

# How continuous is the European Oak Chronology?

Petra Ossowski Larsson<sup>1</sup>, Lars-Åke Larsson  
Pålnäsvägen 1, SE-13333 Saltsjöbaden, Sweden

*Abstract: We report a severe error in one of the key links of the long Irish oak dendrochronology which is an integral part of the terrestrial data sets of IntCal09. The possible consequences for the calibration curve are discussed.*

## Introduction

In 1984, European dendrochronologists had reached consensus about the appearance of a more than 7000 years long European oak dendrochronology<sup>2</sup>. The oak chronologies from Hohenheim (Bernd Becker) and Belfast (QUB, Mike Baillie), said to be independent of and perfectly conform with each other, were then used to develop a radiocarbon calibration curve for the northern hemisphere. Still European oaks are the only trees used in IntCal09 between 10059 to 2090 BP. The oak chronologies were also used to confirm the conventional time span between our time and Roman time, as both definitely match material which is archaeologically of Roman origin.

Both the correctness of the calibration curve, and the number of years between AD 1 and present time, have been questioned and heavily debated. This discussion could come to an end once and for all if it would be possible to demonstrate the continuity of the European oak chronology, and this is the intention of our work.

When we started in 2003 to look for suitable measurement series we learned quickly that neither the German nor the Irish/English raw data which the masters were built of were ever published. Though sitewise mean value curves of German archaeological material were available in Ernst Hollstein's book of 1980<sup>3</sup>. The retrieved Hollstein data revealed major problems in the first millennium AD: a weak section at about AD 800 (which later turned out to be correctly bridged), and a gap between AD 336 and AD 410 (i.e. between Roman time and recent time). Even worse, the Roman end terminated at AD 336 matched the recent time end almost perfectly at AD 543 with 131 years overlap, indicating 207 years too much in our time line! We asked several German dendro labs for completing data but our requests were refused.

This was the situation when in 2010 the complete QUB raw data was published on the Internet, unsynchronized and undated.<sup>4</sup> We were able to synchronize the well-matching material, without any pre-dating, to form three large, among themselves not crossdating collections:

- BelfastAD, a collection of mean value curves covering the time AD 25 - 2006.
- LateBC, a collection - floating in time - but crossdatable towards the European Roman oak chronology to 1155 - 69 BC (conventional date).
- BelfastLong, a floating bog-oak collection covering 4615 years. Conventionally dated (via ITRDB:brit036) to 5452 - 837 BC.

Please note that our interpretation of the raw data is in accordance with Mike Baillie's interpretation as described in his book "A slice through time". Or, with his own words: "Finally, and this is really the acid test; following a Freedom of Information request all our Irish oak data was made available on the web earlier this year. A completely independent and potentially hostile group ( ... ) set in and rebuilt all the main sections of our chronology from scratch, without using radiocarbon at all. They reproduced our chronologies to all intents and purposes exactly. An amazing piece of work for which I give them much credit ...".<sup>5</sup>

But, there is no way to dendrochronologically link these three collections together with QUB material.

BelfastAD and LateBC do not overlap, but we were able to convincingly extend LateBC towards our time with English Roman raw data kindly provided by Cathy Tyers, Sheffield University/English Heritage. The correlation of the English data series towards BelfastAD was much weaker, though we were able to reconstruct Mike Baillie's proposed linkage which supports our conventional time count. However, more data is needed to prove that it is correct.

LateBC and BelfastLong do indeed overlap 316 years, but they are virtually not crossdating. A closer analysis of the proposed link revealed the error which the remainder of this article will be about.

All our work is reported in detail on our home page <sup>6</sup> where it is also possible to download our synchronized mean value curves and see our detailed dating reports.

## **Our methods**

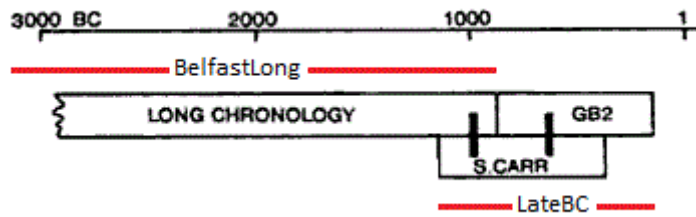
To build our masters, we used one of the modern tools on the market for building master references and chronologies: our program CDendro<sup>7</sup>. CDendro is optimized for handling large data sets and for search of matches in large tree-ring data bases. A number of well-trying algorithms for crossdating and normalization are available, among others Baillie-Pilcher. We usually look at several methods simultaneously and require a high score from all of them to accept a match. Crossdating can be done under interactive supervision with graphical tools and quality check functions.

When building our master references, we followed the advices given by QUB on their homepage in connection with the publication of the raw data, and the methods described in "A slice through time". When building site collections, samples shorter than 100 years, with an overlap less than 70 years and a T-value less than 6 were generally excluded.

## **The linkage of BelfastLong towards LateBC**

A major portion of the Irish QUB material can be crossdated to form a nearly 5000 years long collection covering times before the first millennium BC. There is actually a 75-years gap around BC 2450, however, this gap is securely bridged by English data from Croston moss (1442 years with almost equal overlap on both sides of the gap, corr. 0.33, TT 12.9).

Our Irish long chronology (BelfastLong) is supposed to overlap LateBC at about BC 900 as described in Mike Baillie's "A slice through time", but we can not find any substantial match at all. Something is wrong.

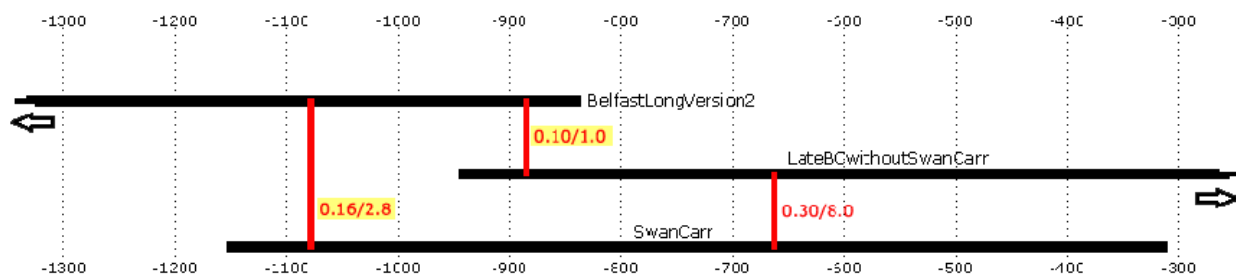


The diagram is from Baillie's book, and shows how the English Swan Carr collection (S.CARR) connects Baillie's Irish Long Chronology to his Garry Bog 2 (GB2) chronology. Our own corresponding BelfastLong and LateBC collections created from the Irish measurement data are shown in red color in the diagram.

So let's figure out how our BelfastLong would be dated conventionally. For that we have to do some "reverse engineering" as the published QUB samples are undated. A 761 years long collection from Thorne Moors in Yorkshire, crossdated by Gretel Boswijk and put on the ITRDB<sup>8</sup> as brit036, gives the answer. It is dated -3016 to -3776 and matches BelfastLong with corr. 0.27, TT 7.7, resulting in a date of -836 for the youngest ring of BelfastLong.

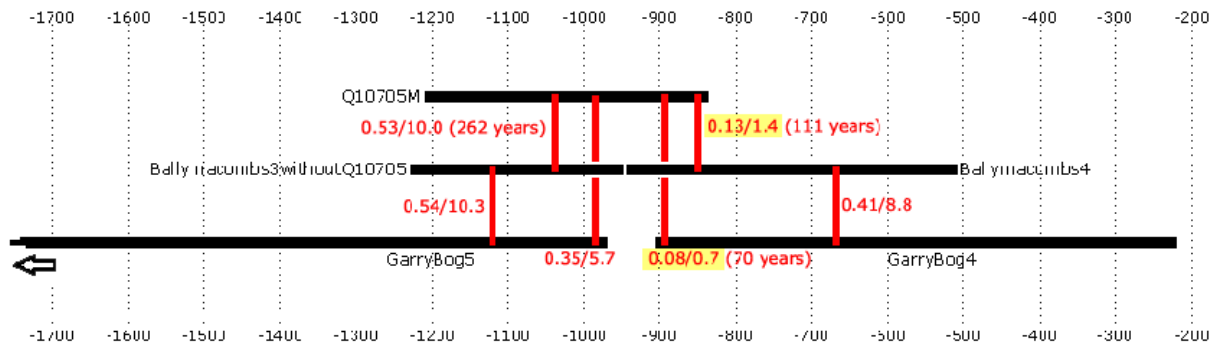
With this dating, BelfastLong overlaps LateBC by 316 years but with a very unsatisfactory correlation (corr. 0.17, TT 3.0). This means that some deeper analysis is required.

The oldest part of LateBC consists of an English collection from Swan Carr, which shows a good match towards the rest of the collection at -311 (corr. 0.30, TT 8.0). Lifting off this collection reveals that the all-Irish parts of BelfastLong and LateBC overlap by 111 years but do not match (corr. 0.10, TT 1.0). An even closer look shows that the mismatching overlapping collections are nevertheless from the same site, Ballymacombs More (county Antrim).



This was not expected! Mike Baillie reported that the Long chronology and LateBC only overlap via SwanCarr and that there is a one-year gap between the two meeting Garry Bog/Ballymacombs More collections, the collection in the Long chronology ending at -948 and the collection in LateBC starting at -946. We find -946 as the oldest ring in our Ballymacombs4 (of LateBC), but -836 instead of -948 as the youngest ring of our Ballymacombs3 (of BelfastLong).

A look into our Ballymacombs3 site collection makes clear what has happened. There is one huge, 380 years long oak curve (Q10705) extending the collection by 112 years. And while the rest of the collection was measured early (Q2203 to Q2272, youngest ring at -948 which is the same as Baillie's dating), the huge oak was measured in August 2009 and therefore was unknown when the long Belfast chronology was linked together in 1983.



Q10705 must have drawn some attention as David Brown measured it several times with very similar results. It fits the rest of Ballymacombs3 with a convincing corr. 0.53, TT 10.0, but there is no match towards Ballymacombs4 (corr. 0.13, TT 1.4 at 111 years overlap). Even if we suspect a badly matching tail and truncate Q10705 by 40 years at its younger end, there is no match. (There is no reason to truncate Ballymacombs4 as it matches in its full length towards Swancarr.)

We believe that, if Mike Baillie had known about this stem, he never would have linked the parts of the Belfast BC chronology the way he actually did.

If, with the new data, this link would be considered to be right anyway, it would not be because of dendrochronology. It would be because of other methods' prerogative to decide what is right in chronology. From a dendrochronological point of view this link is most probably wrong.<sup>9</sup>

How wrong? Well, there is no match within sight. And if we add SwanCarr to LateBC again and look for matches which are better than "as conventionally dated", the first alternative would mean inserting 179 years into the gap. Better alternatives emerge more than 200 years off. But there is no chance to definitely point out a matching point with the material we have at our disposal, the overlaps become too short and the collections become too thin (few samples). Mike Baillie saw the same when he reported the crucial link in 1983<sup>10</sup>: "A consistent match is found with the Swan Carr chronology at this position  $t = 4.7$  (cf GB1) and  $t = 3.6$  (cf BMcC). No other consistent match exists."

## Conclusions

Inserting a large number of years would either push BelfastLong back in time, or LateBC further towards recent time, or maybe both. And as LateBC has a fixed

historical position in relation to BelfastAD, pushing LateBC towards recent time could consequently mean a chronology error if the number of years is sufficiently high.

An error of this kind necessarily also means that there is a fault in Pearson's 14C calibration curve<sup>11</sup> as it is derived from exactly the collections in which we have found the error. This also puts IntCal09 in error as the Pearson calibration is an integral part of its data sets.

## Discussion

"Impossible!" was a spontaneous comment we heard more than once. One well-known dendrochronologist explicated even further: "If you are correct, it is a good thing that the calibration was not done with European wood." What he probably meant was a fact that Mike Baillie mentioned in his Radiocarbon article of 1983: "Both the long chronology and GB2 were "wiggle" matched against the bristlecone-pine results derived by Suess (1978). The exercise suggests that the long chronology spans 5300 to 940 BC ( $\pm 20$ ) while GB2 spans 940 to 220 BC ( $\pm 20$ )." Mike Baillie then described the fine adjustment by dendrochronology which we refer to above and which appears to be in error.

The Suess calibration curve<sup>12</sup> is based on bristlecone pine from Ferguson's investigation<sup>13</sup>. The Suess calibration curve is regarded as historical (see e.g.<sup>14</sup>) and not contained in the IntCal09 data sets.

So, did Mike Baillie manage to synchronise correctly against the American bristlecone pine chronology, and is the bristlecone pine chronology absolute?

We have digitalized the Suess calibration curve published in 1978, and checked the consistency of the dendro material forming the Irish oak part of IntCal09. The result is presented and visualised in our Excel workbook<sup>15</sup>.

We find it most probable that:

- the bodies of all three Irish chronology parts are sound and that the 4100 years long sequence of BelfastLong (5150 to 1050 BC) used for radiocarbon measurement is continuous.
- the 4100 years long sequence of BelfastLong is correctly synchronized against the Suess calibration curve.
- the Suess calibration curve is absolute.

This would mean that the conventional dating of BelfastAD is absolutely correct, while the conventional dating of BelfastLong is nearly correct ( $\pm 20$  years). LateBC, covering the first millennium BC and linking to the European Roman complex, acts as a "slider" between these blocks. Though its wiggle-match against the Suess calibration curve supports its conventional (historical) dating, this is ruled out by the dendro error we have described above. This error is almost a proof that we have a large chronology error between our time and Roman time. The number of years we insert in the gap at BC 950 relentlessly push LateBC and with it the Roman time curves towards our time with about the same number of years!

As an alternative scenario, BelfastAD together with LateBC would be considered as correctly placed on the time line, and BelfastLong is then pushed towards older times by inserting a large number of years. But this is not possible without also putting the Suess curve in error, which in fact means that there would be no correct 14C-calibration curve for this period. We find this scenario less probable as the Pearson and Suess curves follow each other closely over a period of more than 4000 years (corresponding to BelfastLong), thus validating each other.

### What comes next?

Further dendrochronological investigation is needed to determine the link between LateBC and BelfastLong exactly to the year, and finally the link between LateBC and BelfastAD which defines our chronology.

The faulty BC-link could be closed with a few lucky Irish oaks from a bog near Belfast, to be retrieved in the field or already in the lab awaiting measurement like Q10705.

Regarding the link between LateBC and BelfastAD, new Irish/English material could close the case even here. But in the meantime the various dendro groups from the middle of Europe who claim that they bridge the gap could demonstrate this.

Anyway, it would be most meaningful to scatter the doubts on the European oak chronology in order to be able to make a new attempt towards a reliable 14C calibration curve for the first few millennia BC. At the moment this part of the calibration curve appears to rest solely on outdated (?) bristlecone pine measurements from the early 1970s.

---

<sup>1</sup> Corresponding author. Email: [petra@cybis.se](mailto:petra@cybis.se)

<sup>2</sup> Baillie, M.G.L. 1995, A slice through time - dendrochronology and precision dating. ISBN 0713476540

<sup>3</sup> Hollstein, E., Mitteleuropäische Eichenchronologie, Verlag Von Zabern, Mainz, 1980.

<sup>4</sup> [http://chrono.qub.ac.uk/Resources/dendro\\_data/dendro.html](http://chrono.qub.ac.uk/Resources/dendro_data/dendro.html)

<sup>5</sup> <http://www.astorehouseofknowledge.info/w/Talk:Dendrochronology>

<sup>6</sup> <http://www.cybis.se/forfun/dendro/hollstein>

<sup>7</sup> <http://www.cybis.se/forfun/dendro>

<sup>8</sup> <http://www.ncdc.noaa.gov/paleo/treering.html>

<sup>9</sup> It might be argued that our findings are based solely on two stems from the same bog which do not match as they should and that this single mismatch can not be a PROOF that the match is wrong. When comparing 110 years long blocks from Ballymacombs3 towards Q10705, the standard deviation interval for corr coeff is 0.33-0.43 with a mean value of 0.38. That should be compared to the current correlation coefficient of only 0.13 between Ballymacombs4 and Q10705.

<sup>10</sup> Baillie et al., Radiocarbon, Vol 25, No. 2, 1983, P 171-178.

<sup>11</sup> Pearson et. al., Radiocarbon, Vol 28, 1986, 911-34.

<sup>12</sup> Suess, H.E., Radiocarbon, Vol. 20, No. 1, 1978, P. 1-18.

<sup>13</sup> Ferguson, C.W. 1969, Tree-Ring Bulletin, v 29, no. 3-4, p 3-29.

[http://www.treeringsociety.org/TRBTRR/TRBvol29\\_3-4\\_3-29.pdf](http://www.treeringsociety.org/TRBTRR/TRBvol29_3-4_3-29.pdf)

<sup>14</sup> <http://www.radiocarbon.com/tree-ring-calibration.htm>

<sup>15</sup> <http://www.cybis.se/forfun/dendro/hollstein> , ref.24