Oxford Dendrochronology Laboratory
Report 2012/26

THE TREE-RING DATING AT PLAS TIRION, LLANRWST, CONWY (NGR SH 810 591)

Summary

Eight timbers were sampled from the derelict cruck outbuilding at Plas Tirion. Seven series were combined to form the site master **TIRION1**, spanning the years 1418-1545. Three of the purlins retained complete sapwood and all were found to have been felled at nearly the same time in **1498**. The tiebeam and two similar cross beams gave felling date ranges consistent with the spring 1498. Other timbers gave later felling date ranges. Bayesian modelling (using OxCal) reduces the felling date range for these timbers to ***1495-1517***. One sample did however date half a century later, and this was thought to have been a possible insertion or reset timber. This had complete sapwood and dated to the winter of **1545/46**. Thus, two phases of construction were found at this building. The primary phase, including the 'crog loft', was probably erected during 1498, with some adaptation to the loft floor in 1546.

The dating of the main house was more problematic. Only one timber, from the west transverse beam in the kitchen, dated with a last measured ring of 1564. Given that this is the only timber from this part of the house to date, the construction date might actually be some years after 1565. In the main part of the house (north range), four timbers were sampled. None of the samples matched each other, or with any other samples from the site. This would suggest that the timbers had originated from trees which had been managed in some way during their life. Although some produced tentative dates consistent with dated plasterwork dates of 1626 and 1628, these were not strong enough to be considered to be independently dated.

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 at Plas Tirion, Llanrwst, Conwy
(NGR SH 810 591)

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.

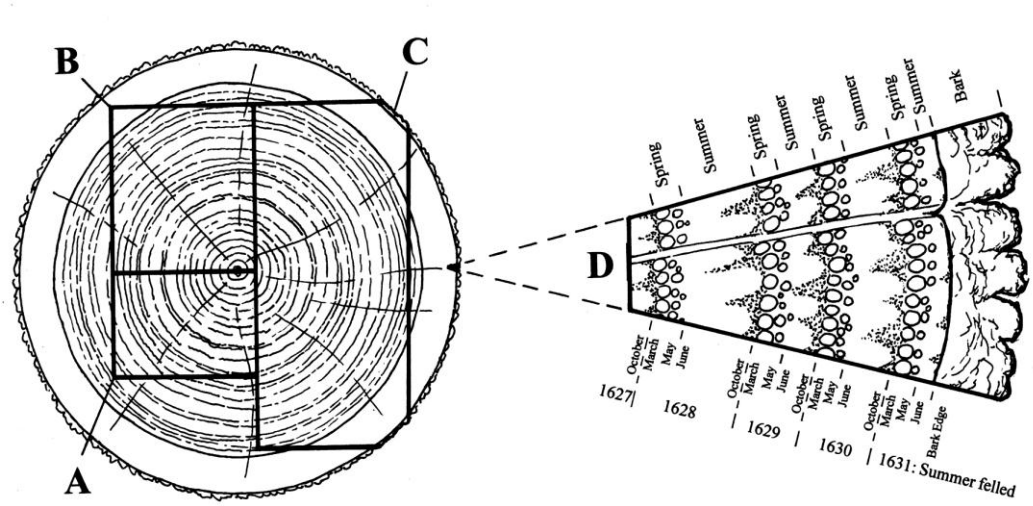
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation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

Plas Tirion is a multi-period complex in the Conwy valley. Below the principal house there are several ranges of farmbuildings which include an earlier house.

1. The multi-gabled principal house commands a view over the Conwy valley. It is a winged gentry house with a T-plan hall range and cross-wing, and with storeyed porch and stair forming front and rear projections. The ground floor has a three-unit plan with parlour, hall, and kitchen cross-wing. The hall range has ovolo-moulded detail (beams, windows and door frames) and several plaster overmantels dated 1626 and 1628. The three-storey cross-wing has a roof of collar-beam trusses; the two-storey hall range has a tie-beam roof with raking struts.

2. The farm buildings below the house include a dilapidated range that incorporates a distinctive cruck-truss with blades of boxed heart (whole tree) rather than halved timbers. The cruck and purlins are heavily smoke blackened and belonged to a medieval domestic building. This is the passage end truss of a downslope sited range which has been reconstructed beyond the lofted end bay, although some framing of uncertain date is incorporated in the stone walls. Whole-tree crucks are found among early pre-1400 crucks in England (but which have proved elusive in Wales). In the event, sampling showed that the trees were felled at the end of the fifteenth century, perhaps when large trees were not available. The cruck is associated with a later cross-beam in the passage which may relate to an inserted floor.

Dendrochronology has therefore established an interesting and in some respects unexpectedly detailed chronology for the site:
1498 cruck-framed hall-house
1545/46 inserted beam (loft) at passage end of hall-house.
1565+ Snowdonian house (= S Wing)
1626-8 Enlargement, with the Snowdonian house becoming kitchen wing of the new range.
NPRN 27773. R F Suggett/RCAHMW/July 2012.

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 **trn**. 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 programs written in BASIC by D Haddon-Reece, and re-written in Microsoft Visual Basic by M R Allwright and P A Parker. DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004) was also used.

RESULTS AND DISCUSSION

Basic information about the samples and their origins are shown in Table 1. Refer to tables 2 & 3 and Fig 1.

Eight timbers were sampled from the derelict cruck outbuilding at Plas Tirion. The crucks and collar were found to be exceptionally fast-grown, therefore only one cruck was sampled. However, the purlins, appeared to be well integrated with the cruck truss and had the same surface patina of light soot encrustation. Three purlins were therefore sampled and all retained complete sapwood. The cruck tie had almost complete sapwood and was sampled as were three other floor beams set at the same level, all of which had similar surface colouration. The tiebeam as well as the other three similar looking beams were also sampled. Another beam, totally clean, as well as contemporary clean cleft and sawn boards making up the present solid floor at tiebeam level, were not sampled.

The cruck blade (**trn1**), despite having complete sapwood, was found to have only 33 rings, but was very fast-grown, with a mean ring width of 5.66mm. Therefore it was unsuitable for further analysis. The purlins (**trn2**, **trn3**, and **trn4**), albeit much smaller, were much slower grown, with an average mean ring width of 1.2mm and had between 69 and 80 growth rings. These matched well with the largest of the cross beams (**trn5**) which had 112 rings and an even smaller mean ring width of 0.83mm, as well as with

the other two cross beams (**trn6** and **trn8**) and the tiebeam to the cruck truss (**trn7**). All seven were combined to form the site master **TIRION1**, with 128 rings, which dated, spanning the years 1418-1545.

Three of the purlins retained complete sapwood and all were found to have been felled at nearly the same time in 1498, sample **trn2** being felled in the very early spring (only some of the spring vessels were formed), **trn3** felled in the early spring (one band of spring vessels formed), and **trn4** being felled in the late spring (spring growth band completely formed). The tiebeam and two similar cross beams did not retain complete sapwood but gave felling date ranges consistent with the spring 1498: **trn6** gave a felling date range of 1495-1525, **trn7** 1484-1514, and **trn8** 1498-1528. This last sample is undoubtedly contemporary with the others but has a slight later shift due to the wide mean ring width of 3.22mm, especially the outermost rings. When run through OxCal, the felling date range of **trn8** is reduced to *1495-1517*.

One sample did however date half a century later, and that was the larger beam, which was thought to have been a possible insertion or reset timber (**trn5**). This had complete sapwood and dated to the winter of 1545/46.

Two phases of construction were found at this building (Figure 1). The primary phase, including the 'crog loft', was probably erected during 1498, with some adaptation to the loft floor in 1546.

The dating of the main house was more problematic. Both the original south wing and the north range had predominantly faster-grown timbers unsuitable for dendrochronology. From the south wing, only two transverse beams from over kitchen were suitable, and the roof above might have been replaced, with timbers having less than 40 – 50 rings. Only two samples were taken from the south wing, and four from the north range.

Only one of the two samples taken from the south wing, sample **trn11**, from the west transverse beam in the kitchen, dated with a last measured ring of 1564. This had what appeared to be complete sapwood but was covered with layers of limewash. There appeared to be a band of spring growth beyond the last complete ring for 1564, suggesting a felling date of spring 1565. However, the surface of the timber may have been abraded beneath the layers of limewash, in which case the felling date may actually be slightly later, i.e. summer or autumn of 1565. Given that this is the only timber from this part of the house to date, the construction date might actually be some years after 1565.

In the main part of the house (north range), four timbers were sampled – a mantelbeam, two principal rafters, and a purlin. Two samples were taken from one principal rafter, **trn22a** and **trn22b**, and these matched together with a *t*-value of 4.0 and an overlap of 63 rings, not very good considering they were from the same parent tree. Nevertheless, they were combined to form the same-timber mean **trn22**. None of the samples matched each other, or with any other samples from the site. This would suggest that the timbers had originated from trees which had been managed in some way during their life. Although some produced tentative dates consistent with dated plasterwork dates of 1626 and 1628, these were not strong enough to be considered to be independently dated.

ACKNOWLEDGEMENTS

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Table 1: Details of samples taken from Plas Tirion. Llanrwst, 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
Cruck Outhouse									
trn1	North cruck blade	-	-	9¼C	33	5.66	1.90	0.17	-
*** trn2**	North upper purlin	1424-1497	1478	19¼C	74	1.20	0.49	0.26	V early spring 1498
*** trn3**	North lower purlin	1418-1497	1478	19¼C	80	1.22	0.42	0.24	Early spring 1498
*** trn4**	NE lower purlin (re-sited)	1429-1497	1468	28¼C	69	1.19	0.36	0.22	Spring 1498
*** trn5**	Inserted east beam	1434-1545	1513	32C	112	0.83	0.49	0.26	Winter 1545/46
*** trn6**	Beam	1424-1484	1484	H/S	61	2.65	0.69	0.18	1495–1525
*** trn7**	Tiebeam to cruck	1426-1481	1473	8	56	1.61	0.78	0.23	1484–1514
*** trn8**	West end beam	1435-1487	1487	H/S	53	3.22	1.36	0.20	1498–1528
***** = component of site master **TIRION1**		**1418-1545**			**128**	**1.23**	**0.63**	**0.22**	
South Wing									
trn11	West transverse beam in kitchen	1452-1564	1537	27¼C	113	1.76	0.97	0.28	Spring? 1565
trn12	East transverse beam in kitchen	-	-	28¼C	132	1.35	0.80	-.22	-
North Wing									
trn21	Mantlebeam	-	-	40¼C	138	1.06	1.25	0.21	-
trn22a	Principal rafter	-	-	*H/S*	*106*	*0.97*	*0.58*	*0.23*	-
trn22b	*ditto*	-	-	-	*81*	*1.78*	*0.81*	*0.20*	-
trn22	Mean of ***trn22a*** and ***trn22b***	-	-	H/S	124	1.35	0.50	0.19	-
trn23	Purlin	-	-	33¼C	97	1.25	1.07	0.27	-
trn24	Principal rafter	-	-	25C	150	1.02	0.61	0.22	-

Key: H/S bdry = heartwood/sapwood boundary - last heartwood ring date; C = complete sapwood, winter felled; ¼C = complete sapwood, felled the following spring; std devn = standard deviation; mean sens = mean sensitivity; NM = not measured

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Table 2: Cross-matching between the components of the site master **TIRION1**

	t-values					
Sample	**trn3**	**trn4**	**trn5**	**trn6**	**trn7**	**trn8**
trn2	5.0	2.7	7.1	5.1	6.9	4.0
trn3		4.2	6.6	4.8	6.0	3.7
trn4			4.5	1.8	1.9	2.2
trn5				4.7	5.6	5.2
trn6					4.2	6.7
trn7						4.2

Table 3: Dating evidence for the site master **TIRION1** **AD 1418–1545** 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	Old Market Hall, Llanidloes	(Miles *et al* 2003)	LNYDLOS1	1424-1589	122	8.2
Wales/borders	Hillside oaks	(Siebenlist-Kerner 1978)	**GIERTZ**	1341-1636	128	8.0
Wales	Royal House, Machynlleth	(Miles *et al* 2004)	ROYALHS1	1363-1560	128	7.3
Wales	Welsh Master Chronology	(Miles 1997b)	**WALES97**	404-1981	128	7.2
Worcestershire	Mamble	(Tyers 1996)	MAMBLE_B	1348-1582	128	7.2
Shropshire	Shropshire Master Chronology	(Miles 1995)	**SALOP95**	881-1745	128	7.1
Wales	Llwyn Llandrinio, Montgomeryshire	(Miles *et al* 2003)	LLWYN	1413-1551	128	7.0
Wales	Brynmaenllwyd, Trawsfynydd	(Miles *et al* forthcoming)	traw12	1468-1664	78	7.0
Shropshire	Bryn Cambric, Clun	(Worthington and Miles 2003)	BRYNCAM	1371-1500	83	7.0
Wales	Lower Cill, Berriew, Montgomeryshire	(Miles *et al* 2006)	BERRIEW	1428-1583	118	6.9
Worcestershire	Bailiff's House, Bewdley	(Fletcher 1980)	BEWDLEY2	1430-1600	116	6.8
Herefordshire	White House, Vowchurch	(Nayling 2000)	WVT9	1364-1602	128	6.8
Warwickshire	Baddesley Clinton	(Miles and Worthington 2002)	BADESLY6	1411-1534	117	6.7
Wales	Bryngwylan, Abergele, Conwy	(Miles *et al* forthcoming)	BRYNGWYL	1430-1586	116	6.7

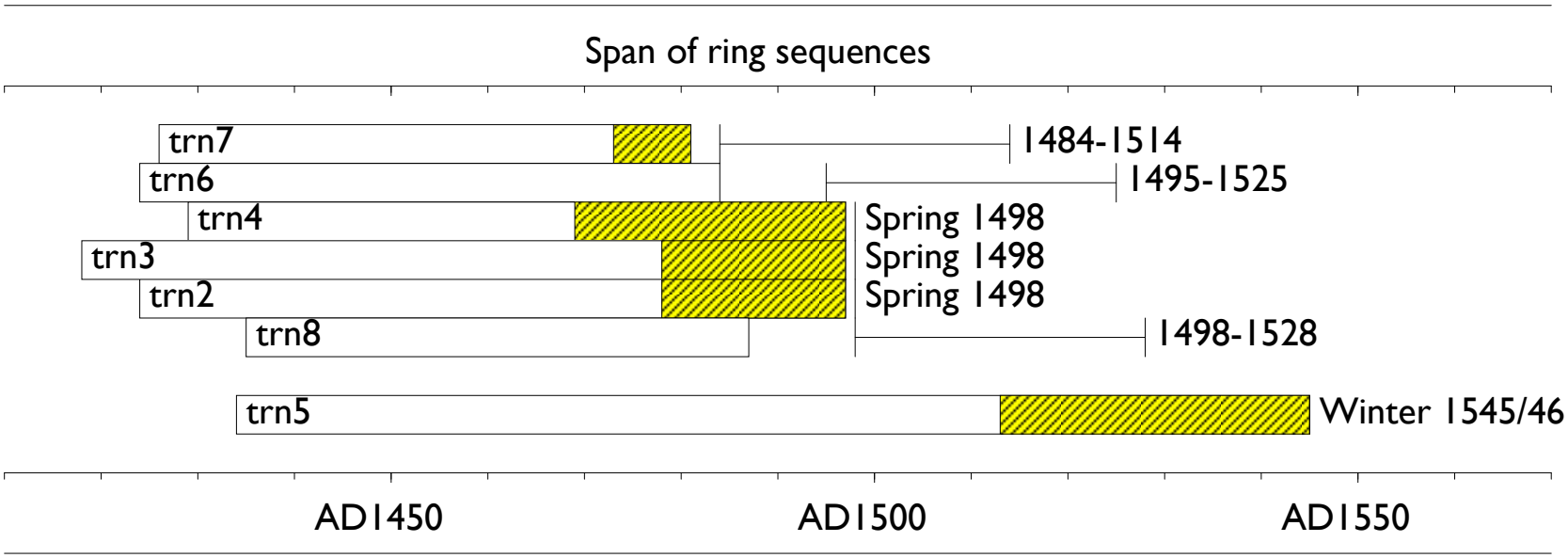

Figure 1: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings

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