SIX MODERN OAK CHRONOLOGIES FROM IRELAND

JON R. PILCHER and MICHAEL G. L. BAILLIE

Palaeoecology Centre, Queen's University of Belfast,
Northern Ireland.

ABSTRACT

Six modern oak tree-ring chronologies from Ireland are presented. All are from planted or from disturbed-natural woodland of *Quercus petrea*. The final chronologies were tested for climate content by the response function method. The results range from 5% to 52% of the chronology variance explained by temperature and precipitation of a 14 month period during and prior to the growing periods. The relationship between these figures and the site and chronology details are examined. The relationship of the individual chronologies to each other is examined and the hypothesis put forward that Ireland can be considered as a single tree-ring area from a dating viewpoint.

Six chronologies éstablies sur des chênes modernes croissant en Irlande sont présentées. Toutes proviennent de forêts de Quercus petrea plantées, ou de forêts naturelles mais perturbées. Le contenu climatique des chronologies finales a été testé par la méthode des fonctions de réponse. Les résultats montrent que 5% à 52% de la variance de la chronologie est expliquée par les températures et les précipitations d'une période de 14 mois couvrant et précédant la saison de végétation. Les relations entre ces résultats et les détails concernant le site et la chronologie sont examinées de même que les relations entre chronologies individuelles. L'hypothèse est émise que du point de vue de la datation, l'Irlande peut être considérée comme une région unique.

Es werden sechs Chronologien aus rezenten Eichen (Quercus petraea) in Irland dargestellt. Sie stammen von Anpflanzungen sowie von gestörten, natürlichen Waldgebieten. Die Chronologien wurden mit Hilfe des Response-function-Verfahrens auf ihren Klimagehalt geprüft. Zwischen 5 und 52% der Varianz in den Chronologien können durch Temperatur und Niederschlag einer Periode von 14 Monaten vor und während der Vegetationszeit erklärt werden. Der Zusammenhang zwischen diesen Beträgen und einigen Standorts- und Chronologieparametern wird geprüft. Die Beziehung zwischen den einzelenen Chronologien führt zu der Annahme, daß Irland vom Datierungsstandpunkt aus als einheitliches Jahrringgebiet betrachtet werden kann.

INTRODUCTION

We present here six tree-ring chronologies from living stands of *Quercus petrea* from Ireland. The sites were selected as far as possible to be more than 80 km and less than 160 km apart. Site details are given in Table 1. Within this broad limitation oak woodland was sought and sampled by increment corer. The cores were measured and crossdated and the measurements converted to indices (Fritts 1976), using a polynomial curve fit. The indices of the individual cores were averaged to form the final site chronologies. None of the sites extends to before A.D. 1800 and the only previously published modern site chronology, Rostrevor (Pilcher 1976) extends to only A.D. 1750. While individual trees in large estates may be considerably older than this, there is no really old oak woodland in Ireland equivalent to the relict forests in Scotland (Baillie 1977) and England.

The chronologies were constructed for two purposes; firstly as part of a pilot study to examine the climate responses of oaks in the British Isles and secondly to examine, using modern trees, the size of the area over which good crossdating could be expected for archaeological dating chronologies.

Table 1. Sampling details for six modern Irish oak chronologies.

SITE	LATITUDE	LONGITUDE	ALTITUDE	NO OF CORES	SITE TYPE
Ardara	54°45'N	8°23'W	30 m	11	Small group of planted trees
Killarney	52°00'N	9°33'W	30 m	18	Open natural oak woodland
Lough Doon	52°50'N	8°40'W	30 m	12	Scattered trees near lake
Eniscorthy	52°50'N	6°32'W	30 m	13	Planted oaks on steep west facing slope
Glen of Downs	53°08'N	6°05'W	100 m	13	? natural oak woodland on steep east facing slope
Cappoquin	52°08'N	7°54'W	150 m	14	Oak woodland on steep east facing slope

CHRONOLOGY STATISTICS

Table 2 lists the statistics of the chronologies, and includes the previously published site of Rostrevor (Pilcher 1976). An average figure for the more useful descriptive statistics is given at the base of the table together with the averages for western and eastern United States given by DeWitt and Ames (1978). The mean sensitivity and standard deviation of the Irish chronologies are very similar to those of the eastern United States sites, but the serial correlation is higher. However, the percent common variance in the chronology is in general higher in the Irish than eastern U.S.A. sites. The mean value of about 37% is between the means of 29% and 60% for eastern and western United States respectively. DeWitt and Ames (1978) show that the low percent common variance effects the desirable level of sampling. The value of 'signal-to-noise ratio' has recently been used as a measure of chronology quality. This is derived from the percent common variance and the number of trees in the chronology. The figure of 15:1 commonly associated with the better western United States arid site chronologies is taken as a desirable target. DeWitt and Ames show that for the eastern United States some 35-40 trees would have to be sampled to reach this value. For most of the Irish sites 25 trees would be adquate. However none of the chronologies presented here reaches this target. The actual signal-to-noise ratios are given in Table 2.

CLIMATE CONTENT OF THE CHRONOLOGIES

In theory the common variance in the chronology should be a measure of the climate signal. It is used in this way by DeWitt and Ames. However the percent variance attributable to climate as calculated by the response function method is often very different from the common variance. The two most likely reasons for this are firstly that the climate data used for the response function does not relate closely to that experienced by the trees and secondly that there is a significant amount of common, non-climatic variance in the chronology. The latter will always be a potential problem in populated areas of the world where forests or woodlands may be affected by forestry practices such as selective thinning. The former problem simply means that the chronology contains useful climate information but that we can't model it directly as we have no local climate data. This does not mean that the chronology will be no use for climate reconstruction. In devising a grid of chronologies for climate reconstruction it would be valuable to be able to distinguish between these two scenarios. In the present case both Glen of the Downs and Cappoquin have what might be classed as reasonable chronologies (average standard deviations, mean sensitivity and serial correlation and over 35% common variance) and yet they have 5 and 7% variance attributable to climate in the response functions. The only common site factor between the two is that they are both steep east facing slopes, perhaps with a significantly different micro-climate from the climate recording stations used. Until a better method of assessing the climate potential of chronologies can be devised sites such as Glen of the Downs and Cappoquin will not be used in climate reconstruction grids.

CROSS CORRELATIONS AND IMPLICATIONS FOR ARCHAEOLOGICAL DATING

The areal extent of a usable dating chronology is not a thing that can be predicted

Table 2. Chronology statistics for six modern Irish oak chronologies.

										ANALYSIS OF VARIANCE							
										RAW DATA		INDICES					
Site	No. of trees	Start year	Start yr. for 10 cores	End year	Number of years	Mean width (mm)	Standard deviation	Mean sensitivity	Serial correlation	% Var. Y	% Var. YT	% Var. Y	% Var. YT	Mean R bet. trees	Mean R with chron.	% var. with climate	Signal-to-noise
ROSTREVOR	18	1750	1757	1975	226	1.0	0.30	0.22	0.56	44.3	55.7	41.8	58.2	0.53		64	12.9
ARDARA	11	1803	1917	1978	129	1.58	0.28	0.21	0.62	34.4	65.6	39.1	60.9	0.49	0.70	22	7.07
KILLARNEY	18	1809	1852	1976	170	1.56	0.24	0.19	0.49	37.4	62.6	29.0	71.0	0.37	0.61	36	7.35
LOUGH DOON	12	1850	1892	1978	129	1.68	0.20	0.14	0.57	20.0	80.0	25.1	74.9	0.27	0.53	22	4.36
ENISCORTHY	13	1811	1861	1978	168	1.34	0.24	0.18	0.56	41.2	58.8	49.1	50.9	0.53	0.73	52	12.55
GLEN OF DOWNS	13	1809	1845	1978	170	0.96	0.32	0.21	0.68	42.3	57.7	39.0	61.0	0.46	0.68	5	8.33
CAPPOQUIN	14	1820	1852	1979	166	1.38	0.25	0.17	0.60	39.7	60.3	36.9	63.1	0.41	0.65	7	8.17
MEAN Ireland					165	1.37	0.255	0.18	0.59	37.0	63.0	37.1	62.9	0.44	0.65	24	8.7
MEAN Eastern U.S.A.							0.238	0.175	0.496			28.7					
MEAN Western U.S.A.							0.380	0.365	0.415			60.0					

Table 3. Students *t* values for cross correlations between seven modern Irish oak chronologies using a high-pass filter. Upper right of matrix gives distance apart in kilometers.

	ROSTREVOR	ARDARA	KILLARNEY	GLEN OF DOWNS	ENISCORTHY	CAPPOQUIN	LOUGH DOON
ROSTREVOR		158	320	105	180	240	215
ARDARA	2.48		315	235	280	290	224
KILLARNEY	5.46	4.46		260	205	115	108
GLEN OF DOWNS	3.18	2.41	3.07		80	155	165
ENISCORTHY	5.39	1.34	6.91	1.34		95	140
CAPPOQUIN	1.42	3.17	3.76	4.23	4.35		85
LOUGH DOON	5.41	7.31	7.10	2.73	4.81	3.04	
MEAN	3.89	3.53	5.13	2.83	4.02	3.09	5.07

or derived theoretically. One can start from a small area and gradually expand until the dating quality forces a halt, or as was found in Germany, some natural barrier such as a mountain range causes a natural break between dating areas. In Ireland the initial dendrochronological effort concentrated on a small area roughly within 80 km (50 miles) of Lough Neagh (Baillie 1973). More recently, crossdating has been established for the prehistoric period between sites throughout Ireland (Baillie 1980). The construction of the modern chronologies presented here gave the opportunity to examine crossdating between widely spaced site chronologies. Table 3 gives the cross correlations expressed of students *t* between all pairs of chronologies and their distances apart in kilometers. The correlations have been calculated using a high pass filter using the Baillie and Pilcher (1973) computer program. This gives a value for crossdating similar to the visual crossdating assessment based on the highest frequencies only. This is what would be used in an archaeological dating context. The most significant thing to emerge is that there appears to be no relationship between distance and correlation. Thus we could postulate that from a tree-ring dating point of view Ireland is a single unit for which a single chronology should be valid. On the other hand the results also suggest that there are considerable site differences that could make the dating of individual archaeological sites difficult. To pursue this idea further two other sets of correlations were performed (Table 4). Firstly each of the six sites against a mean of all six, i.e. an 'all-Ireland chronology', and secondly against the original North of Ireland composite chronology published by Baillie (1973). From this it can be that all individual sites would crossdate well with an area master (of ca. 100 trees) and also with the composite multi-site master (with only 30 trees). The implication for building dating chronologies in a new area is that the effort would be better spent on getting a scatter of trees from throughout the area than on working up a single site chronology.

Table 4. Students *t* values for cross correlations between site chronologies and the composite chronology formed from all sites as well as with the Belfast chronology.

	MODERN COMBINED MASTER	BELFAST CHRONOLOGY
ROSTREVOR	12.42	6.01
ARDARA	10.54	10.32
KILLARNEY	12.33	4.58
GLEN OF DOWNS	6.80	2.89
ENISCORTHY	8.15	4.76
CAPPOQUIN	7.76	2.99
LOUGH DOON	11.63	7.35
BELFAST	9.18	

ACKNOWLEDGEMENTS

The authors wish to thank Elizabeth Francis for assistance with measurement and analysis, and the Laboratory of Tree-Ring Research, University of Arizona for the INDXA computer program. The ring widths and final chronologies (Table 5) will be deposited in the International Tree-Ring Data Bank.

REFERENCES

Baillie, Michael G. L.
1973 A recently developed Irish tree-ring chronology. *Tree-Ring Bulletin* 33: 15-28.
1977 An oak chronology for south central Scotland. *Tree-Ring Bulletin* 37: 33-44.
1980 Dendrochronology – the Irish view. *Current Archaeology* 73: 61-63.
Baillie, Michael G. L. and J. R. Pilcher
1973 A simple crossdating program for tree-ring research. *Tree-Ring Bulletin* 33: 7-14.
DeWitt, E. and M. Ames, editors
1978 Tree-ring chronologies of Eastern North America. *Chronology Series* IV, Vol. 1. Laboratory of Tree-Ring Research, The University of Arizona.
Fritts, H. C.
1976 *Tree-Rings and climate.* Academic Press, London.
Pilcher, J. R.
1976 A statistical oak chronology from the north of Ireland. *Tree-Ring Bulletin* 36: 21-27.

Table 5a. Ardara oak chronology.

	Tree Ring Indices										Number of Samples									
Year	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1803				167	122	113	98	101	104	92				1	1	1	1	1	1	1
1810	112	56	104	89	97	97	109	62	44	63	1	1	1	1	1	1	1	1	1	1
1820	83	57	31	29	52	43	55	43	65	112	1	1	1	1	1	1	1	1	1	1
1830	72	72	51	71	80	74	60	52	107	120	1	1	1	1	1	1	1	1	1	1
1840	89	106	103	90	130	122	106	141	163	202	1	1	1	1	1	1	1	1	1	1
1850	187	107	137	131	159	150	90	99	83	115	1	1	1	1	1	1	1	1	1	1
1860	142	148	165	123	108	123	137	148	91	74	1	1	1	2	2	2	2	3	3	4
1870	110	120	81	97	100	97	91	55	98	78	4	4	4	4	4	4	4	4	5	5
1880	82	102	110	98	86	104	109	91	73	77	5	5	5	5	5	5	5	5	6	6
1890	118	103	109	89	68	86	106	138	87	121	6	7	7	7	7	7	9	9	9	9
1900	129	109	86	126	116	96	98	80	79	106	9	9	9	9	9	9	9	9	9	9
1910	119	106	118	129	90	94	105	90	79	101	9	9	9	9	9	9	9	10	10	10
1920	77	96	84	59	82	93	71	89	68	70	10	10	10	10	10	10	10	10	10	10
1930	85	90	94	98	82	116	117	110	105	138	11	11	11	11	11	11	11	11	11	11
1940	136	142	135	79	70	92	100	147	114	84	11	11	11	11	11	11	11	11	11	11
1950	131	124	118	133	92	113	64	63	83	128	11	11	11	11	11	11	11	11	11	11
1960	121	101	76	67	63	90	90	84	86	99	11	10	10	10	9	8	8	8	8	8
1970	92	96	70	88	100	83	118	142	93		8	8	8	8	8	8	8	8	3	

Table 5b. Killarney oak chronology.

	Tree Ring Indices										Number of Samples									
Year	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1809										106										1
1810	122	172	178	163	141	123	119	107	89	107	1	1	2	3	3	3	3	3	4	4
1820	83	80	95	134	111	92	52	91	100	122	4	4	4	5	5	5	5	6	6	6
1830	121	106	101	114	110	107	84	117	124	87	6	6	6	7	8	8	8	8	8	8
1840	58	64	55	54	87	109	89	90	131	137	8	8	8	9	9	9	9	9	9	9
1850	101	77	112	119	102	121	77	80	60	64	9	9	10	10	10	10	12	12	12	12
1860	104	118	86	84	77	86	106	118	90	79	13	13	13	13	13	13	14	14	14	14
1870	101	170	155	134	103	117	104	82	105	85	14	14	14	14	15	15	15	15	15	15
1880	79	90	115	114	96	90	95	80	108	88	15	16	16	17	17	17	17	18	18	18
1890	133	122	122	65	67	99	80	135	92	83	18	18	18	18	18	18	18	18	18	18
1900	131	111	118	122	160	111	83	83	70	94	18	18	18	18	18	18	18	18	18	18
1910	99	109	109	88	103	121	117	128	97	74	18	18	18	18	18	18	18	18	18	18
1920	64	62	87	84	104	76	112	119	142	109	18	18	18	18	18	18	18	18	18	18
1930	82	90	83	74	60	101	83	89	93	108	18	18	18	18	18	18	18	18	18	18
1940	84	92	99	111	84	117	120	157	108	92	18	18	18	18	18	18	18	18	18	18
1950	102	131	91	111	105	80	79	87	110	94	18	18	18	18	18	18	18	18	18	18
1960	127	84	162	129	120	107	96	87	110	133	18	18	18	18	18	18	18	18	18	18
1970	90	84	68	93	100	81	99	77	84		18	17	17	17	17	17	17	16		

Table 5c. Lough Doon oak chronology.

	Tree Ring Indices										Number of Samples									
Year	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1850	127	112	111	97	113	71	67	87	89	103	2	2	3	3	3	3	3	3	3	4
1860	114	145	147	129	105	110	101	80	52	58	5	5	6	6	6	7	7	7	7	7
1870	72	106	98	89	91	119	109	96	138	95	7	8	8	8	8	8	8	8	8	8
1880	99	102	109	102	97	90	103	90	121	100	8	8	8	8	9	9	9	9	9	9
1890	117	101	116	100	78	117	152	154	86	114	9	9	10	10	10	11	11	11	11	11
1900	123	111	88	91	104	88	78	88	92	117	11	11	11	11	11	11	11	12	12	12
1910	118	118	105	89	89	94	89	99	104	94	12	12	12	12	12	12	12	12	12	12
1920	74	84	89	81	91	89	90	111	111	87	12	12	12	12	12	12	12	12	12	12
1930	77	82	78	64	67	93	87	89	84	90	12	12	12	12	12	12	12	12	12	12
1940	95	82	102	76	84	91	103	125	95	112	12	12	12	12	12	12	12	12	12	12
1950	131	124	114	112	112	135	112	96	120	119	12	12	12	12	12	12	12	12	12	12
1960	154	117	167	120	133	128	99	79	84	91	12	12	12	12	12	12	12	12	12	12
1970	83	88	73	73	94	79	106	91	91		12	12	12	12	12	12	12	12	12	

Table 5e. Glen of the Downs oak chronology.

	Tree Ring Indices										Number of Samples									
Year	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1809										149										1
1810	53	81	110	28	33	44	44	107	157	152	1	1	1	1	1	1	1	2	2	2
1820	122	103	131	163	161	160	108	109	63	85	2	2	2	2	2	3	4	5	5	5
1830	74	79	110	128	148	112	115	157	148	142	6	6	6	7	7	7	7	7	8	8
1840	135	123	108	64	58	95	70	66	49	79	8	8	8	8	9	10	10	10	10	10
1850	84	67	91	87	98	114	88	130	118	114	10	10	10	10	10	10	11	11	11	12
1860	143	142	168	106	66	99	107	66	49	63	12	12	12	12	12	12	12	12	12	12
1870	60	75	71	88	94	72	77	89	102	111	12	12	13	13	13	13	13	13	13	13
1880	129	170	132	104	110	121	102	72	45	81	13	13	13	13	13	13	13	13	13	13
1890	140	120	118	101	118	118	119	94	91	105	13	13	13	13	13	13	13	13	13	13
1900	121	96	85	95	134	119	86	109	138	144	13	13	13	13	13	13	13	13	13	13
1910	148	125	126	113	114	120	105	57	41	67	13	13	13	13	13	13	13	13	13	13
1920	83	94	80	56	70	72	68	96	112	98	13	13	13	13	13	13	13	13	13	13
1930	108	103	78	46	41	47	85	67	49	59	13	13	13	13	13	13	13	13	13	13
1940	78	100	135	105	121	150	95	129	119	110	13	13	13	13	13	13	13	13	13	13
1950	155	172	151	167	125	102	79	74	79	72	13	13	13	13	13	13	13	13	13	13
1960	77	62	145	147	132	128	114	114	107	113	13	13	13	13	13	13	13	13	13	13
1970	91	81	83	103	105	85	72	71	67		13	13	13	13	13	13	13	13	13	

Table 5f. Cappoquin oak chronology.

	Tree Ring Indices										Number of Samples									
Year	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
1813				137	105	98	162	101	69	64				1	1	1	1	2	2	2
1820	85	26	58	78	136	110	66	44	78	136	2	2	2	2	2	2	2	2	2	2
1830	171	117	123	135	105	79	86	151	105	90	2	2	3	3	4	5	5	6	6	6
1840	88	92	80	79	76	109	96	111	112	112	7	7	8	8	8	8	8	9	9	9
1850	128	142	143	117	109	128	90	105	92	93	9	9	10	10	10	10	10	10	11	11
1860	100	96	89	69	76	83	96	114	80	103	11	11	11	11	11	11	11	11	11	11
1870	107	92	96	105	108	122	99	104	106	96	11	11	11	12	12	12	12	12	12	12
1880	102	106	89	99	112	96	102	76	103	104	13	13	13	13	13	14	14	14	14	14
1890	111	103	110	94	100	100	97	129	90	118	14	14	14	14	14	14	14	14	14	14
1900	112	94	99	91	107	89	71	66	74	76	14	14	14	14	14	14	14	14	14	14
1910	109	106	108	90	79	67	72	88	65	59	14	14	14	14	14	14	14	14	14	14
1920	76	65	87	67	96	84	78	95	80	85	14	14	14	14	14	14	14	14	14	14
1930	94	90	110	87	97	140	182	135	138	138	14	14	14	14	14	14	14	14	14	14
1940	115	154	158	115	120	150	141	145	133	158	14	14	14	14	14	14	14	14	14	14
1950	146	136	104	113	79	73	82	92	104	98	14	14	14	14	14	14	14	14	14	14
1960	108	95	134	99	92	96	106	104	91	76	14	14	14	14	14	14	14	14	14	14
1970	69	72	67	63	74	95	77	101	73		14	14	14	14	14	14	14	13	11	