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# DENDROCHRONOLOGY—THE ABSOLUTE IRISH STANDARD

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ABSTRACT. Since the 11th International Radiocarbon Conference considerable advances have been made in European dendrochronology giving several long continuous absolute chronologies. Recent collaboration between European laboratories provides confirmation of the accuracy of these chronologies and, thus, of the standards used for radiocarbon calibration.

## INTRODUCTION

In Baillie, Pilcher, and Pearson (1983) a preliminary review of Belfast dendrochronology was presented as a background to the high-precision calibration. At that time the chronology was not known to be complete but was believed to consist of two major sections, one running from the present to 13 BC, the other spanning ca 200 BC to ca 5300 BC. Most of the discussion at that time centered on the internal integrity of this latter chronology unit. It is now known that the prehistoric chronology covered the years 5289 BC to 229 BC (Pilcher *et al,* 1984). For various reasons that exact dating was used in the presentation of the Belfast high-precision calibration for the BC period (Pearson, Pilcher & Baillie, 1983).

## ESTABLISHING A CONTINUOUS CHRONOLOGY WITHIN THE BRITISH ISLES

In 1982 a tentative link existed across the first centuries BC consisting of chronologies from Roman London, Roman Carlisle and Iron age sites, Navan and Dorsey, in the north of Ireland. The 337-yr Carlisle chronology appeared to match with its end year at AD 90. The 246-yr Dorsey/Navan chronology appeared to match Carlisle with its end year at 116 BC and Garry Bog Two appeared to match Dorsey/Navan with its end year at 229 BC. There was no "second guess" position suggested by consistent matches. The problem was that we could not preclude the possibility that some of these matches were simply wrong, for example, that Dorsey/Navan lay off the end of the Carlisle chronology (the "dendrochronologist's dilemma" of Baillie, Pilcher and Pearson (1983, p 172)). Hence, these links were considered at best tentative when the calibration results were presented at Seattle. In addition, this linkage included the use of Roman London chronologies which were not dated within the framework of independent British Isles chronologies, but were placed in time by reference to the German chronologies of Hollstein (1980) and Becker (1981). This loss of independence would have precluded the possibility of using German data to confirm the Irish chronologies. In late 1983 a re-working of the Roman London chronologies by I Tyers (pers commun) yielded a chronology (Southwark) spanning 252 BC to AD 255. This chronology linked directly to the established Belfast chronology which extended to 13 BC allowing the link to the long prehistoric chronology to stand independent of the German chronologies.

## CROSS-DATING LINKS WITH GERMANY

Comparisons of sections of the Belfast chronology with those of Becker and Schmidt (1982) revealed the possibility of an error in the German chronologies at ca 500 BC (Baillie, 1983). The German chronologies of

Schmidt and Becker for periods earlier than 500 BC had relied on a tentative overlap, established by Hollstein (1980), from 546 to 443 BC. There appeared to be an error of 71 years in this placement. Agreement was reached on the correctness of the Irish chronology in 1984 (Pilcher *et al*, 1984). The outcome of these collaborations was a consensus on the dating of the chronologies from Belfast, Stuttgart, and Köln. Within these European chronologies the Belfast sequence was weak across the first centuries BC while the Stuttgart and Köln chronologies had a small gap at 500 BC. Among the three, a continuous sequence could be confirmed.

## FURTHER CONFIRMATION OF THE EUROPEAN CHRONOLOGIES SINCE 1984

Since the existence of a continuous 7272-yr chronology was published in 1984, a number of lines of evidence have further confirmed the correctness of the Irish sequence.

### *The Internal Evidence*

The evidence for the 13 to 229 BC links is shown in Figure 1. The figures linking the chronology units on the diagram are t values for cross-dating between the chronologies. Recently an additional chronology was

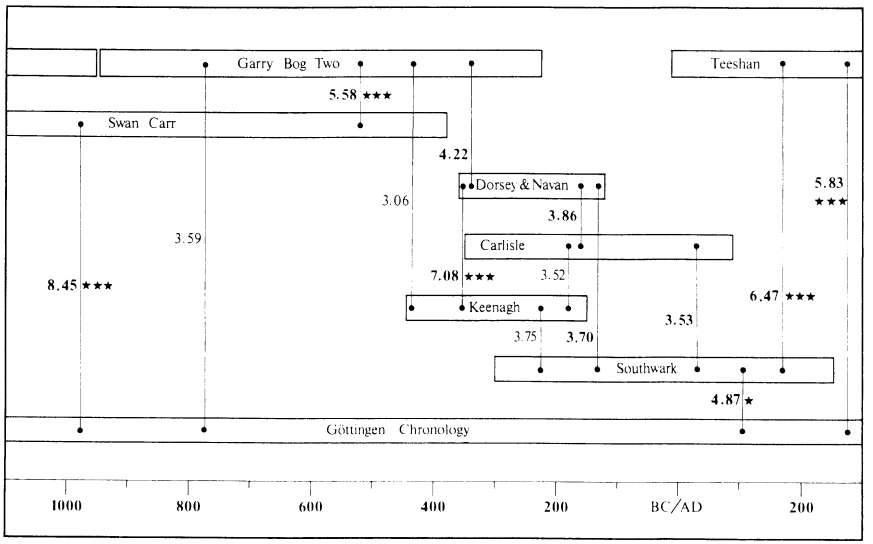


Fig 1. Cross-dating between tree-ring chronologies from Ireland (Garry Bog Two, Teeshan, Dorsey and Navan, and Keenagh) England (Swan Carr, Carlisle, and Southwark) and Germany (Göttingen) in the first millennium BC. Each horizontal block represents a chronology while the vertical lines linking them represent cross-dating between them. The numbers beside the lines give a measure of the quality of the cross-dating. These are the values of Student's *t* calculated by Fisher's *z* transformation of the correlation coefficients of high-pass filtered versions of the chronologies at the relative positions shown on the diagram. Those in bold type are the highest for all positions of overlap of the two chronologies. The stars show the significance probablities, *P*, calculated by using an outlier statistic (Barnett & Lewis, 1978, p 106) to compare the highest *t* value to the empirical distribution of *t* values from the other relative positions of the two chronologies: * means *P* is between 0.05 and 0.01, *** means *P* is less than or equal to 0.001.

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created from timbers from an Iron age trackway from Keenagh in central Ireland. This new chronology spans 446 to 148 BC and acts as an additional link between the long chronology and Dorsey/Navan and shows highly consistent cross-dating with the chronology components covering that date range. All available evidence thus suggests that the internal logic supporting the continuous British Isles chronology is correct.

*The External Evidence*

In the spring of 1985, A Delorme and H-H Leuschner of the Göttingen tree-ring laboratory were kind enough to make available to us a continuous German chronology running from 4163 BC to AD 928. This had been built largely independently of the work in Stuttgart and Köln and is linked to the Hollstein chronology at the younger end (Leuschner & Delorme, 1984). This chronology offered an ideal opportunity to further test the integrity of the British Isles chronology. Figure 1 shows how the Göttingen chronology confirms the link between 13 and 229 BC. In Figure 2, the Belfast prehistoric chronology earlier than 229 BC is represented by three of its main chronology units—the extended long chronology (5289 to 949 BC), Swan Carr (1155 to 381 BC) and Garry Bog 2 (947 to 229 BC). Could these sections be dated against the new Göttingen chronology? In each case significant correlation values were found confirming the precise dating of the sections to their predetermined end years of 949, 381, and 229 BC, respectively. An East Anglian chronology from England (3169

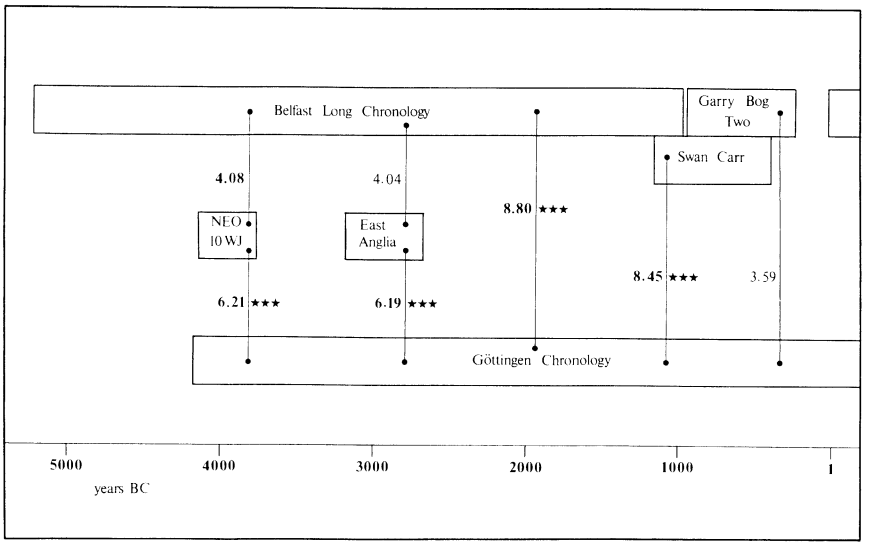


Fig 2. Cross-dating between a continuous chronology from the Göttingen laboratory and chronologies from Ireland, England, and north Germany. The Belfast Long Chronology was produced by truncating the new continuous Belfast chronology at 949 BC. Garry Bog Two is a Northern Irish component of the new Belfast chronology, while Swan Carr and East Anglia are English chronologies. The NEO 10 WJ chronology was supplied by B Schmidt, University of Köln. The *t* values and significance levels are as in Figure 1.

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to 2661 BC) and the NEO 10 WJ chronology from Schleswig-Hollstein (Schmidt, pers commun, 1984) are independent chronologies that match both Belfast and Göttingen, further confirming this dating.

## THE CHRONOLOGY REPLICATION

Once the Belfast chronology was complete, work started on archiving the primary data and rebuilding the chronology as a single continuous sequence. In the process each individual tree in the chronology has been checked and only those samples with high quality cross-dating are included. So far, 658 trees have been included in the sequence spanning 5289 to 116 BC. The distribution of samples with time is shown in Figure 3. As can be seen, there are only two points where replication falls below 10 trees—at 950 BC and at 2500 BC. The former point is bridged by six long-lived individual trees and the latter is one of the two depletion periods discussed in detail in Baillie, Pilcher and Pearson (1983). The other weak point described and justified in the 1983 article can still be seen at 1900 BC.

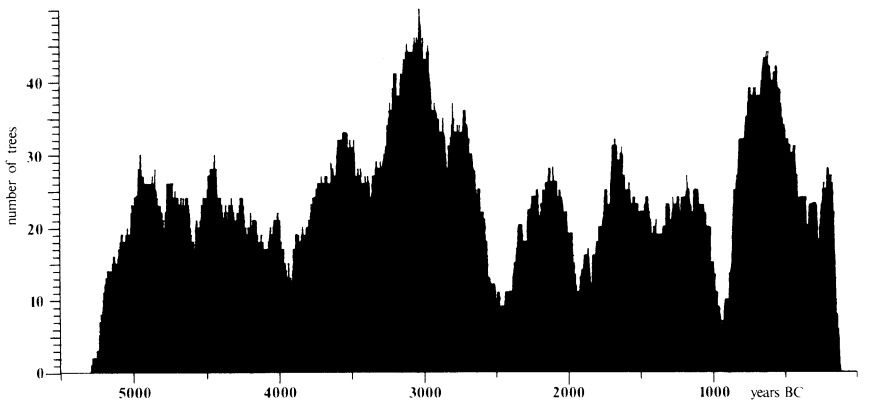


Fig 3. Histogram of the level of replication within the Belfast chronology from 5289 to 116 BC. The points where the histogram dips below 10 trees are at 950 and 2500 BC. Other less severe depletion periods are apparent at 1900 and 3900 BC.

## CONCLUSION

We are confident in presenting this chronology to the radiocarbon world as a primary standard of high integrity on which to base the radiocarbon calibration.

## ACKNOWLEDGMENTS

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