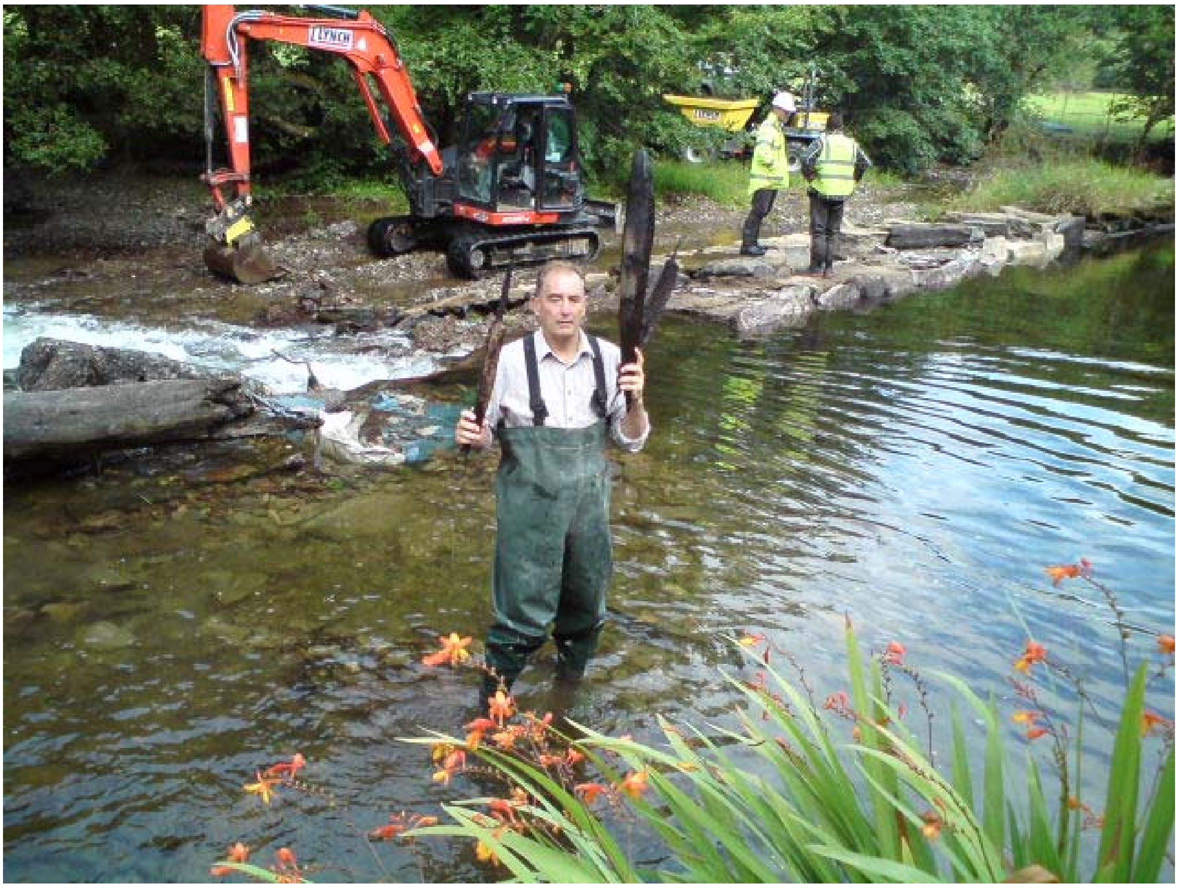
DENDROCHRONOLOGICAL ANALYSIS OF OAK TIMBERS FROM DULVERTON WEIR, NORTHMOOR ROAD, DULVERTON, SOMERSET, ENGLAND

Tree-Ring Services Report: TADW/25/14

Dr Andy Moir



Tree-Ring Services
Oakraven Field Centre, Jubliee Road,
Mitcheldean, Gloucestershire, GL17 OEE
Email: enquiries@tree-ring.co.uk
www.tree-ring.co.uk

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SUMMARY
Measured tree-ring series from thirteen stakes recovered from Dulverton Weir are matched together to form an 87-year site chronology, which is dated to span AD 1717 to AD 1803. Two stakes probably converted from the same tree are identified to have been felled around AD 1784. The dating of just these two stakes provides tentative evidence for a phase of construction or repair around AD 1784.

Three other stakes identified as having been felled around AD 1801, AD 1803 and AD 1803, together with consistent felling-date ranges produced from all the other stakes dated provide strong evidence that a further major phase of construction or repair of the weir occurred around AD 1803.

While this analysis identifies two likely phases of construction or repair of the Dulverton Weir, it is important to understand that weirs are often periodically damaged by floods and repaired. Therefore, as historical evidence suggests, the stakes dated here may not necessarily be as old as the weir itself. Additional analysis of stakes from other parts of the weir may identify other earlier phases of construction or repair.

KEYWORDS

Dendrochronology, 19th Century, Weirhead, Weir, Somerset, Dulverton.

Figures

Tables

Photos

INTRODUCTION

The increased interest in Britain's past is demonstrated by such television programmes as "Time Team" and "The House Detectives". More and more people wish to know precisely when ancient buildings were constructed in order to better understand the history of their occupants and land in which we live. Although it is sometimes possible to date a building on stylistic grounds, a precise date is rare except when there is a date-stone or documentary evidence.

The increasing use of dendrochronology (tree-ring dating) has changed this scenario, at least for buildings with timbers containing sufficient rings for analysis. The science is simple in concept. The width of a tree's growth rings varies from year to year, so that each series of years has a unique pattern of narrow and wide rings. We now know in detail the pattern of rings shown by oak trees in England for at least the last 2000 years, and there is some work in progress on other species, such as pine, beech and yew. Tree-ring dating typically involves small cores of wood being taken from the structural timbers of a building. Once sanded to a polished finish, these samples show the pattern of rings laid down during the lifetime of the trees from which the timbers were cut. If this pattern is then compared with "master chronologies" it is often possible to identify the felling date of the trees with astonishing accuracy. Where bark is present, it is possible to give a precise year, sometimes even the season of the year. We know that oak for building was almost always used "green", (unseasoned, not having been felled and prepared until required), so construction dates can be determined in which we can place considerable confidence.

Recording Timber-Framed Buildings

National trends in building activity inevitably conceal regional differences that can only be explained by detailed local studies. The Royal Commission on the Historical Monuments of England (RCHME) has analysed 53 medieval buildings in Kent (Pearson 1994). Hampshire County Council has analysed well over 100 buildings in the county (Roberts 2003). These projects utilize the specific dates provided by tree-ring analysis to refine the typological and stylistic dating of buildings.

Tree-Ring Services is committed to the development of date-range spans for stylistic features to help refine the dating of timber-framed buildings. Buildings are recorded using a ‘Tick-Box’ sheet (available at www.buildingarchaeology.co.uk) which is used to summarise the most common and distinctive ‘key features’. This information is entered into a purpose-built Building Archaeology Research Database (BARD), a resource then available for further analysis (Moir *et al.* 2012). BARD has been used to analyse 177 dwellings in Surrey and establish date ranges for 52 key features (Wild and Moir 2013). Each additional building tree-ring dated by Tree-Ring Services adds to this research and should eventually allow date ranges to be extended to other counties.

Harris (1978) provides a useful introduction to the study of timber-framed buildings, while Brunskill (2000) details the study of vernacular architecture. Alcock's (1996) glossary provides illustrative drawings which are particularly useful in facilitating the naming of timbers in a building.

Figure 1: Area location map

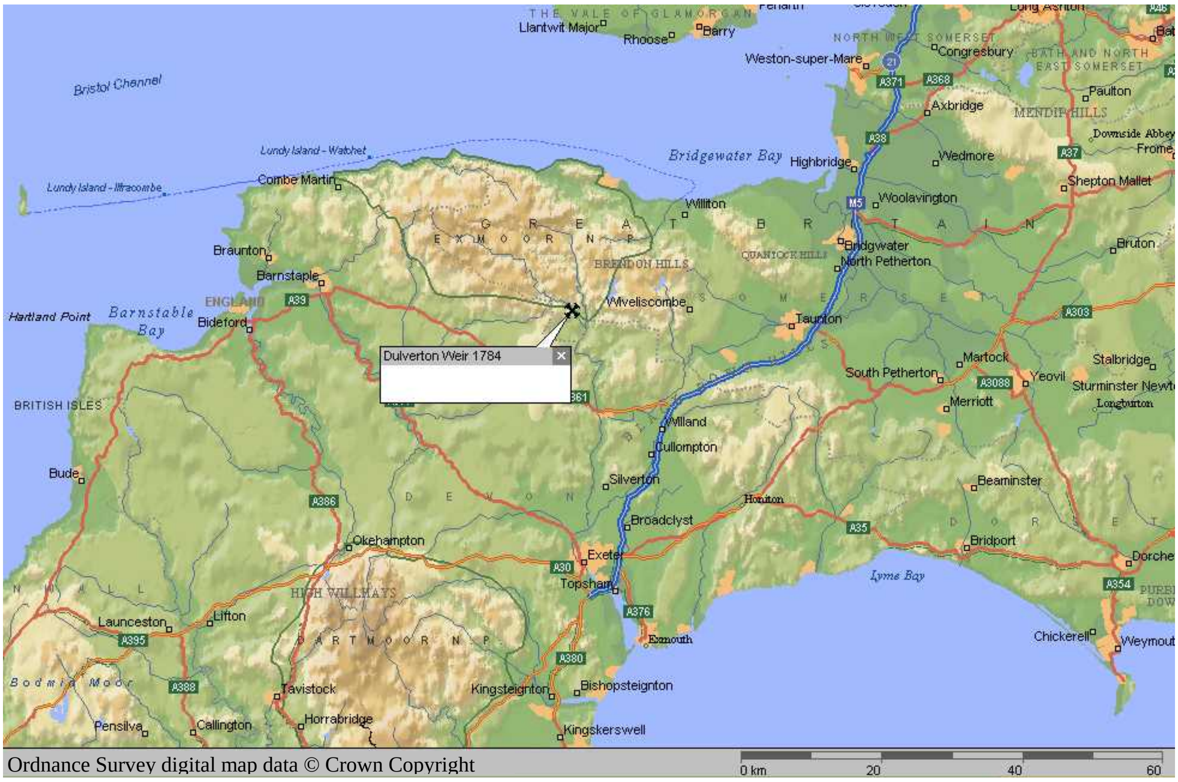
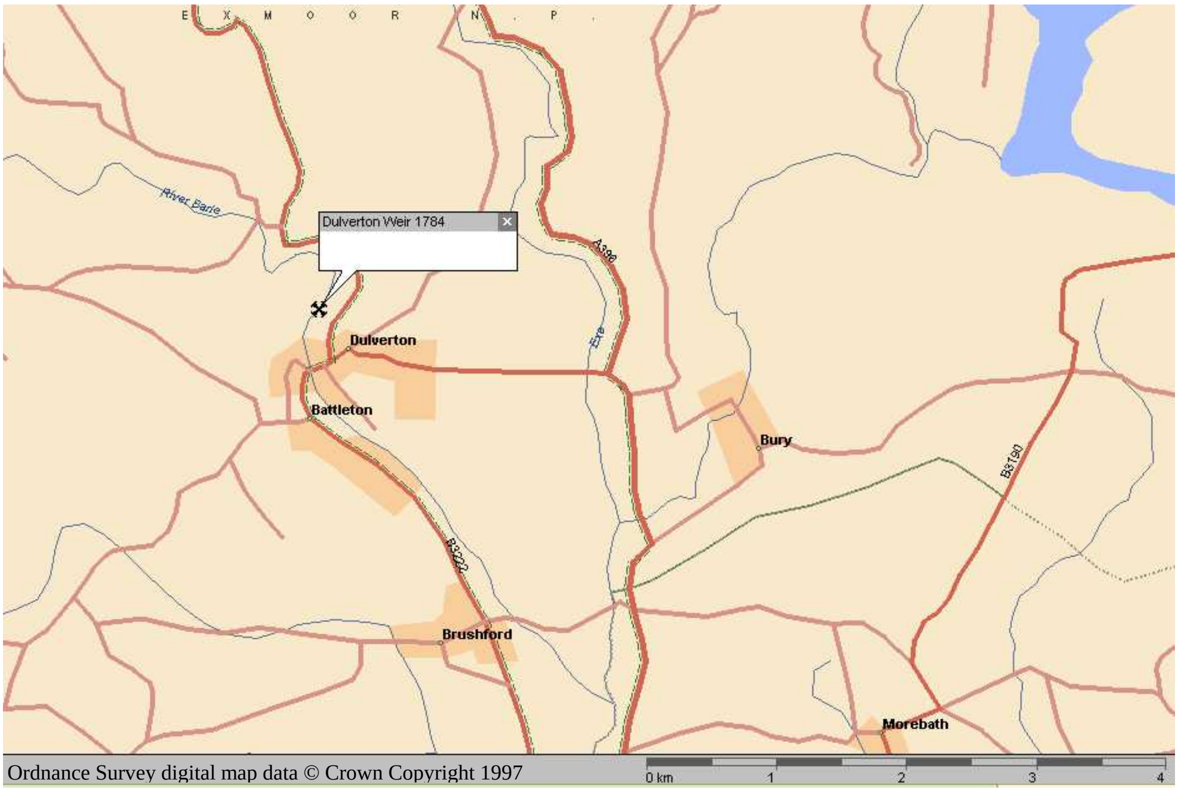


Figure 2: Site location map



Objective of the Analysis

The main objective of this analysis was to provide dendrochronological evidence to date stakes recovered during the temporary repair of the southern part of the weir.

Dulverton Weir (SS 9138 2833)
Dulverton is the southern gateway to Exmoor. The small town stands between the rivers Barle and Exe, which converge a mile down the valley. The weir is located on the River Barle at Dulverton. The Dulverton mill leat starts at the weirhead, where it leaves the river Barle to flow south through the western side of the town before rejoining the river south of Dulverton bridge. A survey by English Heritage (Gathercole 2003) indicates that a water mill in Dulverton dates back to at least 1331. The existence of a mill implies the existence of a leat and a weir to feed it. In 1568 there were 6 mills in the Dulverton area (Gathercole 2003). By the second half of the 1700's the weir & leat are regularly mentioned in the Dulverton Manor Courts records (www.victoriacountyhistory.ac.uk/.../DULVERTON_Manor_Court.doc).

The following descriptive paragraphs on the weir have been drawn from information and photographs kindly provided by the residents at Weirhead.:

> Dulverton Weir diagonally crosses the River Barle in broadly a north/south axis, in a slight 'crescent' shape with the inside of the crescent facing upstream. The current visible structure is 65 metres long. The southern (downsteam) end, consists of a 25 metre section constructed of stakes and rounded stones faced with flat larger stones. (**Photos 1,2 & 3)**.

Photo 1: Dulverton Weir section showing original rounded stones still in position

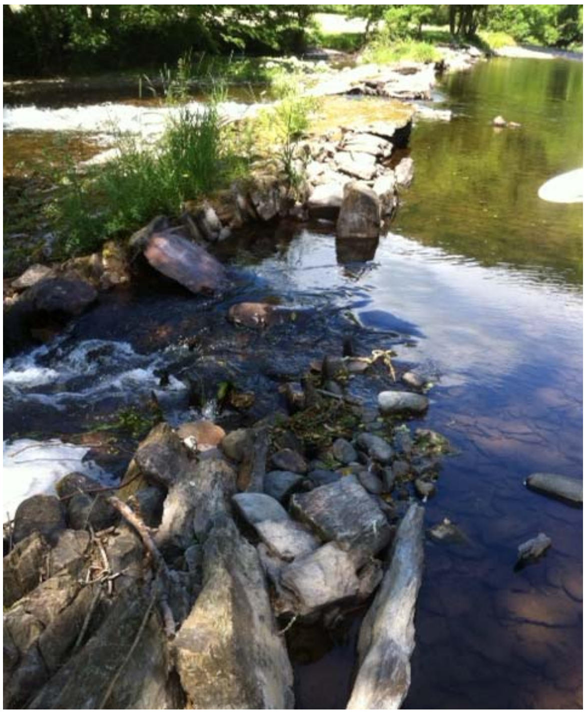


Photo 2: Dulverton Weir section showing flat facing stones (now buried under the temporary repair).

> The middle part of the weir consists of a 35 metre long section which was repaired in sandstone in 2000/2001. The northern end of weir (upstream), consists of a 10 metre long section made up of large rocks that serves as a fish pass, and which has been placed and replaced sporadically over the last 20 years. A further 46 metres of

structure exists downstream of the weir in a 'feeder' leat with facing stones placed where the bank was raised to contain and funnel the head of water down into the town.

An additional 16 metres exists upstream of the current weir (now buried in the river bank) which is identifiable in a 1930's photograph (**Photo 4**) showing that the weir started much further upstream than can be see today . There are identifiable stones from this section still in the bank. In 2012 after extensive flooding more stakes were visible in the bank further upstream than the 1930's photograph shows. These have now disappeared from sight once more under shingle. It is therefore likely that the weir structure is at least 130 meters long.

Photo 3: Dulverton Weir section showing stakes still in position (now under the temporary repair).

Photo 4: A 1930's photograph the red shaded area showing weir that is now part of the river bank

Dulverton Weir and part of Dulverton Leat are currently in the ownership of West Somerset District Council, who hold the duty of repair. Thirty eight stakes were recovered from the best preserved downstream (southern) part of Dulverton Weir which were uncovered during temporary repairs made to the weir in September 2014. The stakes were recovered from in front (upstream) of the weir during placement of stone filled gabions in front of the weir itself (**Photo 5**).

Photo 5: Dulverton Weir after temporary repairs in 2014

METHODOLOGY

Methods employed by Tree-Ring Services in general are those described in English Heritage guidelines (Hillam 1998). Part 2 of the Guidelines is designed for large projects in conjunction with other specialist disciplines and is not applicable to the type of privately commissioned dendrochronological analysis generally conducted by Tree-Ring Services and is therefore not used. Details of the methods employed for the analysis of this building are described below.

Sampling and Preparation

Whenever possible, timbers with more than 50 annual growth rings are selected for sampling. This is necessary to provide a pattern of rings of sufficient length to be unique to the period of time when the parent tree was growing.

Tree-ring series are revealed through sanding with progressively finer grits to a 600 abrasive grit finish to produce results suitable for measuring. When required, for example where bands of narrow rings occur, further preparation is performed manually. Where requested, extraction holes are "made good", employing pine dowelling, wood-glue, sawdust and wood stains to restore the timbers to their original appearance.

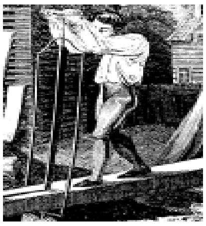
Measuring and Cross-matching

Tree-ring series are measured under a ×20 stereo microscope to an accuracy of 0.01mm using a microcomputer-based travelling stage. All samples are measured from the centremost ring to the outermost. Samples considered unsuitable for dating purposes are then rejected. These include samples with disturbed ring series which cannot be measured due to knots or bands of extremely narrow rings, and those samples with fewer than 40 rings.

Samples of fewer than 50 rings are sometimes rejected from dendrochronological analysis because their ring patterns may not be unique (Hillam *et al.* 1987). Although this is certainly true of all ring series of fewer than 30 rings, which should not be used in dating (Mills 1988), samples with 30 to 50 rings may be dated in some circumstances (Hillam 1998). Because samples taken by Tree-Ring Services are often from listed structures, it has been felt wise to maximize the recorded amount of data, and series of 40–50 rings are included in analysis and considered for dating, usually when they match well with a number of other series. Samples are measured twice and the two sets of measurements cross-matched and plotted visually as a check. Where series match satisfactorily they are averaged and the resulting series are used in subsequent analysis. Series containing fewer than 50 rings are suffixed ‘-S’, and series from managed trees ‘-M’ to help indicate that additional caution must be exercised in dating.

Cross-correlation algorithms are then employed to search for the positions where tree-ring series correlate and therefore possibly match. All statistical correlations are reported as *t*-values derived from the original CROS73 algorithm (Baillie and Pilcher 1973). A value of 3.5 or over is usually indicative of a good match as it represents the value of *t* which should occur by chance only once in every 1000 mismatches (Baillie 1982), and the higher the *t*-value the closer to congruency in the cross-matching. However, due to the remaining small risk of high *t*-values being produced by chance, all indicated correlations are further checked to ensure that corroborative high results are obtained at the same relative position against a range of independent tree-ring series. Visual comparisons of series are also employed to support or reject possible cross-matches and serve as a means of identifying measuring errors.

Timber Groups



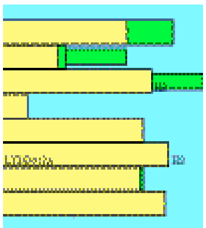
A further element of the tree-ring analysis of buildings and archaeological assemblages is the grouping of timbers within the sampled material. Inspection of *in situ* timbers may indicate that samples derive from a common timber, while common arrangements of anatomical features (knots & branching) may also indicate that samples are derived from a single tree.

Tree-ring analysis is used to support suggestions of same-tree groups between samples based on a combination of information. Timbers derived from the same tree are generally expected to have *t*-values over 10, although lower *t*-values may be produced when different radii measured from the same tree are compared. Tree-ring series producing *t*-values of 10 or above are examined to identify same-tree groups. Good comparisons of visual matching, growth rates, short and longer-term growth patterns, are combined with pith information, sapwood boundaries, bark and anatomical anomalies, to help decide whether timbers are likely to come from the same tree. Where timbers are assessed as deriving from the same tree, to avoid bias the series are averaged to produce a single tree-ring series before inclusion in the final site chronology, but inevitably some same-tree samples go undetected by dendrochronology.

Chronology Building and Cross-dating

The process of cross-matching compares all tree-ring series against one another and those found to cross-match satisfactorily together are combined to create an average series. The site mean(s) and individual ring series which remain unmatched with the site mean are then tested against a range of established reference series (reference chronologies). Significant *t*-values replicated against a range of series at the same position with satisfactory visual matching are similarly used to establish cross-matches with reference chronologies. Where cross-matching is established against dated reference chronologies, calendar dates can be assigned to the site series. The dates of the first and last rings of dated series are produced as date spans. These dates should not be confused with felling dates.

Felling Dates



Series dated by the cross-dating process provide calendar year dates for the final tree-ring present in the measured timber sample. The interpretation of these dates then relies upon the nature of the final rings in the series. Where bark survives intact on a sample a felling date is given as the date of the last ring measured on the tree-ring series. Based on the completeness of the final ring it is sometimes even possible to distinguish between spring, summer or winter fellings, corresponding to approximately March to May, June to September and October to February, respectively. Where timbers were felled in either spring or summer and the final ring is incomplete and therefore not measured, allowance has to be made for the one-year discrepancy between the end of a measured series and the actual year of felling.

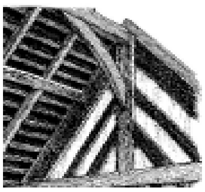
Sapwood Estimates

Where bark is missing from oak samples, as long as either sapwood or the heartwood/sapwood boundary have been identified, an estimated felling-date range can be calculated using the maximum and minimum number of sapwood rings that were likely to have been present. Sapwood estimates have varied over time with different data sets, geographical location and researchers. A general trend identified is that the number of sapwood rings in oak decreases from north to south and from west to east across Europe.

However, simply not enough is yet understood about sapwood variations and the mechanisms responsible for them. A generally accepted sapwood estimate of between 10 and 55 rings for British and Irish oaks (at 95% confidence) was given in 1987 (Hillam *et al.* 1987). Analysis of the increased data set available ten years later indicates a range of 10 to 46 rings to be more appropriate for England (Tyers 1998). Currently, as research in areas improves, sapwood estimates are refined and new estimates applied. Therefore, when dendrochronological dates are produced, the reference to the sapwood estimate used in its calculation should always follow.

This report applies a sapwood estimate of a minimum of 9 and maximum of 41 annual rings, which means that 19 out of every 20 trees examined is expected have between 9 and 41 sapwood rings. This sapwood estimate is currently applied to most of the south-east region and has been arrived at by Oxford Dendrochronology Laboratory (Haddon-Reece *et al.* 1990, Miles 1997). Felling-date ranges have been calculated by adding the sapwood estimate of minimum and maximum missing rings to the date of the heartwood/sapwood boundary. Felling-date ranges have been refined by the presence of surviving sapwood where appropriate, see **Table 2**. Where samples ending in heartwood were dated, "felled after dates" have been calculated by adding the minimum expected number of missing sapwood rings to the samples' final ring dates. These dates represent the earliest probable felling dates. However, the actual felling date of a tree may be decades later due to an unknown number of missing heartwood rings.

Felling Groups



It is common to find that timbers used in the construction or repair of smaller buildings, or identifiable parts of larger buildings, date into groups whose felling dates occur within a narrow range of years. These groups are called associated fellings. Where they are identified the average heartwood/sapwood boundary of the component timbers is used to calculate an overall estimated period of felling. Close location association and a short (21 years at most) range of heartwood-sapwood boundary dates are normally used to define these groups. The estimates do not assume that trees within a group were felled at the same time. However, evidence published by the Nottingham University Tree-Ring Dating Laboratory indicates that the range estimate encompasses the possible different individual felling dates (English Heritage 2001). Where bark is present within a group of timbers and other evidence does not dispute the date, it is assumed that all the trees within a felling group were felled in the same year.

Date of Construction

It is vitally important to understand that dendrochronological analysis provides dates for when trees were felled and not necessarily when their timbers were used. Green or freshly felled wood is, however, far easier to work and it is standard practice to assume that medieval timbers were felled as required and used green (Rackham 1990, Miles 1997). However, the use of previously felled timbers in vernacular construction was not uncommon, with short-term stockpiling of usually not more than 1 to 2 years (Miles 1997), and the use of leftovers or re-used timbers may certainly give rise to differences between felling dates and the date of construction where samples are analysed in isolation. A number of samples having a close range of felling dates are required from different elements of a building either to strongly indicate a single date of construction or to identify separate phases of construction.

Tree-Ring Services - Methods and Criteria

Tree-ring analysis and graphics are achieved via a dendrochronological programme suite developed by Ian Tyers of Sheffield University (Tyers 1999). Location maps are produced using *Microsoft AutoRoute Express GB 98 Auto Street Navigator*, which uses Ordnance Survey digital map data © Crown Copyright 1997. Alcock's (1996) timber-framed building nomenclature has been adopted throughout to facilitate regional comparisons. Summary features of most buildings dated, are made available on the Building Archaeology Research Database (Moir *et al.* 2012). Tree-Ring Services reports are published with tree-ring data to enable independent verification and allow their use in dating. Report may be ordered through the website at www.tree-ring.co.uk.

For the analysis of a building an initial assessment is conducted with the owner and recommendations in line with English Heritage guidelines on sampling strategies made, (i.e., that a minimum of 8 to 10 samples are obtained per building or per phase). However, the final decision concerning the number of samples taken for analysis rests with the individuals who commission the analysis. It is generally beyond the scope of an analysis to describe a building in detail or to undertake the production of detailed drawings. Without the benefit of other specialist disciplines there is always the danger that re-used timbers may be inadvertently selected, and the conclusions presented in a report may be modified in the light of subsequent work.

RESULTS

On the 15th September 2014, 38 stakes recovered during repairs to Dulverton Weir were delivered to Tree-Ring Services (see **Photo 6)**. Twenty-two stakes with good dendrochronological potential were measured and sub-sampled (see **Photo 7**). Then thirteen stakes with highest dendrochronological potential were sub-sampled (see **Photo 8**). Oak timbers with the most rings and/or best survival of sapwood were the main considerations. These sections for dendrochronological analysis were labelled sequentially from TADW01 to TADW13.

Photo 6: The full cohort of stakes recovered from the weir

Photo 7: Twenty-two stakes measured and sub-sampled

Photo 8: Thirteen sub-sections of stakes that underwent dendrochronological analysis

All the stakes were confirmed as oak (*Quercus* spp). Two of the thirteen sub-samples sections contained less than 50 rings, and so were identified by the suffix (-S), i.e. TADW03-S and TADW18-S.

All thirteen series were found to match together (**Table 1**).

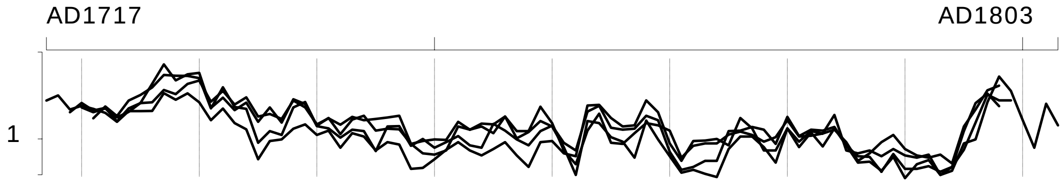
Table 1: Cross-matching between the thirteen series from Dulverton Weir

Filenames	Start dates	End dates	02	03-S	06	07	11	12	15	17	18-S	19	21	22
TADW01	AD1721	AD1776	5.93	-	\	6.16	4.42	5.56	10.80	-	3.23	5.07	4.04	3.67
TADW02	AD1729	AD1778		-	6.14	5.30	5.66	5.27	6.02	3.33	3.05	4.60	5.33	3.36
TADW03-S	AD1741	AD1784			-	3.34	4.22	4.18	3.61	-	4.30	4.48	-	3.57
TADW06	AD1748	AD1801				4.65	-	-	-	3.35	-	3.48	3.82	-
TADW07	AD1739	AD1788					5.67	6.10	7.93	3.71	4.36	5.63	5.29	7.07
TADW11	AD1720	AD1803						9.37	5.44	-	4.19	9.05	3.74	9.50
TADW12	AD1721	AD1798							5.73	-	4.86	10.19	4.96	11.71
TADW15	AD1730	AD1784								-	3.15	7.03	4.30	4.88
TADW17	AD1741	AD1791									-	-	4.55	-
TADW18-S	AD1741	AD1783										4.03	5.32	3.35
TADW19	AD1719	AD1798											4.86	9.85
TADW21	AD1735	AD1800												4.78
TADW22	AD1717	AD1799												

KEY: - = *t*-values less than 3.00. \ = overlap < 30 years.

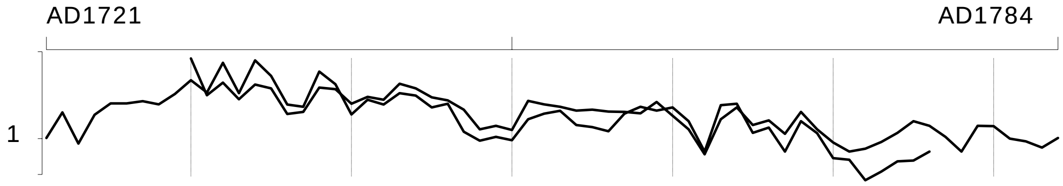
Four pairs of series (TADW11, TADW12, TADW19 & TADW22) displayed high *t*-values over 9. The series share very similar short growth patterns and longer-term growth rates (**see Figure 3**). Pith evidence also supported the hypothesis that both sequences derive from the same parent tree. These sequences were averaged to produce a single tree-ring sequence named TREE-1 for inclusion in the final site mean sequence to avoid bias.

Figure 3: Plot of probably same-tree ring sequences TADW11, TADW12, TADW19 and TADW22



Two other pairs of series (TADW01 & TADW15) also displayed a high *t*-value of 10.9. These series share very similar short growth patterns and longer-term growth rates (**see Figure 4**). These two series were averaged to produce a single tree-ring sequence named TREE-2 for inclusion in the final site mean sequence to avoid bias.

Figure 4: Plot of probably same-tree ring sequences TADW01 and TADW15



Nine series (TADW02, TADW03-S, TADW06, TADW07, TADW17, TADW18-S, TADW21, TREE-1 and TREE-2 were combined to form an 87-year site mean chronology named DULVT-WR. The DULVT-WR chronology was found to produce consistently high *t*-values against reference chronologies (**Table 2**), with the first ring of the series at AD 1717 and the final ring of the series at AD 1803.

Table 2: Dating evidence for the site mean chronology DULVT-WR against reference chronologies

DULVT-WR dated AD 1717 TO AD 1803					
File	Start Date	End Date	*t*-value	Overlap (yr.)	Reference chronology
ENGLAND	AD404	AD1981	6.16	87	England Master Chronology (Baillie and Pilcher 1982 unpubl)
WINCHSTR	AD1635	AD1972	6.07	87	Winchester - Hampshire (Barefoot 1975)
EXETR-CB	AD1698	AD1805	5.84	87	St Johns Chapel - Exter Cathedral - Exeter - Devon (Arnold *et al.* 2006)
MILLB-IM	AD1702	AD1799	5.62	83	Insworke Tide Mill - Millbrook - Cornwall (Moir 2011)
WKF-A25	AD1676	AD1771	5.12	55	St Marys Church - Winkfield - Berkshire (Arnold and Howard 2006)
WARWK-MP	AD1746	AD1801	4.91	85	13 Market Place - Warwick - Warwickshire (Author, unpublished)
EAST_MID	AD882	AD1981	4.90	87	East Midlands published version (Laxton and Litton 1988)
VICTORY	AD1640	AD1800	4.87	84	HMS Victory (Barefoot 1975)
BRNGHST1	AD1664	AD1781	4.83	65	Church Farm - Bringhurst - Leicestershire (Groves *et al.* 2004)

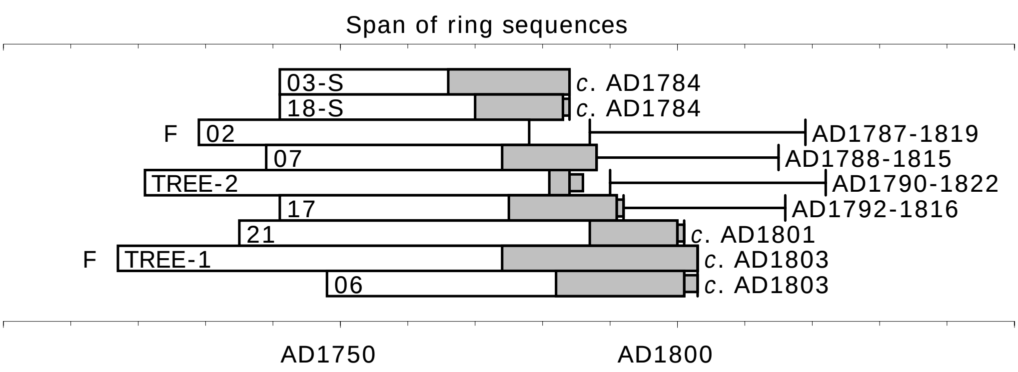
HERWOR2	AD1729	AD1969	4.52	87	Hereford and Cumberland Modern (Siebenlist-Kerner 1978)
STONE-1	AD1387	AD1998	4.52	87	Stoneleigh Abbey - Warwickshire (Howard *et al.* 2000)
BRIDSO-B2	AD1681	AD1772	4.20	56	Great Bidlake - Bridestowe - Devon (Arnold and Howard 2011)

KEY: **Bold** = indicates a composite reference chronology consisting of multiple site chronologies.

INTERPRETATION

Felling Dates

The sapwood allowance used to calculate the felling dates now discussed is presented in **Table 3**, and the bar diagram (see **Figure 5**) helps to demonstrate the findings visually.



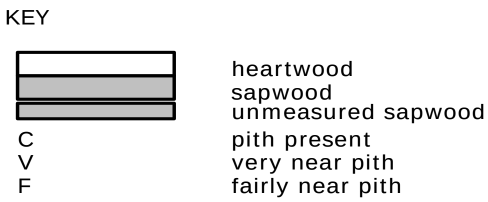


Figure 5: Bar diagram showing the date interpretations for the series dated from Dulverton Weir

No bark could be identified on any of the samples. Full sapwood appeared to survive on five samples. However, as the outer rings were slightly eroded they are recorded here as *circa* dates, to indicate that the precise year of felling could be one or two years later.

Two stakes dated (TADW03-S and TADW18-S) produce felling dates around AD 1784. Due to the possibility of re-use, the dating of just two stakes can provide only tentative evidence that a phase of construction (or repair) of the weir occurred in AD 1784, or soon after.

Stake TADW21 produces a felling date around AD 1801 and stake TADW06 produces a felling date around AD 1803. Four other stakes (TADW11, TADW12, TADW19 and TADW22) are likely to all be from the same tree, which was felled around AD 1803. The felling-date ranges produced from four other samples dated are consistent with fellings identified around AD 1801 and AD 1803 and together this provides strong evidence to indicate that a further phase of construction or repair of the weir occurred around AD 1803.

Timber analysis

All the timbers sampled from the weir were oak. Cross-matching with local reference chronologies of the periods is insufficient to indicate whether the timbers used in construction or repair of the weir came from a local source, although this is likely the case.

CONCLUSIONS

Measured tree-ring series from thirteen stakes recovered from Dulverton Weir are matched together to form an 87-year site chronology, which is dated to span AD 1717 to AD 1803. Two stakes probably converted from the same tree are identified to have been felled around AD 1784. The dating of just these two stakes provides tentative evidence for a phase of construction or repair around AD 1784.

Three other stakes identified as having been felled around AD 1801, AD 1803 and AD 1803, together with consistent felling-date ranges produced from all the other stakes dated provide strong evidence that a further major phase of construction or repair of the weir occurred around AD 1803.

While this analysis identifies two likely phases of construction or repair of the Dulverton Weir, it is important to understand that weirs are often periodically damaged by floods and repaired. Therefore, as historical evidence suggests, the stakes dated here may not necessarily be as old as the weir itself. Additional analysis of stakes from other parts of the weir may identify other earlier phases of construction or repair.

ACKNOWLEDGEMENTS

I would like to thank the Hull and Romain families of Dulverton for commissioning this analysis and Philip Hull for kindly supplying the initial cohort of stakes and photographs of the weir.

Table 3: Summary of dendrochronological analysis

Sample	Timber Conversion	Stake Length (mm)	Section Dimensions (mm)	Rings	Sapwood	Average Growth Rate (mm/yr)	Sequence Date Range	Felling Date	Rings to Pith		Age Estimate
TADW01	D1	890	90 x 75	56	-	1.64	AD1721-AD1776	see 15			see 15
TADW02	D1	680	80 x 65	50	+HS	1.50	AD1729-AD1778	AD1787-1819		10	60
TADW03-S	D1	101	60 x 65	44	18+?B	1.44	AD1741-AD1784	AD1784?	>	15	59
TADW04	A1	970	80 x 60								
TADW05	C1	700	65 x 60								
TADW06	D1	600	70 x 55	54	19+2+?B	1.28	AD1748-AD1801	AD1803?	>	15	69
TADW07	C1	860	85 x 65	50	14	1.73	AD1739-AD1788	AD1788-1815	>	15	65
TADW08	D1	930	70 x 50								
TADW09	D1	710	75 x 85								
TADW10	D1	1220	90 x 85								
TADW11	D1	900	110 x 60	84	29+?B	1.34	AD1720-AD1803	AD1803?		10	94
TADW12	D1	810	110 x 65	78	20	1.27	AD1721-AD1798	see 11			see 11
TADW13	C1	770	70 x 60								
TADW14	D1	810	80 x 65								
TADW15	D1	730	95 x 65	55	3+2	1.63	AD1730-AD1784	AD1790-1822	>	15	70
TADW16	D1	550	65 x 55								
TADW17	D1	1040	120 x 90	51	16+1	2.33	AD1741-AD1791	AD1792-1816	>	15	66
TADW18-S	D1	1000	110 x 80	43	13+1+?B	2.24	AD1741-AD1783	AD1784?	>	15	58
TADW19	D1	1040	110 x 70	80	19	1.37	AD1719-AD1798	see 11			see 11
TADW20	C1	1160	90 x 115								
TADW21	D1	750	90 x 75	66	13+1+?B	1.34	AD1735-AD1800	AD1801?	>	15	81
TADW22	D1	220	100 x 55	83	24	1.19	AD1717-AD1799	see 11			see 11

KEY	
+	= additional information not measured on the core
(+)	= unmeasured heartwood rings at the beginning or end of the core
HS	= heartwood/sapwood boundary
?B	= probable bark
¼B	= spring bark
½B	= summer bark
Bw	= winter bark
A1	= boxed heartwood
B1	= halved
C1	= quartered
D1	= eighthed

Note: Timber dimensions were generally taken at the core sample location and are not necessarily the maximum dimensions of the timber

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APPENDIX I: Raw ring-width data

Ring widths (0.01mm), starting with innermost measured ring

TADW01

101	161	91	154	189	189	197	186	224	288
230	395	228	413	311	185	178	336	268	155
202	185	227	218	176	188	113	96	103	97
142	157	165	128	123	114	157	178	166	176
137	79	183	188	111	122	79	137	110	70
68	47	55	66	67	79				

TADW21

210	196	155	168	200	165	146	146	145	158
183	204	142	106	140	126	183	210	184	154
177	159	133	138	156	133	119	79	169	125
105	139	120	122	113	114	111	106	106	99
90	105	134	95	113	135	106	132	121	142
99	100	97	80	95	87	81	90	74	58
108	88	135	135	262	249				

TADW02

347	406	216	238	164	163	150	160	145	188
212	125	126	135	163	176	138	183	112	90
110	99	136	143	125	172	159	170	151	175
175	208	155	97	192	159	130	133	92	111
102	104	74	61	71	89	107	104	106	130

TADW03-S

248	237	285	286	221	234	258	146	169	128
134	139	157	126	161	196	172	142	130	113
129	70	101	134	108	97	117	147	137	171
123	125	104	113	122	108	106	75	71	106
96	94	92	100						

TADW06

212	224	205	205	231	181	241	180	210	171
213	216	191	195	115	215	156	118	187	150
183	170	151	106	90	115	129	120	95	97
104	90	118	102	94	87	83	68	61	59
62	58	68	55	52	63	52	76	59	86
82	74	89	103						

TADW07

170	176	174	152	183	150	115	157	163	103
114	98	140	166	157	179	176	189	146	231
239	216	199	100	293	274	186	217	172	251
196	157	137	157	209	193	181	224	178	158
186	179	183	164	181	219	96	142	130	118

TADW11

177	162	174	148	163	192	272	386	289	322
331	175	211	168	193	136	177	134	205	188
126	121	102	118	115	80	125	126	88	100
85	94	105	89	85	131	116	99	89	115
127	93	81	164	182	122	118	120	152	140
79	57	60	67	67	115	116	124	118	91
149	105	118	116	124	89	65	66	56	72
49	63	68	52	56	92	99	194	310	238
141	85	189	128						

TADW12

145	180	151	200	222	254	319	314	313	301
174	255	178	172	93	115	107	177	195	127
146	109	142	152	116	120	119	91	77	75
81	125	118	132	130	150	101	113	138	125
86	52	138	133	103	95	71	139	99	73
54	57	53	50	83	104	104	86	65	121
86	112	87	121	89	73	72	55	76	58
58	61	55	60	115	191	227	181		

TADW15

427	219	276	204	266	248	156	162	252	245
188	213	202	270	248	211	200	169	118	126
117	198	186	178	166	169	163	162	158	194
151	118	75	142	176	128	139	109	162	118
93	79	83	94	111	137	126	103	79	126
125	100	95	85	101					

TADW17

469	477	575	458	358	575	333	283	347	333
403	356	278	247	332	232	193	393	228	204
159	172	244	222	160	245	181	170	135	155
135	117	151	203	161	132	159	88	100	148
145	133	144	191	96	121	124	131	160	152
193									

TADW18-S

236	195	194	258	327	475	394	282	253	126
151	190	189	158	238	257	216	257	285	260
206	107	213	220	151	217	244	285	225	243
246	253	193	174	194	178	166	112	104	178
253	238	275							

TADW19

162	192	167	175	137	174	191	194	243	225
271	288	196	238	186	212	150	157	143	200
177	130	145	129	149	140	143	147	152	91
96	99	98	136	118	125	111	150	115	115
179	133	81	63	116	158	93	91	111	133
128	116	71	88	92	92	108	114	107	95
103	140	104	106	110	118	94	67	77	94
107	83	74	71	75	64	125	170	241	262

TADW22

200	220	170	182	172	160	136	165	165	166
229	203	228	194	140	173	133	119	69	96
99	120	130	107	116	85	111	104	81	94
90	58	59	69	82	94	81	74	83	94
74	60	94	96	77	73	183	185	146	125
128	201	162	92	67	96	97	100	89	146
121	81	81	121	95	115	110	154	81	77
81	73	83	74	71	75	52	60	82	134
223	201	201							

APPENDIX II: Mean ring-width data

Title : Dulverton Weir - Dulverton - Somerset [DULVT-WR] 9 timber mean
Ring-width QUSP data of 87 years length
Dated AD1717 to AD1803
Unit of Measurement 0.01mm
Average ring width 161.10   Sensitivity 0.18

AD1717							200	220	166	183
	131	166	117	164	190	205	245	221	284	347
	203	264	182	225	187	165	147	206	202	151
	217	205	240	230	205	267	208	156	172	144
AD1751	178	191	171	169	186	186	159	201	193	178
	152	98	193	181	132	163	141	174	147	140
	118	116	122	129	130	129	129	104	109	140
	135	132	136	137	89	98	96	92	99	93
	98	70	65	56	95	98	147	151	185	159
AD1801	94	189	128							