THE BELFAST OAK CHRONOLOGY TO A.D. 1001

MICHAEL G. L. BAILLIE

Palaeoecology Laboratory,
The Queen's University, Belfast

ABSTRACT

The initial tree-ring chronology for the north of Ireland extended to A.D. 1380. Considerable difficulty was experienced in consolidating an extension back across the 14th century. This difficulty, partially founded on historical factors, has now been resolved and suitable timbers have been obtained to allow the presentation of the Belfast chronology to A.D. 1001.

La première chronologie du chêne obtenue dans le nord de l'Irlande, s'étendait jusqu'en 1380 A.D. La prolongation de cette chronologie au cours du 14e siècle s'est heurtée à de nombreuses difficultés, partiellement causées par des facteurs historiques; de nouvelles poutres ayant été trouvées, la chronologie dite de Belfast a pu être étendue jusqu'à 1.001 A.D.

Die Jahrringchronologie für Nord-Irland reichte anfänglich bis 1380 n.Chr. zurück. Bei der Absicherung der über das 14. Jahrhundert hinausgehenden Verlängerung traten beträchtliche Schwierigkeiten auf. Diese Situation, die teilweise auf historischen Faktoren beruht, konnte jetzt verbessert werden. Es wurden geeignete Hölzer gefunden, die den Aufbau der Belfast-Chronologie bis 1001 n.Chr. ermöglichten.

INTRODUCTION

Four years ago, an oak chronology was presented for the north of Ireland spanning the period A.D. 1380 to 1970 (Baillie 1973). At that time a number of timbers, from a natural source, had yielded a floating chronology spanning the approximate period A.D. 1000 to 1450. These oaks, dredged from the bed of the River Blackwater in 1969, were initially assumed to be sub-fossil or 'bog' oaks. Two radiocarbon determinations, UB-287 (A.D. 925 ± 60) and UB-550 (A.D. 1125 ± 35), placed these oaks in the early middle ages (Smith et al 1971, 1973). Thus they represented one of the youngest groups of naturally preserved oaks encountered during extensive studies within the north of Ireland (Pilcher 1973).

Unfortunately this proved to be a limited source of material and only one of the Blackwater trees, Q.U.B.51b, extended forward far enough in time to overlap with the Belfast A.D. 1380 to 1970 absolute chronology. The ring pattern of this tree showed a significant agreement with the Belfast chronology, $t = 3.70$, with an overlap of 83 years ending in A.D. 1462. However, since it was felt inadvisable to base a master chronology on the ring pattern of a single tree at that point, it was clear that more material was necessary to bridge the 14th century and confirm the cross agreement for the period A.D. 1380 to 1462.

Extensive searching for suitable 14th and 15th century oak timbers brought to light some interesting and worrying factors. In the north of Ireland no buildings with extant timbers survived from before A.D. 1600. Many 17th century buildings did however produce oak timbers and a consistent pattern began to emerge. The oldest of these oaks, felled in the 17th century, had all started life in the last decades of the 14th century. Historically it had always been assumed that the forests present in the north of Ireland at the time of the Plantation, in the early 17th century, were primeval; remnants of the original indigenous forests. The tree-ring evidence appeared here to be at odds with historical considerations.

If these building timbers were in fact from ancient forests it was curious that no examples exhibited ring patterns longer than 280 years, since oaks regularly reach ages of 400-500 years in natural conditions within the British Isles. The assumption had to be that the forests existing in the 17th century were the result of regeneration in the late 14th century.

Taken on its own this inference would have been no more than a possibility. However, parallel work on medieval timbers from excavations and buildings in the Dublin area began to show a similar trend. By 1973, a 450 year floating oak chronology had been developed for Dublin. On archaeological grounds, including numerous coin finds associated with levels sealing wooden structures, this floating chronology could be assigned to the approximate period A.D. 850 to 1300 (Baillie 1977a). In an attempt to extend this Dublin chronology forward in time, to join with the present day or with the existing Belfast chronology, numerous sources of later medieval timbers were investigated. This work yielded a 200 year chronology spanning the period A.D. 1357 to 1556, dated by cross agreement with the Belfast and Giertz chronologies (Baillie 1977b). It proved impossible to obtain timbers which would span the 14th century and join the two Dublin chronologies. Thus two areas in Ireland exhibited acute shortages of material for this period. Two other British Isles chronologies were known to end in the 14th century. The chronology constructed by Giertz for the England-Wales border area ended in A.D. 1341 and one using material from the Bishop's House, Sheffield, constructed by Morgan, ended in 1359 (personal communications in both cases). It appeared in the face of this accumulated evidence that it might be extremely difficult to obtain material to bridge and consolidate the 14th century.

HISTORICAL CONSIDERATIONS

An hypothesis which might help to explain a regeneration phase for oaks towards the end of the 14th century is as follows. Norman expansion within the British Isles in the 12th and 13th centuries saw exploitation of land on a large scale. The setting up of villages, moated sites, castles, and ecclesiastical estabishments, and the expansion of towns all relied heavily on oak timbers for constructional purposes. In addition this was taking place at a time reckoned to be a climatic optimum (Goudie 1977:119-29) and it is likely that the late 12th and 13th centuries saw an expansion of population and trade. Pressure was brought on existing land and more marginal land was cleared and brought under cultivation. So the use of timber on a large scale and the pressure on land could both have contributed to a decline in the existing forests.

This growth situation went rapidly into reverse from the late 13th century onwards. Exhaustion of marginal land and economic deterioration began to weaken the stretched population. This weakening was coupled almost certainly with a climatic deterioration, exemplified in England by a period of extremely wet summers in the second decade of the 14th century (Ladurie 1972:45-47). It is against this background that the Black Death takes its toll. The ravages caused by successive epidemics in the years following A.D. 1349 are widely reckoned to have reduced the already weakened population by as much as one third. This population reduction eased the pressure on land resources as survivors were enabled to fall back onto the better land. It is possible to suggest that at this time the marginal land was abandoned and allowed to return to forest.

In Ireland we appear to have a variation on this theme. Norman involvement begins when the southeast of the country is seized by Richard De Clare (Strongbow) in 1171. Subsequent expansion by Norman barons saw two thirds of the country feudalized by around 1300. Presumably during this period there were heavy calls on oak timbers and land resources. A weakening effect in Ireland was the constant fighting between Norman barons and Irish kings complicated by friction between rival barons vying for large tracts of land. Given this problem, the forward movement of the conquest of Ireland ceased in the early 14th century and rapidly went into reverse. The stiffening of Irish resistance, especially with the Scottish inspired Bruce wars, A.D. 1315 to 1318, saw the beginning of an increasingly stressed situation for the Normans. Bad harvests added to the general distress and the Norman population began to decline as people drifted back to England or assimilated Irish culture. An increasingly important problem with the Norman 'conquest' was that many barons became absentee landlords living on their other holdings in Britain or France. Thus in 1361 Edward III was complaining about 'magnates' taking the profits from Irish estates but not defending them (Beckett 1966:16-37). As a measure of the downward spiral of the 14th century, the area of English influence, by 1400, was confined to about one third of the country.

So we can see a variety of factors which might have given rise to land being allowed to return to forest in the later 14th century. This admittedly simplified picture seems to offer an explanation of the facts observed in these tree-ring studies. Two examples of how this situation affects dating attempts on medieval buildings can be found at Dunsoghley Castle., Co. Dublin, and Caerlaverock Castle, Dumfriesshire. Dunsoghley is reputedly the last medieval castle in Ireland to retain its original timber roof. Historically its building date is not clear but it is unanimously held to belong to the first half of the 15th century (DeBraffny and Mott 1977:110). Examination of the *in situ* roof trusses and coring of a truss removed during renovations showed that the timbers used came from young oaks, none of the cores yielding more than 40 rings. Although these short ring patterns could not be dated dendrochonologically, they point to the timbers having come from trees regenerating in the late 14th century.

At Caerlaverock Castle several phases of timber bridge construction were recovered from the moat during excavations (Rigold 1975). The first three phases were datable and form the subject of a future paper. The oak timbers used in these building phases, of which the latest is circa A.D. 1370, were all long lived; the average being around 200 years with one example having 420 rings. The fourth building phase, consistent on other evidence with an early 15th century date, yielded only timbers with short ring records. Although the fourth phase timbers were of similar dimensions to those used in the earlier phases, 30 to 40 cm square, the maximum length of ring pattern was only 60 years.

Clearly early 15th century buildings are not, in general, the places to search for ring patterns to bridge the 14th century in Ireland and Scotland. It is possible that similar factors may be responsible for the findings in England (above) that ring patterns of 16th and 17th century timbers end in the 14th century. In addition it would be consistent with the finding that, in a number of oak timbers from medieval and Tudor buildings in southern England the number of annual rings rarely exceeded 100 (Fletcher et al 1974). This would be expected in 15th and early 16th century building timbers if there was a depletion in forests in the 14th century.

CONSOLIDATION OF THE BELFAST MASTER CHRONOLOGY

The history of Ulster in the early medieval period has all the features of the Norman conquest outlined above. In 1177 John De Courcy and his followers overthrew the combined forces of the northern kings and laid claim to the whole northern province (Ulster). Beckett (1966) states that neither De Courcy nor his successors extended their power west of Lough Neagh (Figure 1). Ultimately, after 1333 De Courcy's successors, the De Burghs, were to lose most of the north to the Irish O'Neills and O'Dohertys. This date again conforms to the idea of the Norman conquest falling apart in the 14th century.

Here we have a likely reason for the 17th century timbers from the east of Ulster being due to late 14th century regeneration. However, the important point is that the area to the west was always in Irish hands. In this area few medieval buildings remain — none at all with extant timbers — instead we have a group of crannogs — artificial islands or lake dwellings — often built or refurbished in the 15th or 16th centuries. These crannogs occur in areas where the regeneration model need not apply, because of the lack of Norman exploitation (Figure 1).

Between 1969 and 1976 several crannogs were visited when water levels were low. A few were found to have accessible structural timbers preserved by virtue of their waterlogged condition. Ring patterns covering the 15th century were obtained, but only one timber Q.U.B. 968 from Lough Eyes, Co. Fermanagh, covered part of the 14th century. In 1977 however, an extensive programme was undertaken by members of the Archaeological Survey Section of the Department of Environment for Northern Ireland. This survey involved visiting over 100 crannog sites in Co. Fermanagh and since the establishment of construction dates constituted one of the major aims of the programme, dendrochronologists were involved from the beginning. In the course of this cooperative work some of the sites with accessible timbers were visited in the late summer of 1977 and samples removed for dating. One of these sites, Corban Lough, provided a series of oak timbers felled in the mid 15th century. These timbers provided ring patterns which spanned the 14th century and confirmed the Blackwater-Belfast crossdating (Figure 2). The Corban Lough timber which yielded the longest overlap with the Belfast 1380 to 1970 chronology was Q.U.B. 3017, the t value being 3.69 for an overlap of 77 years. Both Q.U.B. 51b and Q.U.B. 3017 were tested against the Belfast chronology at every position of overlap and no other significant cross correlations were found. In addition, the cross agreement both visually and statistically ($t = 4.7$) between these two samples was highly significant at the position specified by the individual agreements with the 1380 to 1970 chronology.

A further 'natural' timber, Q.U.B. 942, originally thought to be bog oak, from Toomebridge, Co. Antrim had been dated by radiocarbon to the medieval period (UB 993, 405 ± 40 B.P., Pearson unpublished). This timber also confirmed the Belfast extension. However, simultaneously with the Corban Lough find, a further series of Toomebridge timbers was obtained. This group yielded a 270 year chronology which cross matched with the A.D. 1380 to 1970 chronology and spanned the years A.D. 1231 to 1500. This cross agreement is shown in Figure 2 and the respective statistical correlations are listed in Table 1.

On the basis of this corroborative evidence an extended Belfast chronology was

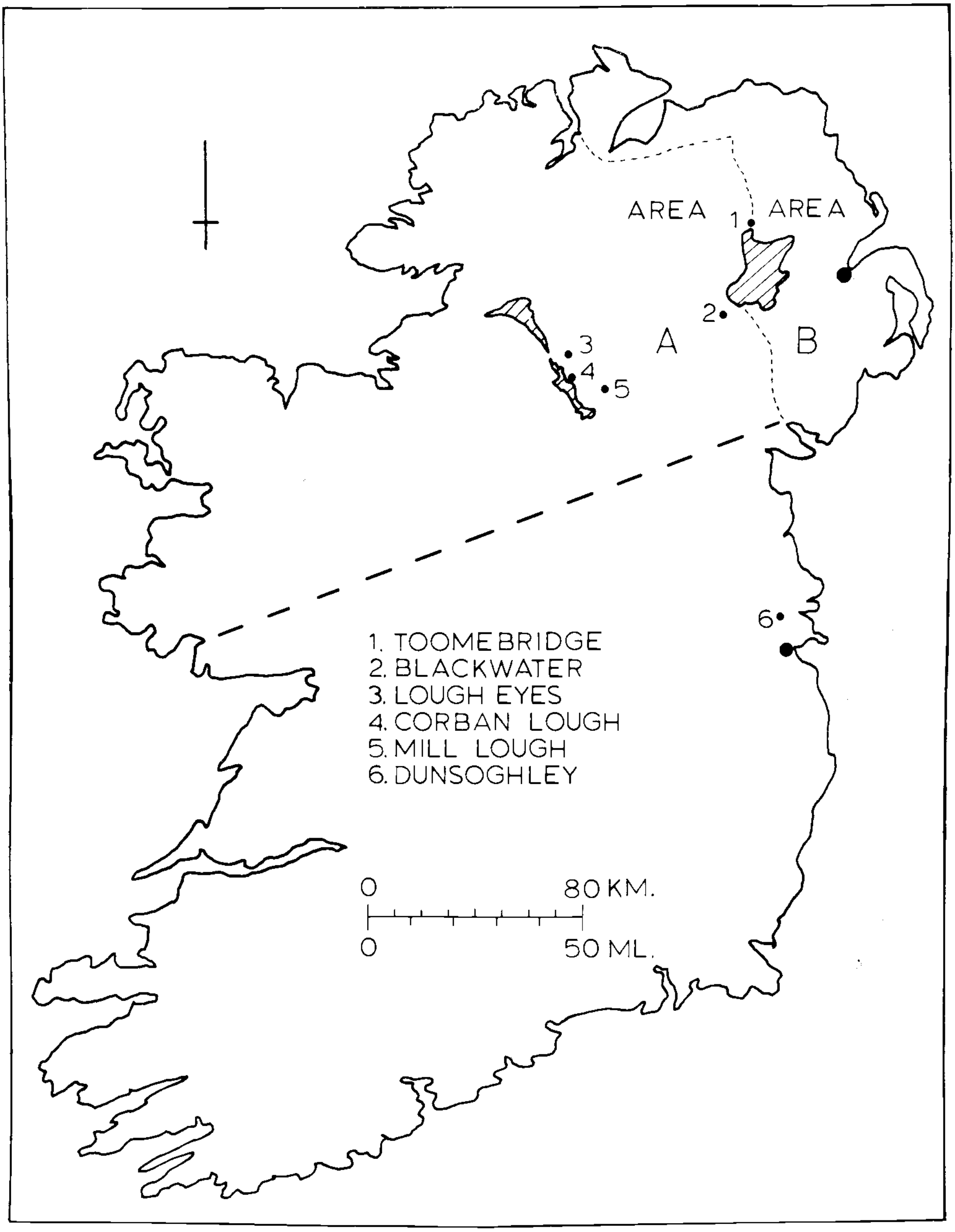

Figure 1. Ireland showing *Area A*, the northwest region least affected by the Norman Conquest; *Area B*, the Anglo-Norman Earldom of Ulster; and, the sources of timber.

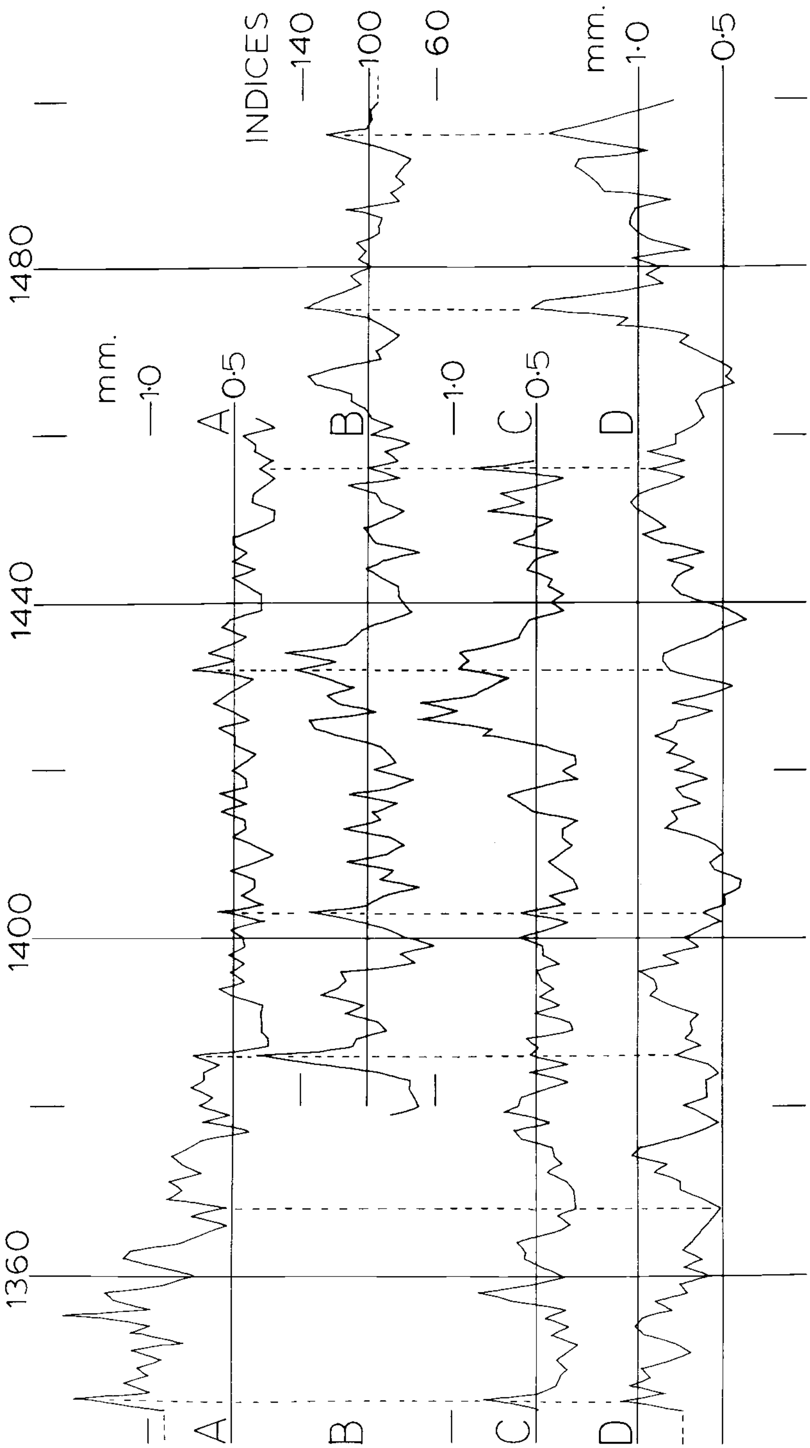

Figure 2. Overlap between *A*, Blackwater timber Q.U.B. 51b; *B*, Belfast index chronology A.D. 1380-1970; *C*, Corban Lough timber Q.U.B. 3017; and *D*, the Toomebridge mean chronology A.D. 1231-1500.

Table 1. Statistical comparison of the ring patterns.

Comparison	*t* Value	Years overlap
B cf A	3.7	83
B cf C	3.7	77
B cf D	5.2	121
A cf C	4.7	124
A cf D	5.0	129
C cf D	4.8	132

A = Blackwater Q.U.B. 51b
B = Belfast A.D. 1380-1970 index chronology
C = Corban Lough Q.U.B. 3017
D = Toomebridge mean chronology

constructed using ring patterns from the Blackwater River, crannogs in Lough Eyes, Mill Lough and Corban Lough and natural timbers from Toomebridge. The extended Belfast chronology covers the period A.D. 1001 to 1970.

Choice of Index Format

The majority of European master chronologies have been produced by meaning accumulated data. This procedure appears to beg questions regarding the averaging of ring patterns derived from wide and narrow ringed timbers and in particular the meaning of the wide rings towards the centre of one tree with the relatively narrow outer rings of another. An obvious solution is to convert ring widths to yearly indices by fitting some type of regression line to the overall ring pattern and dividing the ring widths by the yearly values of the fitted curve. The original Belfast chronology (Baillie 1973) was constructed using a running mean technique which converted each ring width to a percentage of the average of five rings. These percentage average indices retain all of the high frequency information while removing all trends. The resulting indices could be meaned directly since they were strictly comparable. From the point of view of computer dating, index masters of this type were ideal since it is the high frequency information which is being matched. However, the removal of short and medium term trends reduced the usefulness of this type of master for visual matching.

The optimum tree-ring chronology would be one which contained realistic year to year, short, medium, and long term trends. In theory the mean chronology probably comes closest to this ideal but only when large numbers of individual ring patterns are available. Even then, the presence of regeneration phases, for example, as discussed above, can introduce unacceptable 'steps' into the chronology unless data are arbitrarily removed. In practice the Tucson INDXA package comes as close to producing meaningful master chronologies as anything likely to be available in the near future. INDXA offers a choice of curve fits to the raw ring pattern and produces indices with meaningful year to year, short and medium term trends (Fritts et al 1969). As with any indexing procedure long term trends are removed. A fundamental question in dendrochronology is whether or not meaningful long trends can be deduced from data made up of relatively short ring patterns.

The advantage of INDXA produced master chronologies is that they are instantly comparable. Trends are real and are not due to factors such as tree age or regeneration cycles. The extended Belfast index chronology is listed in Table 2.

Notes on the Data Used

All of the data used in the Belfast chronology conform to the following format. Ring widths were measured to accuracies of .05 mm using a travelling stage and binocular microscope, similar in basic design to the Bannister Incremental Measuring Device. The total ring width was measured in all cases, that is, the ring width for a year is the radial distance from the beginning of the spring vessels of that year to the beginning of the spring vessels of the following year. For visual comparisons the ring widths were plotted directly, that is, raw ring widths against a scale in years. All cross matches are visual and are backed up by significant *t* values calculated using the Belfast CROS program (Baillie and Pilcher 1973). No other criteria have been used for the establishment of cross agreements. In addition, only complete ring patterns have been used in the production of the master chronology. In this respect one is forced to agree with Barefoot (1975) when he condemns the artibrary exclusion of segments of tree-ring pattern "thought" to be atypical. Thus, in order to obtain an optimum amount of information from a ring pattern and to produce a meaningful master there seems little alternative to conversion of raw ring widths to indices (see above).

All of the evidence from the area of study, including cross agreements between individual ring patterns and between site chronologies, suggests that in the north of Ireland we are dealing with a single tree-ring area for which there exists only a single "true" master chronology. Obviously there is a percentage of material whose ring patterns do not cross match with the majority. This could be due to importation, distortion, or extreme site conditions. However, no evidence exists to suggest that there is any internal consistency within these 'rare' ring patterns. This is quite different from Fletcher's finding of Type A, Type B, and possibly other recognisable patterns from southern and eastern England in the period A.D. 1200 to 1600 (Fletcher 1977). Further, the Belfast chronology stands in its own right as totally independent of any other dendrochronological work. It was constructed using the basic principles of dendrochronology and relies on no other considerations excepting cross agreements between ring patterns. It is thus independent of historical information and so can ultimately be used to confirm or disprove documentary dates. In this respect it was the first long absolute chronology to be completed in the British Isles.

CONCLUSION

This absolute Belfast chronology forms the second major building block on the way towards a 6000 year chronology for the north of Ireland. A long, 2990 year, floating chronology has already been published by Pilcher et al (1977). This long chronology covers the approximate period 1000 to 4000 B.C. and has already gone some way towards resolving problems in the calibration of the radiocarbon timescale (Pearson et al 1977). Between these two chronologies, that is between 1000 B.C. and 1000 A.D., two further floating chronologies, of 700 and 800 years respectively, are already in existence. The quest to fill the three remaining 'gaps' is of high priority. However it has to be recognized that 'natural' depletions, similar to the humanly induced example outlined above for the 14th century, may have occurred during the last 6000 years and consolidation of these gaps with material from the north or Ireland alone may prove difficult. Other work at Belfast, on correlations between chronologies from different geographical areas, lends hope that it may be possible to use ring patterns from other areas within the British Isles to bridge these gaps once suitable chronologies are available (Baillie 1978).

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Table 2. Belfast oak master index chronology.

	Tree Ring Indices										Number of Samples									
Date	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1001		170	99	117	93	74	51	41	49	49		1	2	2	2	2	2	2	2	2
1010	60	66	52	40	70	71	85	102	85	89	2	3	3	3	3	3	3	3	3	3
1020	73	122	116	158	134	112	130	121	104	86	3	3	3	3	3	3	3	3	3	3
1030	80	78	97	99	122	140	137	136	118	136	3	3	3	3	3	3	3	3	3	3
1040	158	140	177	159	195	154	144	132	142	115	3	4	4	4	4	4	4	4	4	4
1050	90	112	107	104	94	106	102	85	114	80	4	4	4	4	4	4	4	4	4	4
1060	112	83	64	69	76	67	85	89	101	78	4	4	4	4	4	4	4	4	4	4
1070	108	84	71	81	79	95	84	78	93	107	5	5	5	5	5	5	5	5	5	5
1080	71	65	75	79	93	151	133	126	127	117	5	5	5	5	5	5	5	5	5	5
1090	97	83	89	126	113	98	67	82	78	89	5	5	5	5	5	5	5	5	5	5
1100	91	63	98	104	87	105	106	86	102	104	5	5	6	6	6	6	6	6	6	6
1110	98	95	76	69	84	105	127	125	113	89	6	6	6	6	6	6	6	7	7	7
1120	101	116	101	119	83	110	91	107	112	102	7	7	7	7	7	7	8	8	8	8
1130	128	119	109	113	114	111	97	107	127	160	8	8	8	7	7	7	7	7	8	9
1140	150	150	122	120	78	90	96	89	82	94	9	9	9	9	9	9	9	9	9	9
1150	104	83	83	90	84	82	88	84	80	88	9	9	9	9	9	9	9	9	9	9
1160	85	75	70	72	75	71	59	79	73	71	9	9	9	9	9	9	9	9	9	9
1170	73	69	71	73	66	77	74	76	83	99	9	9	9	9	9	9	9	9	9	9
1180	94	84	96	93	84	80	89	89	94	131	9	9	9	9	9	9	9	9	9	9
1190	152	132	173	160	198	201	147	99	96	82	9	9	9	9	9	9	9	9	10	10
1200	108	114	113	87	57	73	77	72	70	88	10	10	11	11	11	11	11	11	11	11
1210	115	117	116	106	116	98	101	116	108	94	11	11	11	11	11	11	11	12	12	12
1220	93	110	92	74	105	101	99	106	104	112	12	12	12	12	12	12	12	12	13	13
1230	124	105	87	91	93	130	106	110	93	117	13	13	13	13	13	13	13	13	13	13
1240	93	85	100	124	101	85	80	92	90	84	13	13	13	12	12	11	11	11	11	11
1250	81	116	86	71	72	96	102	105	93	116	11	11	11	11	10	10	10	11	11	11
1260	128	123	129	93	104	102	86	102	125	133	11	11	11	11	12	12	12	12	12	12
1270	107	118	92	105	80	76	81	73	90	76	12	12	12	12	12	12	12	12	12	12
1280	99	101	102	95	102	113	114	83	99	103	12	12	12	12	12	12	12	12	12	12
1290	117	84	110	112	102	93	93	103	88	90	12	12	12	12	12	12	12	12	12	12
1300	76	102	135	116	104	100	127	98	104	114	12	12	11	11	11	11	10	10	10	10
1310	110	114	105	117	97	107	110	98	108	78	10	10	9	9	10	10	10	9	9	9
1320	89	99	88	95	78	87	89	89	112	98	9	9	8	8	8	8	9	9	9	9
1330	109	88	90	93	69	100	71	90	110	120	9	9	9	9	9	9	9	9	9	9
1340	109	99	117	97	74	115	82	104	103	111	9	9	9	9	8	8	8	8	8	8

Table 2 (continued)

	Tree Ring Indices										Number of Samples									
Date	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1350	91	92	67	120	106	127	101	129	124	115	8	8	8	7	7	7	7	7	7	7
1360	73	105	97	102	108	89	89	111	79	95	7	7	7	8	8	8	8	8	8	8
1370	92	92	96	94	111	115	110	88	91	105	8	8	8	8	9	9	9	9	10	10
1380	106	92	85	75	91	81	109	101	108	89	11	11	11	12	12	12	12	12	12	12
1390	81	105	91	128	110	122	132	95	114	101	13	13	13	13	13	14	14	14	14	14
1400	117	94	82	95	75	84	72	68	76	83	13	14	14	14	14	14	14	14	14	14
1410	74	77	94	108	93	96	94	111	98	85	14	14	14	14	14	14	14	14	14	14
1420	124	96	105	112	114	122	131	105	126	127	14	14	14	14	14	14	14	14	13	13
1430	106	105	135	124	152	125	118	110	102	89	13	13	13	13	13	12	11	11	11	10
1440	77	81	80	93	101	91	67	94	100	102	11	11	12	12	12	12	12	12	12	12
1450	90	79	90	95	111	80	101	82	90	76	13	14	14	16	17	17	17	17	17	17
1460	96	86	98	101	110	109	132	135	117	93	17	17	18	18	19	19	19	21	22	22
1470	94	90	81	89	100	139	129	113	103	109	23	23	23	23	23	23	23	23	23	24
1480	98	105	102	105	93	94	93	112	80	84	24	25	26	27	27	27	27	27	27	27
1490	78	82	79	73	83	102	124	100	99	99	27	28	28	29	29	29	29	29	29	31
1500	95	92	105	98	126	126	122	99	94	100	32	33	33	33	34	34	34	35	35	35
1510	96	102	98	87	83	99	104	103	106	98	36	37	37	38	38	39	39	40	40	40
1520	76	83	83	82	77	86	98	99	92	86	40	40	40	40	40	40	41	41	40	40
1530	94	103	92	108	97	117	114	112	98	117	40	40	40	40	40	40	40	39	39	39
1540	122	115	90	95	89	102	104	97	98	136	38	39	38	38	38	38	38	38	38	39
1550	119	144	104	104	106	119	102	106	115	125	39	39	39	39	39	39	38	38	39	40
1560	94	98	92	76	103	91	94	112	90	119	40	40	41	40	40	40	40	40	41	41
1570	111	112	95	88	116	93	83	93	88	88	41	42	42	42	40	40	40	41	41	42
1580	122	102	82	83	109	106	95	95	82	98	42	42	43	42	42	42	41	41	39	39
1590	85	87	94	99	115	123	111	106	98	89	39	38	37	37	38	38	37	37	37	35
1600	83	74	76	72	98	88	100	110	101	80	34	34	34	34	34	34	34	34	34	34
1610	94	91	73	92	88	98	97	97	101	103	34	34	34	33	32	32	32	32	32	30
1620	121	128	134	124	104	96	103	101	92	122	30	29	29	30	31	31	30	30	29	28
1630	112	88	94	96	99	99	96	128	125	106	27	27	27	26	26	26	26	27	27	27
1640	118	125	105	95	87	91	87	86	88	91	27	25	25	25	25	24	24	24	24	25
1650	91	69	64	74	96	120	98	90	110	120	25	25	23	23	21	21	21	20	19	18
1660	109	86	103	113	111	109	92	100	99	118	18	18	16	16	16	15	14	14	14	13
1670	123	110	116	126	110	80	76	88	85	98	12	12	12	12	12	12	12	11	11	11
1680	96	85	110	78	105	91	91	88	77	99	11	11	11	11	11	11	11	11	9	9
1690	95	113	90	95	130	100	91	106	91	100	9	9	10	9	9	9	9	8	8	8

Table 2 (continued)

	Tree Ring Indices										Number of Samples									
Date	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1700	94	90	108	115	119	100	116	119	106	106	8	8	8	8	8	8	8	8	8	8
1710	111	111	101	108	82	82	94	118	120	122	8	7	7	7	7	6	3	2	2	2
1720	134	121	99	162	147	93	96	95	75	99	2	2	2	3	3	3	3	3	4	4
1730	96	84	72	75	70	72	61	55	94	84	4	4	5	5	7	7	7	7	7	7
1740	66	67	69	118	109	73	80	102	98	129	8	8	8	8	8	9	9	9	9	9
1750	115	121	121	102	118	132	117	90	86	87	10	10	10	10	10	10	10	10	10	11
1760	98	98	103	143	113	90	117	95	115	107	11	12	12	12	12	12	14	14	14	14
1770	96	83	102	97	102	84	100	88	106	109	14	14	14	14	14	14	14	15	15	15
1780	95	105	85	93	116	101	97	66	99	104	15	15	15	15	15	16	16	16	16	16
1790	86	77	103	76	77	93	81	94	124	118	16	16	16	17	18	18	18	18	18	18
1800	96	101	75	63	79	99	108	114	111	93	18	18	18	18	18	18	18	18	18	18
1810	80	116	121	102	99	94	71	59	106	112	18	18	18	18	18	18	18	18	19	19
1820	88	75	91	96	81	96	98	101	98	129	19	19	19	19	20	20	20	20	20	20
1830	101	108	121	122	144	133	108	100	120	96	20	20	20	20	19	20	20	20	20	20
1840	57	73	100	88	73	94	108	105	120	102	20	20	19	19	19	19	21	22	22	22
1850	119	102	91	106	116	110	102	98	99	102	22	22	22	22	22	22	22	22	22	22
1860	94	116	103	88	100	117	102	98	94	80	23	23	23	23	23	23	23	23	23	23
1870	107	123	96	105	97	111	100	81	97	88	23	23	23	23	23	23	23	23	23	23
1880	68	84	105	90	97	80	99	91	86	91	23	23	23	23	23	23	23	24	24	24
1890	128	123	119	93	70	109	120	123	82	98	24	24	23	23	23	23	23	23	23	22
1900	109	111	97	118	109	97	86	93	91	89	21	20	20	20	20	20	20	20	20	20
1910	111	110	121	118	101	101	110	112	129	114	20	20	20	20	20	20	20	20	20	20
1920	111	132	108	86	98	100	84	100	85	88	20	20	20	20	20	20	20	20	20	20
1930	86	82	89	90	80	101	120	90	78	112	20	20	20	20	20	20	20	20	20	20
1940	102	117	98	81	77	94	106	136	107	99	20	20	20	19	19	19	19	19	18	18
1950	126	109	102	108	95	94	81	77	85	100	18	18	18	18	18	17	17	17	16	16
1960	103	80	88	76	95	81	109	92	104	109	16	16	16	15	14	13	13	10	7	5
1970	111										2									