Oxford Dendrochronology Laboratory
Report 2011/8

THE TREE-RING DATING OF NANT UCHAF, GROES, DENBIGHSHIRE (NGR SH 989 639)

Summary
Four of the seven timbers sampled were dated. Cross-matching between the relatively short ring width series was variable, with three series being included in the site master chronology, and a further two series being dated. These two exhibited unusual growth patterns. The timbers were felled over a period from summer 1487 to winter 1488/89, making construction most likely in **1489**, or within a year or two after this date.

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The Tree-Ring Dating of Nant Uchaf, Groes, Denbighshire
(NGR SH 989 639)

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.

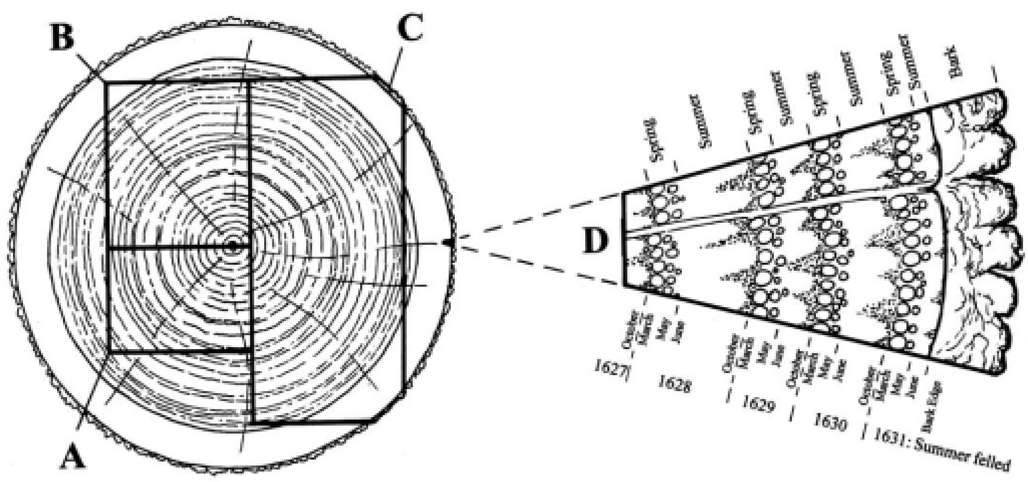
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation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

NANT UCHAF, GROES

SAMPLING

Sampling took place in January 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 **deni**. 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 1000 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 measured and 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 and other analyses were carried out using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004).

RESULTS AND DISCUSSION

Seven timbers were sampled from this house. Two timbers, the south cruck to Truss 1 and Truss 3 had to be sampled twice due to the fact that it was not possible to get a straight line of access to sample. The two resulting pairs of samples (**deni1a** and **deni1b**) and (**deni3a** and **deni3b**) did not have sufficient number of rings overlap to allow the sequences to be conclusively cross-matched. Therefore the individual sequences were used in the final analysis.

Three samples were found to match together (Table 2): the north cruck to Truss 3 (**deni3**), the south cruck to the same truss (**deni4a**), and the yoke to Truss 4 (**deni7**). These were combined to form the 114-ring site master **DENBY8**. This was compared with the reference chronologies and dated, spanning the years 1375-1488 (Table 3b).

The second sample from the south cruck of truss 3 (**deni4b**) did match well with the north blade from the same truss (**deni3**) with a *t*-value of 7.54 and with the site master with a *t*-value of 5.63, dating to 1488. However, in comparing this sample individually with the reference chronologies there was no corresponding matches at that date. Clearly this sample was exhibiting some extremely local growth patterns which were not reflected in the other samples from the site or the reference chronologies. Consequently this sample was considered to be dated, but not included in the site master. The sample from the north lower purlin in Bay 2 (**deni2**) did not match any other of the other samples from the site, but did match extremely well individually with the reference chronologies (Table 3a). Thus this sample dated to 1486 but again was not included in the site master.

All four of the dated timbers retained bark edge, and were therefore able to give precise felling dates. These ranged from the summer of 1487 for sample **deni2**, spring 1488 for sample **deni3**, and winter 1488/9 for samples **deni4b** and **deni7**. Given this clustering of felling dates, Nant Uchaf was most likely constructed during 1489.

Table 1: Details of samples taken from Nant Uchaf, Groes.

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
deni1a	South cruck T2	undated	-	-	36	3.06	1.60	0.27	unknown
deni1b	*ditto*	undated	-	13C	27	3.62	1.19	0.26	unknown
deni2	North lower purlin, Bay 2 (reset)	1429-1486	1469	17½C	58	1.67	0.68	0.24	Summer 1487
* **deni3**	North cruck, T3	1413-1487	1476	11¼C	75	2.71	1.17	0.27	Spring 1488
* **deni4a**	South cruck, T3	1388-1444	-	-	57	2.75	1.22	0.27	
deni4b	*ditto*	1432-1488	1469	19C	46	2.57	0.95	0.24	Winter 1488/89
deni5	North V-strut T3	undated	-	14C	51	2.19	0.98	0.21	unknown
deni6	South cruck, T4	undated	-	14C	54	3.10	1.62	0.23	unknown
* **deni7**	Yoke T4	1375-1488	1464	24C	114	2.06	0.85	0.25	Winter 1488/89
* = included in Site Master **DENBY8**		**1375–1488**			**114**	**2.39**	**0.89**	**0.21**	

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 dated elements at the site

t-values			
Sample	**deni4a**	**deni4b**	**deni7**
deni3	2.7	7.5	4.7
deni4a		*	5.7
deni4b			2.3

Table 3a: Dating evidence for the site series **deni2** **AD 1429–1486** against dated reference chronologies, regional chronologies in **bold**

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap (yrs):*	*t-value:*
Rutland	Flore's, Oakham	(Arnold *et al* 2008)	OKMASQ02	1408–1591	58	6.5
Hampshire	St Michael's Cottage, Chilbolton	(Miles *et al* 2007)	CHLBLTN1	1421–1554	58	6.4
Shropshire	Shropshire Master Chronology	(Miles 1995)	**SALOP95**	881–1745	58	5.4
Shropshire	Abcott Manor, Clungunford	(Miles and Worthington 2002)	CGFA	1422–1545	58	5.3
Shropshire	Botwood Barn, Ditton Priors	(Miles *et al* 2004)	DITTON3	1350–1476	48	5.2
Wales	Rose and Crown, Gwydwn	(Miles and Worthington 2000)	GWYDWN	1411–1571	58	5.2
Oxfordshire	Harpsden Court, Harpsden	(Miles *et al* 2009)	HARPSDN1	1413–1571	58	5.1

Table 3b: Dating evidence for the site master **DENBY8** **AD 1375–1488** against dated reference chronologies, regional chronologies in **bold**

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap (yrs):*	*t-value:*
Wales	Hafod Llansilin Denby	(Miles *et al* 2003)	HAFOD	1337–1431	57	6.0
Devon	South Yarde	(Groves and Hillam 1993)	SYARDE	1309–1447	73	6.0
Wales	Old Beaupre Castle	(Miles *et al* 2010)	obc7	1374–1473	99	6.0
Wales	Parc Llanfrothen	(Miles *et al* 2006)	BDGLRT22	1386–1669	103	5.7
Buckinghamshire	Baylins Farm	(Miles and Worthington 2002)	BAYLINS1	1352–1446	72	5.7
Wales	Plas-Ucha Llangar	(Miles and Haddon-Reece 1996)	PLASUCHA	1315–1434	60	5.6
Northumberland	St Lawrence Church, Warkworth	(Arnold and Howard 2010)	WKWBSQ02	1324–1443	69	5.6
Devon	21 The Mint, Exeter	(Nayling 2001)	MINT_T4	1350–1429	55	5.5
Wales	Ty Mawr, Castell Caereinion	(Miles and Haddon-Reece 1996)	TYMAWR1	1346–1459	85	5.5
Wales	Plas Mawr House	(Miles 1997b)	PLASMAWR	1360–1578	114	5.5
Herefordshire	Pound Farm, Kington	(Nayling 2002)	POUNDT7	1316–1441	67	5.5
Somerset	16-18 High Street, Bruton	(Miles and Worthington 1997)	BRUTON1	1335–1429	55	5.4
Devon	Leigh Barton, Churchstow	(Groves 2006)	LBC-A	1345–1484	110	5.3
Wales	Welsh Master Chronology	(Miles 1997c)	**WALES97**	404–1981	114	5.2

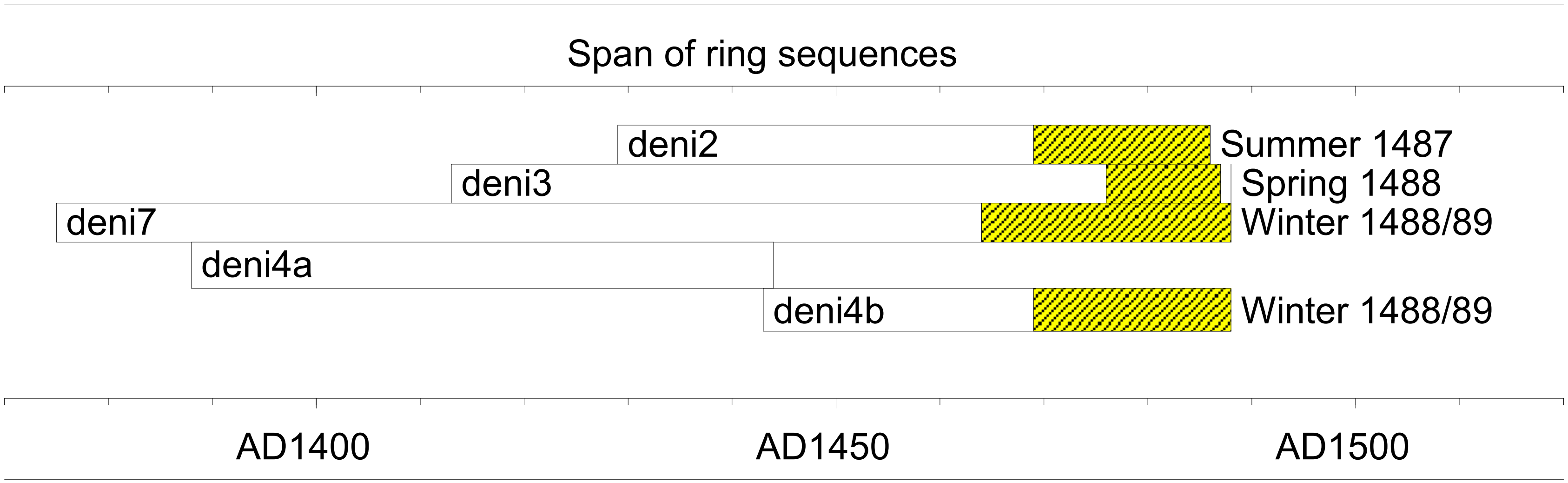


Figure 1: Bar diagram showing the relative positions of overlap of the dated series, along with their felling dates. Hatched yellow sections represent sapwood rings

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