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A RECENTLY DEVELOPED IRISH TREE-RING CHRONOLOGY

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ABSTRACT

An initial study of samples from 30 recently felled Irish oak trees established the validity of the dendrochronological method in Ireland and provided a standard chronology from A.D. 1649 to the present. Using timbers from previously undated post-medieval buildings in the north of Ireland this chronology has been extended back to A.D. 1380. The chronology has been used for the dating of numerous post-medieval timbers, of which two groups are discussed.

INTRODUCTION

Prior to 1968, no serious dendrochronological work had been undertaken in Ireland. A few results had been obtained by an American worker, Gwyneth Harrington, on material removed from the Ballinderry Crannog No. 1, excavated by Hencken in the 1930's (Harrington 1943). Although her findings were apparently encouraging, "The most important result at present is that even this small sequence (50 years) and correlation show that dating from tree rings in Ireland can be done, though not as easily and clearly as in more favourable regions," they led to the generally accepted belief that tree-ring dating would not work in Ireland. It is likely that the real reason for the total disinterest in tree-ring dating as a tool for the Irish archaeologist and historian was founded on the short staffing in those disciplines and the lack of any financial support for a research project to fully investigate the possibilities.

The present work commenced in 1968 (Pilcher 1973) and concentrated on the problems of establishing a modern standard chronology to facilitate the dating of Irish medieval and post-medieval oak timbers (Baillie 1973). In order to reduce possible sources of difficulty, the initial project was limited to the north of Ireland, within an 80 km (50 mile) radius of Lough Neagh (Figure 1). This area of approximately 20,000 square km represents a small climatic area sheltered from the prevailing weather by the mountainous west coast. It was hoped that the results obtained in the initial study would not however be limited to timbers from this area but would extend to at least part of the central lowlands and the east coast.

SELECTION OF OAK AS THE MATERIAL FOR STUDY

At the present time there are two basic types of woodland in Ireland. Firstly there are large tracts of coniferous forest which have been State-planted, mostly in this century, and consist of non-indigenous species. Secondly there are private woodlands, mostly on old estates, which tend to contain mixed hardwoods and softwoods. These estates were planted in the 18th and 19th centuries, in response to the shortage of timber brought about by earlier exploitation, and contain quantities of oak, ash, and elm as well as a considerable number of exotics. Tree-ring chronologies could be established for some of these species as far back as A.D. 1700 but oak is the only species of which still older examples might be obtained. In the 17th century, the building traditions imported into the north of Ireland all demanded oak timbers. Because of this, considerable quantities of Irish oak of 17th century date are still in existence. Earlier than the 17th century the only timber consistently recovered from medieval buildings and archaeological excavations is oak and, as shown by Pilcher (1973), dated samples of oak derived from bogs, lakes, and archaeological sites survive from at least as far back as 8000 B.P. These factors together with the successful use of oak in the construction of European chronologies (Huber and Giertz 1970) made it the only timber which could be used for a medieval and post-medieval dendrochronological project in Ireland.

MEDIEVAL TIMBERS IN THE NORTH OF IRELAND

While it is not intended to look in detail at the history of the Irish forests, it is necessary to give some historical reasons for the relative shortage of medieval timbers in the north of Ireland as compared with the situation in other western European countries.

Firstly, the area was not successfully subjugated and settled until the early 17th century. Buildings dating to before 1600 rarely survived the 17th century intact. The large tracts of woodland, containing oak and elm, which were to be found throughout the country in 1600 were heavily exploited and were almost exhausted by 1725, due to the excessive demands of trades like iron-working, ship-building, coopering and tanning

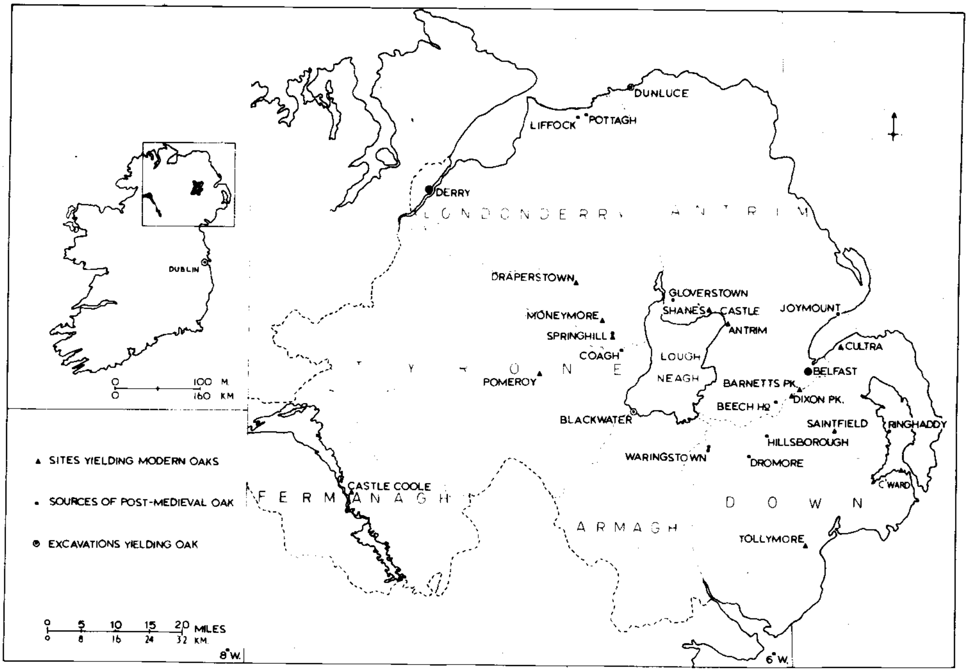

Figure 1. Map of the area of study showing sources of recently felled, medieval and post-medieval oak timbers.

Table 1. Sources of recently felled oaks with details of number of trees, altitude, and century in which the estates were founded.

Place	County	Century	Number	Altitude (ft)
Castlecoole	Fermanagh	18th	5	100+
Pomeroy	Tyrone	18th	1	250+
Springhill	Londonderry	18th	2	250
Moneymore	Londonderry	19th	1	100+
Castledawson	Londonderry	19th	1	250
Shane's Castle	Antrim	17th	4	50+
Antrim	Antrim	–	1	100+
Barnetts Park	Antrim	18th	4	50+
Dixon Park	Antrim	18th	1	50+
Cultra	Down	19th	3	100+
Saintfield	Down	18th	2	150+
Castleward	Down	18th	2	50+
Tollymore	Down	18th	3	350+

(McCracken 1971). Thus few early oak trees had the opportunity of surviving to the present day. A major Rebellion beginning in 1641 decimated the wooden buildings of the early 17th century and a further period of unrest associated with the Revolution of 1688 thinned out those built after the Restoration in 1660. There is considerable evidence that the once wooded countryside was almost treeless by the time Georgian estates were being enclosed and planted (Baillie 1973).

ADVANTAGES OF OAK FOR TREE-RING DATING

As previously outlined by Huber and Giertz (1970), oak is an excellent timber for tree-ring studies. By comparison with most species growing in temperate climates oak is long lived and most Irish specimens attain an age of between 100 and 250 years. Being ring-porous, its ring record is normally clear and unambiguous. It does not suffer from missing or double rings, although, in common with the findings of German workers, an example has been noted where enlarged summer vessels gave one ring the appearance of double growth.

Perhaps the most important advantage of oak, with respect to the accurate dating of buildings, lies in the fact that even with its outer rings missing, an oak sample which shows traces of sapwood can be given an estimated felling date. While in theory the only way to identify the outside growth ring of a tree is by the presence of bark, in practice there are two cases where the certain presence of the outer ring can be established. First, if a beam retains the original curved surface of its sapwood, the 'waney edge' (Schove and Lowther 1957), observation of a transverse section should show the outer ring continuous over a significant arc of the circumference. In addition, where the sapwood is completely preserved, the striated cambial surface can frequently be recognized by contrast with the smooth facets left by axe or adze. Second, if a number of pieces of timber from a building or structure all show the apparent outer year of their sapwood to be the same, it can be inferred that this indicates the date of felling of all the trees in the group.

Samples of oak are often obtained with their sapwood either wholly or partially missing. Where the heartwood-sapwood transition is recognizable, whether by color change or by microscopic examination of the spring vessels, it is possible to obtain an approximate felling date for the tree by adding an estimated number of sapwood rings after the transition. Sapwood occupies a more or less fixed number of the growth rings of an oak. This is because the sapwood is the portion of the tree containing live parenchyma cells. Lowson (1966) states that the dying of the parenchyma cells, after perhaps 10 or 15 years, is preceded by numerous changes in the wood which visibly differentiate the active sapwood from the inactive heartwood. Thus it is possible, by measuring the number of sapwood years in a large population of trees which retain all their sapwood, to establish a mean figure as a basis for estimation of missing sapwood. Two estimates exist for the number of sapwood rings in German oaks. These are, 20± 6 (Holstein 1965) and 25 (Huber 1967). A similar estimate derived from all Irish oaks studied in this project yields a mean of 32± 9 where ± 9 represents one standard deviation on the mean (Baillie 1973). This number, added to the mean outer heartwood year, is used to estimate the felling date of Irish oaks with missing sapwood. The use of a mean outer heartwood year allows for the fact that the heartwood-sapwood transition may not always follow the line of a single ring.

SAMPLE PREPARATION AND MEASUREMENT

Medieval oak timbers are found preserved in waterlogged conditions or as seasoned timbers in buildings. In the latter case, there is normally little deterioration apart from the sapwood which is, without exception, badly attacked by insects. Oak saturated with water presents few problems since the heartwood is generally highly resistant to decay. Slow drying of wet samples produces little distortion of the ring records since the relative width of any ring to its neighbours is unaffected by warping. Saturated sapwood is normally measured while wet by slicing with a scalpel or razor to expose the lines of empty spring vessels. Transverse sections of dried samples are sanded to a fine polish. Ring measurement is carried out using a travelling stage and binocular microscope. The equipment used in Belfast is similar to the Bannister (1972) tree-ring measuring apparatus and measures to an accuracy of 0.05 mm.

REPRESENTATION OF DATA

The primary data produced in any tree-ring project takes the form of long sequences of ring width measurements. The actual units are irrelevant providing that a degree of internal consistency exists within an individual laboratory.

The four basic representational techniques used in tree-ring studies are skeleton plots, ring width plots, plots of logs of ring width, and plots of index values.

In all cases, a horizontal scale in years is employed. Skeleton plots are mainly of use where the trees are extremely sensitive to a single aspect of the factors influencing growth. With deciduous trees growing in temperate climates, the information stored in the overall ring pattern is more important than the occasional signature years and the skeleton plot method is not used. In most work on Irish timbers direct plots of ring width or log ring width are used. Either of these formats can be used in the visual cross-matching of ring patterns.

Tree-ring indices are produced by dividing the measured ring width values by the yearly values taken from a curve fitted to the series of ring widths (Ferguson 1968). A method adopted with ring patterns of Irish oaks is to produce an index value by converting the measured ring width to a percentage of the mean of the five ring widths of which it is the central value. The resultant smoothed curve has a mean value of 100 percent. The spread of values about 100 percent can be normalized by the use of logs of these percentage values. These percentage average indices are used in the computation of correlation coefficients between ring patterns and in the production of master chronologies where the indices can be meaned directly.

CROSS-CORRELATION OF TREE-RING PATTERNS

Any dendrochronological study involves the establishment of cross-correlations between ring patterns. This is true for chronology extension, dating against floating, or standard chronologies and comparison of chronologies from different areas. The plot of a tree-ring pattern presents itself to the eye as a jagged curve. Visual matching between ring patterns can be achieved by observation of the patterns of wide and narrow rings in polished samples or by observing plots of ring widths. Figure 2 shows a cross-correlation

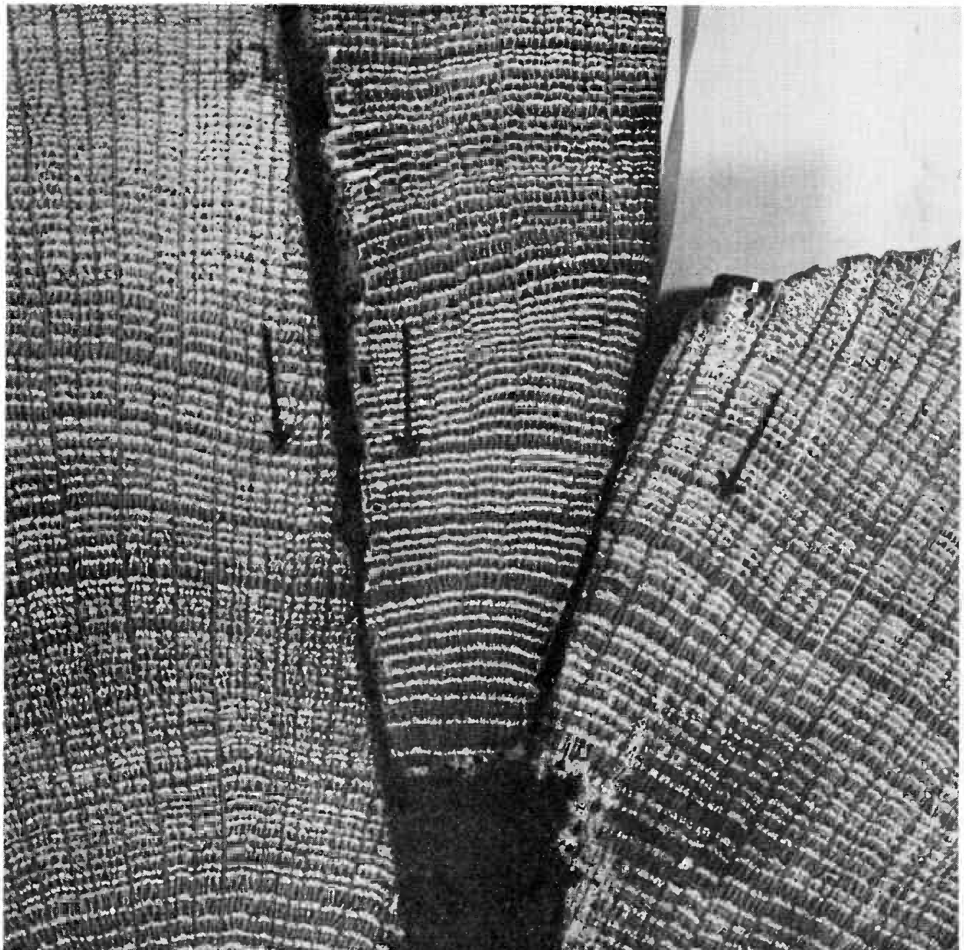

Figure 2. Visual crossdating between Q.U.B. 1122 (Dublin), Q.U.B. 29 (Coagh) and Q.U.B. 536 (Hillsborough). The year DATUM (A.D. 1580) is arrowed in each case.

established on the basis of a signature pattern occurring in each of three Irish oak samples. The wide signature ring for the year A.D. 1580 is indicated in each case. Instances of this kind are rare in oak (Huber and Giertz 1970). Visual comparison of ring width plots involves superimposing the two patterns under study and shifting their relative positions until such time as significant agreement is obtained between them. In practice the observer looks at significant features in one pattern and attempts to duplicate them in the second. In addition, at a position of good fit, the area between the curves is at a minimum. The limiting case of this is where two identical curves are compared, at their position of best fit the area between them decreases to zero. This reduction of the area between ring patterns may be detected visually. However, visual matching is subjective and the ability of a trained observer to find sufficient similarities, in two long ring patterns, to establish a cross-correlation, is not a measurable quantity. Thus it is essential, for consistent results, that some repeatable measure of the significance of a cross-correlation should be produced to substantiate a visual match.

Schove and Lowther (1957) drew attention to the subjective nature of visual matching of tree-ring patterns and quoted a powerful non-parametric statistical method for checking visual agreements. This method involves calculation of the percentage agreement, or percentage parallel variation coefficient, between two ring patterns. This is a measure of the number of years where the two ring patterns under comparison show similar increases or decreases in ring width. The statistical significance of any departure from the expected value of 50 percent can be determined. Eckstein and Bauch (1969) published a computer program which moves one ring pattern past another and calculates the percentage agreement coefficient and significance level at each position of overlap.

It was discovered that the relatively short ring patterns of between 100 and 150 years, frequently met with in studying Irish oak timbers, produced percentage agreement figures, for actual matches, within the three standard deviations expected from the normal distribution of percentage agreement figures around the 50 percent value. That is, within the limits $50 \pm 3\ (\frac{50}{\sqrt{\eta}})$ (Huber and Giertz 1970).

Thus, in the lists of percentage agreement coefficients produced in moving one pattern past another, the actual position of correlation was obscured by the normal distribution of coefficients for mis-match or random correlations. In order to accentuate the actual cross-correlation, a parametric statistical test was introduced which took account of the magnitude of the year to year variations in ring widths. A program was written which calculated the product moment correlation coefficient r between two sets of ring widths, at every position of overlap. Student's t is calculated to relate the values of r to probabilities. Details of this program can be found elsewhere (Baillie and Pilcher 1973). The significance of the values of t obtained from the actual position of cross-correlation between ring patterns was found to be several orders of magnitude greater than those established by the non-parametric percentage agreement method.

MODERN OAK CHRONOLOGY

Only one of the modern oak samples collected for initial cross-correlation and chronology building, Q.U.B. 457, did not come from an 18th or 19th century estate. Few oaks occur on unenclosed land and those in hedgerows seldom attain a mature age. The oak trees used in this study were not grown specifically for their timber, most having been grown in open stands, avenues, or light woodland. These trees had been allowed to spread and branch early as opposed to the tall straight grown timber of the original

Table 2. Results of correlation between 21 individual timbers and an initial master chronology constructed fom nine timbers of known felling dates. The length of overlap, correlation value and the date of the outer ring are listed in each case. Trees with known felling dates (not included in master chronology) are marked*.

		Q.U.B. No.	Length (Years)	*t*	Outer Ring
Pomeroy	I	65	170	8.36	1963
Springhill	I	1059	103	2.99	1868
	II	1060	151	5.84	1900
Moneymore	I *	532	83	4.00	1969
Draperstown	I	558	123	4.46	1968
Antrim	I	457	135	7.53	1969
Barnetts Pk.	I	466	178	6.11	1970
	II	467	111	7.29	1970
	III	462	108	7.28	1954
	IV	456	150	3.28	1922
Dixon Pk.	I *	531	193	5.82	1969
Cultra	I *	41	144	4.34	1967
	II *	44	120	4.71	1967
	III *	45	120	3.89	1967
Saintfield	I	1129	178	3.99	1957
	II	1128	140	3.48	1962
Castleward	I	66b	143	5.51	1966
	II	66a	143	4.70	1966
Tollymore	I	67a	208	5.08	1966
	II	67b	244	4.80	1966
	III	67c	132	2.34	1966

forests. Because of this, the oaks had not been cropped but had been felled in routine clearance or because they had become diseased or dangerous.

While collection has been conditional largely by availability of recently felled trees, the resistant nature of oak stumps has allowed trees felled within the last two decades to be sampled for study. In a number of these cases the poor condition of the sapwood has meant the loss of the outer growth rings. A total of 30 oaks have been used here and a number of others have been rejected on grounds of complacency of ring record, distortion of ring pattern, or exaggerated ring width. The distribution of sites from which oaks have been sampled is shown in Figure 1, and listed in Table 2. In collecting these samples for study it was found that, in oaks containing more than 100 growth rings, size is largely unrelated to age. This finding is in agreement with that of Jones (1960). Some of the largest specimens sampled for this study contained only 120 to 150 growth rings. It follows from this that, in attempting to find very old living trees, it is not possible to use diameter or girth as a criterion.

Of the 30 oaks studied, 14 had known felling dates. The ring patterns of the trees with known dates showed significant cross-correlations both visually and when tested statistically. On the basis of these agreements a standard chronology was constructed using the ring patterns of nine trees from two sites 110 km (70 miles) apart, Castlecoole and Shane's Castle. This group contained the oldest modern tree obtained so far, Q.U.B.

528, from Shane's Castle. The resulting standard chronology covering 322 years extended back to A.D. 1649.

Each of the 21 other samples were compared with the standard chronology. These comparisons were carried out for three reasons. Firstly, to see if significant cross-correlations could be established between individual trees of known felling dates and the standard chronology, secondly to establish the dates of the outer years of samples which were otherwise undated and thirdly, to observe the range of *t* values established, as a guide to later work.

Table 2 lists the *t* values obtained and gives the date of the outer year of each sample. The apparent age of some of the samples is accounted for by the fact that some trees exhibited bands of narrow rings or areas of physical deterioration which precluded the measuring of their total ring patterns. Trees with known felling dates are marked with an asterisk.

With the exception of Q.U.B. 67c and 1059, the *t* values obtained were all significant. This shows that a standard chronology produced from as few as nine trees contains a reliable record of the relative quality of each growing season within the area of study. Of the two samples which produced low significance levels, Q.U.B. 67c produced *t* values of 5.17 and 6.44, with its outer year at 1966, when cross-correlated with Q.U.B. 67a and 67b from the same site.

Figure 3 shows the ring patterns of four modern trees from widely differing locations within the area of study. These are plotted in semi-log format against a parametric standard chronology of all 30 trees. A non-parametric standard chronology is included for comparison. A number of signature years are marked at 1816, 1840, 1894, 1898 and 1939. Over the period from 1800 to 1970 a total of 20 years exhibit 90 percent agreement in trend between all of the trees studied.

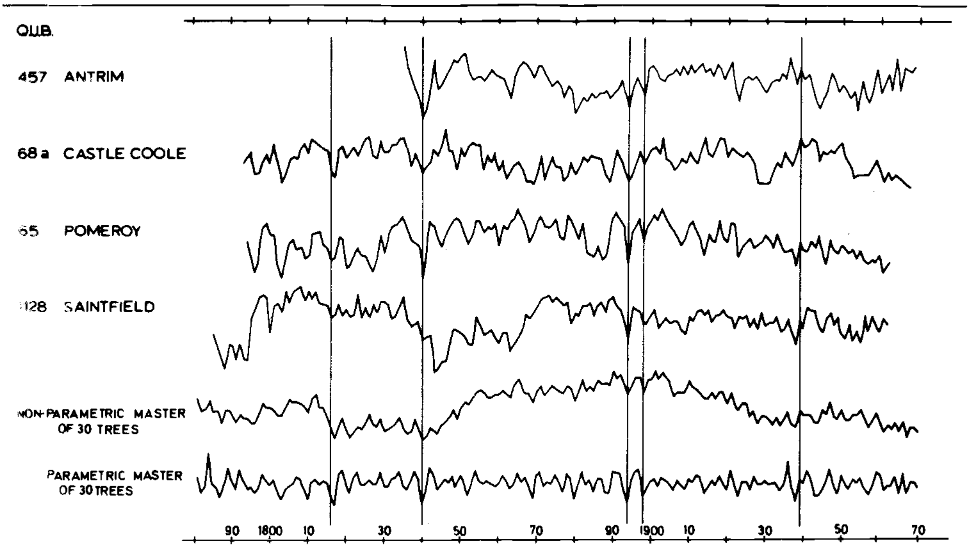

Figure 3. Ring patterns of four recently felled oaks with parametric and non-parametric master chronologies for the period 1780 to 1970. The signature years 1816, 1840, 1894, 1898, 1939 are indicated.

In the 30 samples studied and cross-correlated, no case of a missing or double ring was recorded. Confirmation of the accuracy of the oak record was obtained from Q.U.B. 68a from Castlecoole. In this sample, an extremely narrow ring follows a series of wide rings. The narrow ring can be established, on the basis of a ring count, to be 234 years before the felling date of the tree in the winter of 1968-69. This establishes the date of this narrow year as 1734. The total lack of summer wood in the ring for that year indicates a severe setback to the young tree in the early summer of 1734. Irish sources record 1734 as having been noticeable for a late and severe frost on the 15th to 17th of May (Wilde 1856). This would explain the setback to the tree's growth in that year and tends to confirm the accuracy of the ring count. Furthermore, the ring record of this tree is confirmed by the records of all of the other trees investigated.

The number of trees making up the standard chronology decreases rapidly before 1740. Only two recently felled trees have been acquired, during the period of this project, which began life before 1700. Both of these came from a stand in Shane's Castle estate which was considered by the estate manager to be natural rather than planted.

Ideally a standard chronology, for the area of study, should be made up from equal numbers of trees from sites spaced regularly throughout the area. Since on the basis of the availability of modern oak timbers this is an impossible condition to fulfill, an attempt has been made to balance the number of trees included in the standard chronology between two halves of the area of study. The reason for avoiding the use of large numbers of trees from any one site is that they could transmit localised trends into the standard chronology.

The results of this modern study show that significant correlations can be obtained between the ring patterns of oak trees growing within the area of study.

EXTENSION OF THE MODERN STANDARD CHRONOLOGY

Historic circumstances made it very unlikely that the 322 year standard chronology could be extended by the acquisition of still older living trees. In order to extend the standard chronology back in time timbers had to be obtained which had been felled some time after 1649. Due partly to the troubled nature of the 17th century in the north of Ireland, few records exist to establish the construction dates of buildings of that period. Thus it was not possible to look for timbers in buildings of known dates. This situation necessitated an approach similar to that used by Douglass with timbers from prehistoric Indian settlements. Since the dates of the settlements were unknown, he constructed a floating tree-ring chronology which he extended forward in time until eventually a cross-correlation was obtained between it and an existing standard chronology (Bannister 1963).

In 1969 a series of oak beams were removed from the floor of the Fort at Hillsborough, Co. Down (Figure 1). Historic evidence and signs of reutilisation of the timbers, pointed to the beams having possibly derived from the original 1662 building phase of an adjacent church. The Church of St. Malachy in Hillsborough had been dismantled and rebuilt on a grand scale in the mid-18th century, around the time of a recorded renovation of the Fort (Baillie 1973, 1974). The ring patterns of a number of the timbers from the Fort were cross-correlated. A table giving percentage agreement coefficients and Student's t values for these cross-correlations can be found elsewhere (Baillie and Pilcher 1973). The resulting floating chronology and some of its constituents are shown in Figure 4. An arbitrary increasing signature year was designated DATUM (arrowed in Figure 2, Hillsborough Fort sample Q.U.B. 536 is shown on the right) and the overall floating chronology designated (DATUM – 200) to (DATUM + 60).

None of the samples from the Fort exhibited sapwood. Only one, Q.U.B. 544 exhibited a heartwood-sapwood transition, the mean transition occurring at (DATUM + 45). Allowing for missing sapwood an estimated felling date for Q.U.B. 544 would fall in the range (DATUM + 77) ± 9. The historical evidence suggested that no overlap existed between the floating and standard chronologies.

In 1971, during removal of an oak roofed farmhouse from Gloverstown to the Ulster Folk Museum at Cultra, Co. Down, opportunity arose to sample a number of the structural timbers. This house although apparently belonging to either the late 17th century or the first half of the 18th century, possessed no specific building date. The timbering techniques used, butt purlins and trusses, suggested that the house might be later than the cruck built houses common in the north of Ireland in the 17th century (Gailey 1974). The timbers from the Gloverstown house showed no signs of re-use and many possessed complete sapwood. In this case, cross-correlation of their ring patterns was carried out visually using the existence of the outer growth rings as a guide. Figure 5 shows the ring patterns of eight of the Gloverstown timbers plotted together with the resultant master chronology.

High correlation values were obtained between the Gloverstown master and the Hillsborough master (Figure 5). Values for percentage agreement coefficient and Student's t of 67 percent and 5.9 respectively were obtained. Both of these indicated a very high level of significance. This cross-correlation extended the overall floating chronology forward in time to (DATUM + 136). Since on the historical evidence for

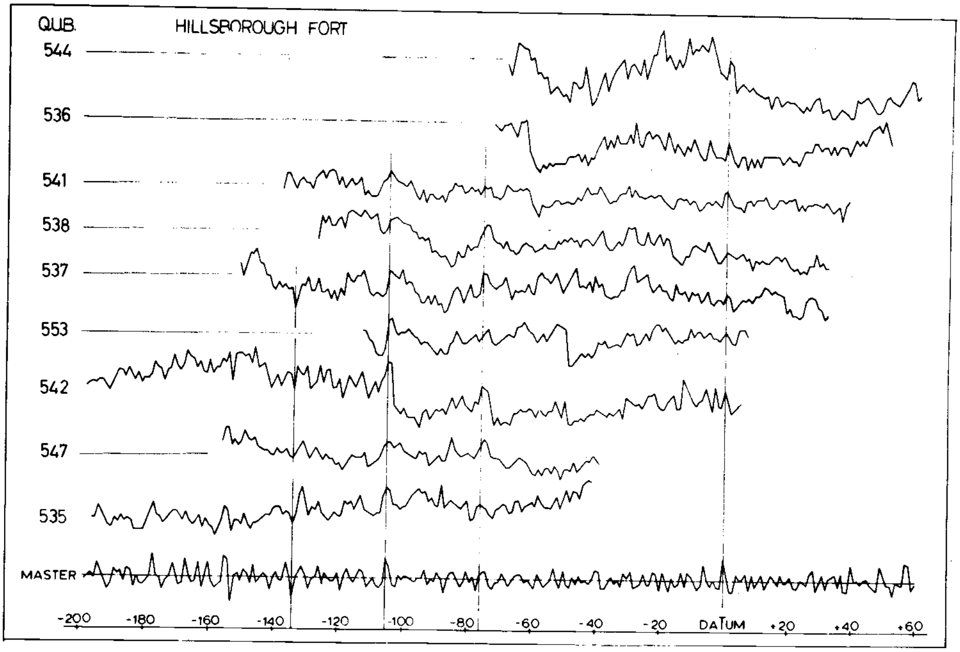

Figure 4. Ring patterns of nine timbers from Hillsborough Fort with parametric Hillsborough floating master chronology. The signature ring labelled DATUM is also shown in Figure 2.

Hillsborough Fort it could be assumed that (DATUM + 60) was no earlier than 1624 ± 9, it could equally be assumed that (DATUM + 136) was not earlier than 1698 ± 9 (Baillie 1974). According to this hypothesis, a definite period of overlap should have existed between the Gloverstown floating chronology and the modern standard chronology. A significant cross-correlation was obtained with the outer year of the floating chronology (DATUM + 136), equivalent to the calendar year 1716 (Figure 5). The correlation values for this 68 year overlap being 61 percent and $t = 3.1$ for percentage agreement coefficient and Student's t respectively.

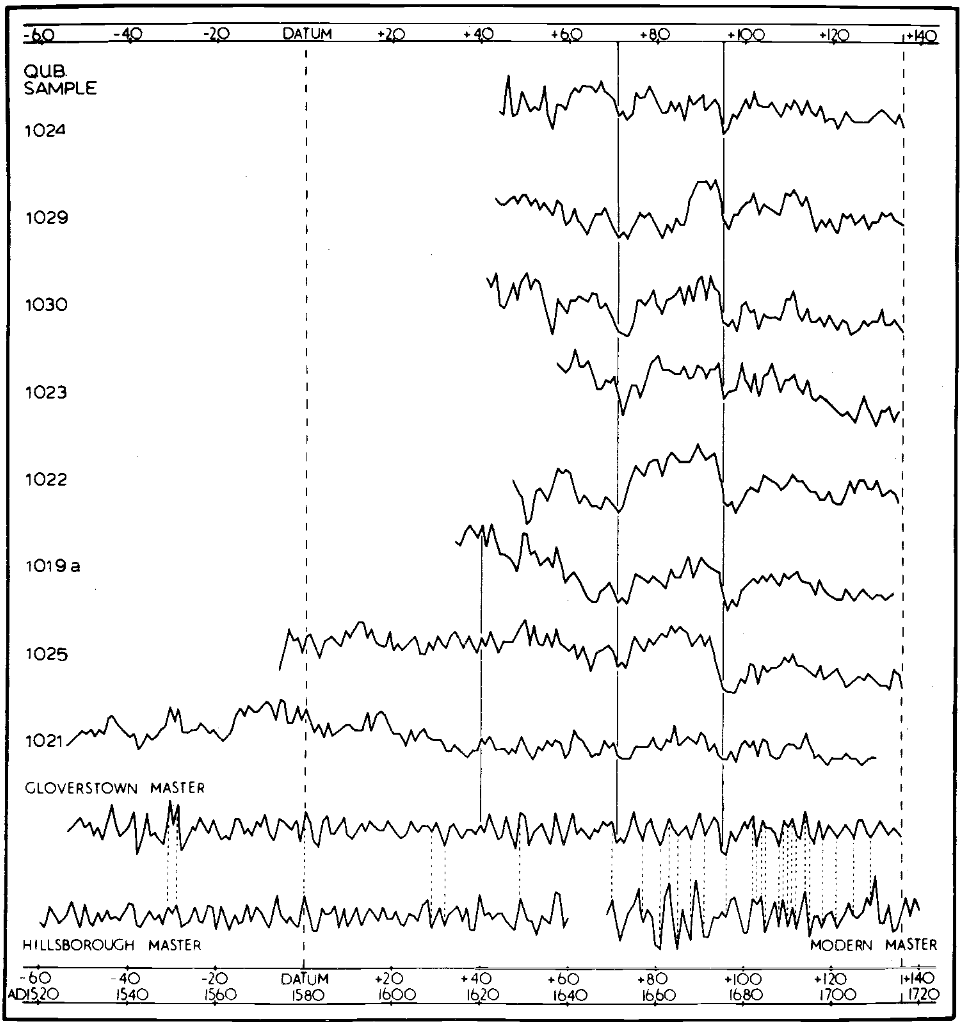

Figure 5. Ring patterns of eight timbers from Gloverstown House with the parametric Gloverstown master chronology linking the Hillsborough floating chronology and the modern standard chronology.

THE 591 YEAR BELFAST STANDARD CHRONOLOGY

Consolidation of the floating chronology established the year DATUM as the calendar year A.D. 1580. This placed the probable felling date of the Hillsborough timbers within the range 1655 ± 9, tending to confirm the Church of 1662 as the original source. In addition, the standard chronology was extended back in time to A.D. 1380. The total 591 year standard chronology is shown in Figure 6 together with the number of constituent timbers.

In the north of Ireland, valuable typological material is often found in an undated context. The primary function of the standard chronology is to elucidate some of the dating problems posed by architectural historians and archaeologists. Two examples are given below.

In 1972 a group of seven timbers was obtained from a ruinous cruck-built house at Pottagh, Co. Derry. The house was of interest on account of its position (Figure 1) and constructional technique but was completely without historical documentation. A floating master chronology was produced using the ring patterns of the timbers from the house. Comparison of this Pottagh master with the standard chronology yielded a correlation value of $t = 9.31$ with the outer sapwood year of the Pottagh timbers equivalent to the calendar year 1665.

A second group of timbers, the remains of a clinker-built boat, were obtained from the bed of the River Blackwater (Figure 1) during dredging operations in 1969. In the absence of any dating evidence, a radiocarbon determination was obtained for a sample from the keel, Q.U.B. 366. The radiocarbon age of this sample, U.B. 617, determined as 410 ± 55 B.P. or A.D. 1540 ± 55 (Smith and others 1973) suggested that dating against the standard chronology might be possible. A floating master chronology was constructed from the seven Blackwater Boat timbers. Comparison of the Blackwater master with the standard chronology yielded a correlation value of $t = 9.12$ with the outer surviving year of the Blackwater timbers equivalent to the calendar year 1661. Since none of the Blackwater samples retained either sapwood or a heartwood-sapwood transition, the boat must have been constructed from timbers felled in the range 1693 ± 9 or later.

Figure 7 shows the Pottagh and Blackwater master chronologies, with some of their constituents, plotted against the standard chronology.

CONCLUSION

The very high correlation coefficients obtained between the Pottagh and Blackwater site masters and the standard chronology shows clearly that the basic standard chronology is of immediate use in the dating of historic and other medieval and post-medieval timbers from the north of Ireland. It is hoped that in the near future an updated version of this Belfast standard chronology will be produced which will include the ring records of more than 100 trees from 30 different sites throughout the area of study.

The high degree of consistency between the master chronologies from Pottagh, Blackwater, Hillsborough and Gloverstown indicate a common response to the climatic factors influencing tree growth within the north of Ireland. For example the wide growth rings for the years 1549, 1551, 1574 and 1580 are duplicated in both Figure 4 and Figure 6. This consistency of response lends weight to the hope that in the future it may be possible to infer past climatic conditions, in the north of Ireland, from tree-ring chronologies.

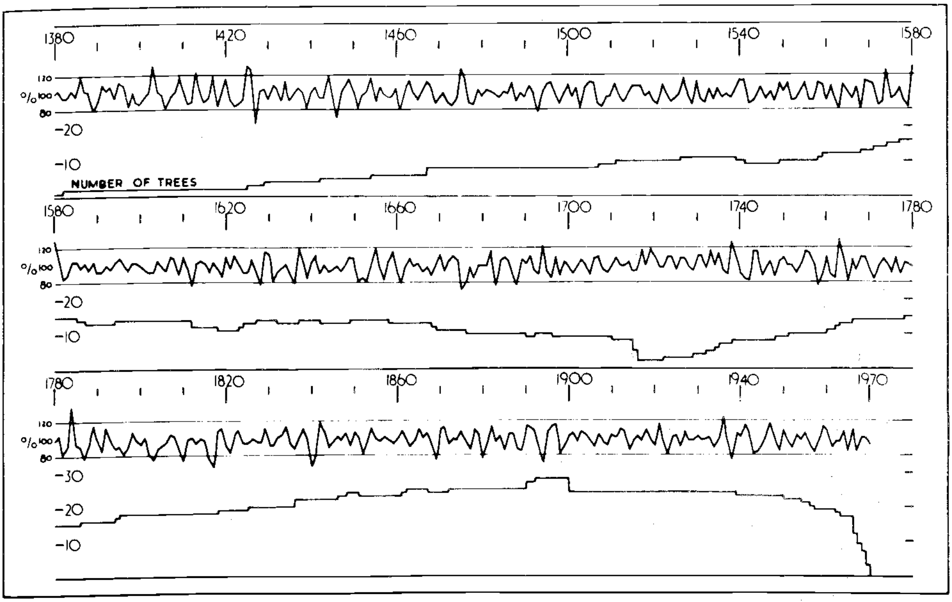

Figure 6. The 591 year Belfast standard chronology plotted in parametric form together with the number of constituent timbers.

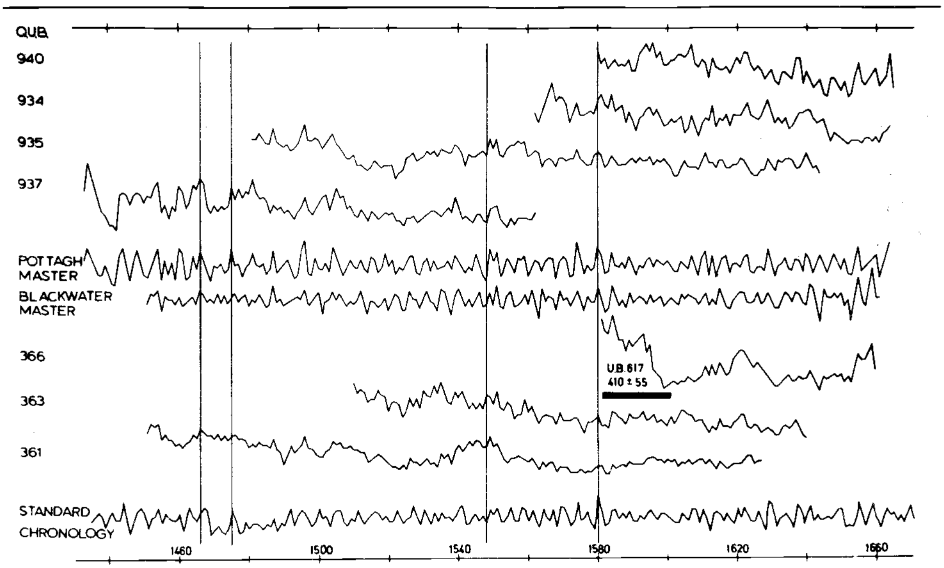

Figure 7. Ring patterns of timbers from Pottagh House and the Blackwater Boat with their respective master chronologies. Part of the 591 year standard chronology is shown for comparison.

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