Palaeobotanist 50 (2001) 101-105
0031-0174/2001/101-105 $2.00

Network of tree-ring series in Estonia connected with north European chronologies

ALAR LÄÄNELAID

Tartu University, 40 Lai St., Tartu 51005, Estonia. Email: alarl@ut.ee

(Received 07 February 2000; revised version accepted 10 December 2001)

ABSTRACT

Läänelaid A 2001. Network of tree-ring series in Estonia connected with north European chronologies. Palaeobotanist 50(1) : 101-105.

The present paper describes the course of building up the tree ring network of Scots pine (*Pinus sylvestris* L.) in Estonia. Although the construction timber in this region of the Baltic comes from two tree species, Scots pine and Norway spruce (*Picea abies* Karst.), only the former was used for comparisons between the average tree ring series in Estonia and tree ring chronologies of Scots pine from other neighbouring areas: Sweden, Finland, Latvia and Poland. The dated tree ring series were compared using Student's t-criterion. It appeared that Estonian tree ring series of pine generally showed the greatest similarity with the chronology of Gotland pine in Sweden (the t-value with the average series of growing pines in north-western Estonia reaching 9·59). The similarities with other matched tree ring chronologies were also significant. It can be concluded that Estonia belongs together with other Baltic Sea countries to the same dendroclimatological region of uniform tree growth. This fact enables to use dated tree ring chronologies from the neighbouring areas to confirm the dating of tree ring sequences in Estonia.

Key-words—Tree-rings, Network, *Pinus sylvestris* L., Estonia, N Europe.

एस्टोनिया में उत्तर यूरोपीय कालानुक्रम से सम्बद्ध वृक्ष वलय श्रेणियों का संजाल

अलर लानलेड

सारांश

प्रस्तुत शोध पत्र में एस्टोनिया के स्कॉट्स पाइन (*पाइनस सिल्वेस्ट्रिस* एल.) के वृक्ष वलय संजाल की निर्मिति प्रक्रिया वर्णित की गयी है। यद्यपि बाल्टिक के इस क्षेत्र की काष्ठ स्कॉट्स पाइन एवं नार्वे स्प्रूस (*पाइसिया एबीज़* कार्स्ट) नामक दो वृक्ष प्रजातियों से निर्मित है, परन्तु नार्वे स्प्रूस को कुछ समीपवर्ती क्षेत्रों, जैसे - स्वीडन, फिनलैण्ड, लाटविया एवं पोलैण्ड से प्राप्त स्कॉट्स पाइन की वृक्ष वलय कालानुक्रमिकी के साथ-साथ एस्टोनिया की औसत वृक्ष वलय श्रेणी की तुलना हेतु भी प्रयुक्त किया गया है। स्टूडेण्ट्स टी-क्राइटेरियन की सहायता से वृक्ष वलय श्रेणियों की आयु की तुलना की गई थी। ऐसा प्रतीत होता है कि पाइन की एस्टोनिया वृक्ष वलय श्रेणी सामान्यतः स्वीडन की गॉटलैण्ड पाइन कालानुक्रमिकी (उत्तर-पश्चिमी एस्टोनिया में वृद्धिमय पाइन औसत श्रेणी से युक्त टी-मान 9·59 तक पहुँचता हुआ) के साथ गहन समरूपता प्रदर्शित करती है। कुछ अन्य विदेशी वृक्ष वलय कालानुक्रमिकी के साथ संगति भी महत्त्वपूर्ण है। इससे यह निष्कर्ष निकलता है कि एस्टोनिया बाल्टिक समुद्र के आस-पास अन्य देशों के साथ एक समान वृक्ष वाले उसी वृक्ष जलवायुविक क्षेत्र से सम्बन्धित है। यह तथ्य एस्टोनिया के वृक्ष वलय अनुक्रम के आयु निर्धारण की पुष्टि हेतु समीपवर्ती क्षेत्रों के वृक्ष वलय कालानुक्रम को प्रयुक्त करने के लिए सहायक सिद्ध हो सकता है।

संकेत शब्द—वृक्ष वलय, संजाल, *पाइनस सिल्वेस्ट्रिस* एल., एस्टोनिया, उत्तरी यूरोप.

INTRODUCTION

THE aim is to find out if old buildings in Estonia can be dated on the basis of the tree ring chronologies in other neighbouring countries. In other words, it is the question of geographical extension of a dendroclimatologically uniform region. Some idea of the possible range of dendroclimatologically uniform regions in Scandinavia was obtained from a map presented by Bartholin (1993). According to the map, the uniform region of pine in central part of Sweden covers roughly a north-southward elongated area three times as large as Estonia, which lies not far in the east of that region. One can easily imagine the extension of this region eastward so that it will also cover the area of both Estonia and southern Finland on the eastern coast of the Baltic Sea. In the above-referred paper, Bartholin stated that "in practice these areas are larger" in addition, he gave some examples on successful dating of the Scandinavian tree ring curves by mean curves of Poland and Finland. Presumably, the climate is more uniform in this region along the east-west direction than along the north-south direction. Using similarities between the tree ring series in these regions can prove these considerations.

Estonia, the northernmost of the three Baltic countries in northern Europe, has now its own tree ring network of pines that is connected with the tree ring chronologies of pines in other neighbouring countries (Fig. 1).

The tree ring samples from Estonia came from roof constructions of old buildings, mainly churches, but also from other buildings and extant trees. The common construction timber of this area is Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* Karst.). As pine and spruce have different biology, and they form different tree ring sequences, there was a need to distinguish, firstly, the samples of these tree species, and secondly, to develop separately tree ring averages for these species. Pine and spruce wood has often been used mixed in the same construction, or the framework of a roof is made of one tree species and repaired with another. Borer cores of centuries-old wood sometimes do not reveal visual features of the tree species. Therefore, in all cases the tree species of the cores of the construction wood was

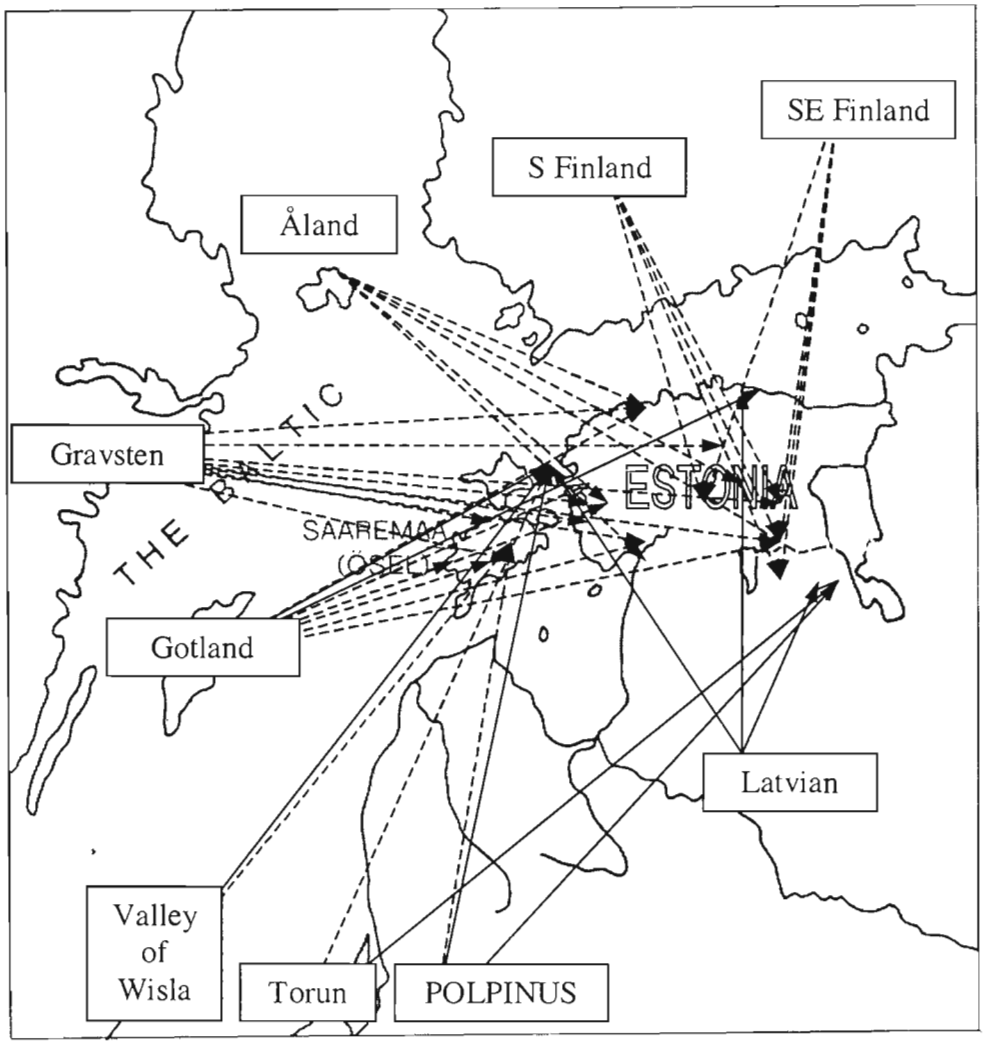

Fig. 1— The location of tree ring series of pine in Estonia significantly correlated with the pine chronologies of the neighbouring areas around the Baltic Sea. The correlation was estimated by Student's t-criterion. The dashed line arrows indicate connections of construction wood, the solid line arrows of growing pines in Estonia. Labels on the map mark the correlated chronologies outside Estonia; details of them are given in the text.

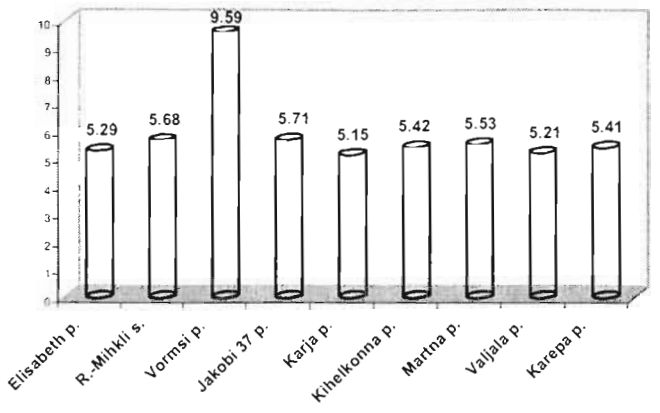

Fig. 2— Student's t-values of Estonian average pine series with Gotland pine chronology (Bartholin, personal commun, 1998). Ordinate: Student's t-values. Abscissa: names (toponymes) of the average tree-ring series. Numbers next to the bars show overlapping of the series in years, at the top of the bars - t-value; p. = pines, s. = spruces. Vormsi pines is a series of extant trees, the rest series come from buildings.

determined microscopically. It appeared that pine and spruce occurred nearly in equal numbers among the sampled construction timber.

MATERIAL AND METHODS

Usually 10 to 30 cores were extracted from different beams of a construction. The tree ring widths were measured and the ring sequences were synchronized between themselves by graphs and Student's t-values. Well synchronizing tree ring curves of the same species were joined into an object average series, consisting usually of 5 to 10 or more initial series. These average series were dated by reference chronologies, using also earlier dated average tree ring series from Estonia (Läänelaid, 1999a, b). Some of the average series were dated by longer Estonian average series of growing pines or spruces. The dated objects located in different parts of Estonia - on the sea islands in the western part, on the continent in north-western Estonia, and in northern and eastern Estonia. Altogether there were about 40 sample locations over Estonia that were involved in the present research (Läänelaid, 1998).

The correlation among the average tree ring series of old buildings in Estonia varies. Some of the series reveal high correlation, and some of them do not correlate at all between themselves. Besides the distance between the sample sites, correlation of the average tree ring series is apparently related to the similarity of the conditions at the sites of the tree stands.

In order to connect Estonian tree ring network with neighbouring areas, the average pine tree ring series of buildings were correlated with available tree ring chronologies in Sweden (pine chronologies of Gotland and Gravsten, both by Bartholin, personal commun, 1998), Finland (pine chronologies of Åland by Bartholin, personal commun, 1991, of southern Finland by Zetterberg, personal commun, 1998, and of south-eastern Finland by Lindholm, personal commun, 1998), Latvia (Bauska church by Zunde, personal commun, 1998; Latvian pine chronology by Špalte, 1979), and Poland (modern pine chronologies of Torun, POLPINUS, northern Poland, and the Valley of Wisla, all by Zielski, personal commun, 1989, 1992a, 1992c, 1995).

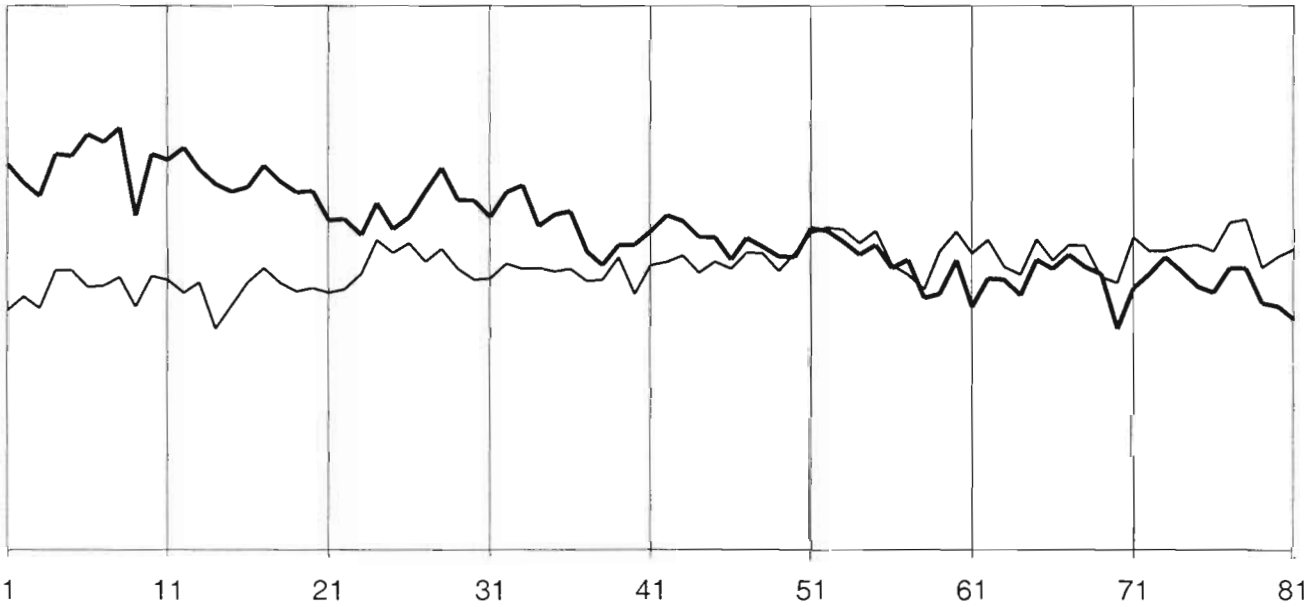

Fig. 3—An 80-year cut of matched tree ring series of extant pines from Vormsi Island, NW Estonia (thick line), and Gotland pine chronology (Sweden). Student's t = 9·59. Abscissa: years. Ordinate: ring widths in logarithmic scale.

RESULTS

It appeared that of these reference chronologies, Gotland pine chronology gave the highest correlation with Estonian object series. The Swedish island of Gotland is situated in southwest from Estonia. The buildings and sites that correlated with Gotland chronology are distributed over Estonia (Fig. 1); however, the connections tend to be presented mostly in the western part of Estonia. This fact may lead to the speculation that the high similarity between the tree ring curves is due to the timber trade as the construction wood for western Estonian buildings was presumably often imported from Gotland in the past. This presumption is however disproved by the highest correlation, t = 9·59, of the series of extant growing pines on Vormsi Island in Estonia with the Gotland pine chronology (Fig. 2). Even an untrained eye can recognize the similarity of the matched graphs of these tree ring series (Fig. 3). Thus, we can conclude that the sampled Estonian construction timber was not necessarily imported from Gotland, but the similarity of the tree ring curves is due to the similar climate on the Estonian and Swedish islands in the Baltic Sea.

Pine chronology of Gravsten, lying west from Estonia, reveals high correlation with the Estonian tree ring series from different parts of the area (Fig. 1). The highest t-value, 5·5, is revealed with some average series in eastern Estonia: Karlova Mansion and Uppsala House in Tartu, and Kursi Church (Fig. 4). Nevertheless, it is much lower than the t-value between Gotland chronology and Vormsi pines (where it is 9·6); hence, it does not allow presuming timber import from Gravsten to Estonia.

Pine chronology of Finnish Åland islands, situated in northwest from Estonia, yields generally lower t-values compared to the Estonian series than the previous reference chronologies. Still, it correlates well with several object series over Estonia. The highest t-value, 7·5, is with long pine series (205 years) of Karuse Church in western Estonia. Nevertheless, it does not mean that the timber was imported from Åland.

The pine chronology of southern Finland that is situated northward from Estonia reveals lower t-values with Estonian object series than the previous references. The highest t-value is reaching to 4·46 with the pine series of Tampere House in Tartu, southeastern Estonia.

The pine chronology of southeastern Finland provides t = 4·58 as the highest, with an average series of four objects from eastern Estonia (Nõo, Palamuse, Pilistvere churches, and Jakobi Street 45 in Tartu). From these similarities it is clear that the investigated Estonian construction timber did not originate from Finland but was rather of local origin.

Tree ring series of Bauska Church, southern Latvia (Zunde, personal commun, 1998), gave considerable correlation with three Estonian series; of them t = 5·73

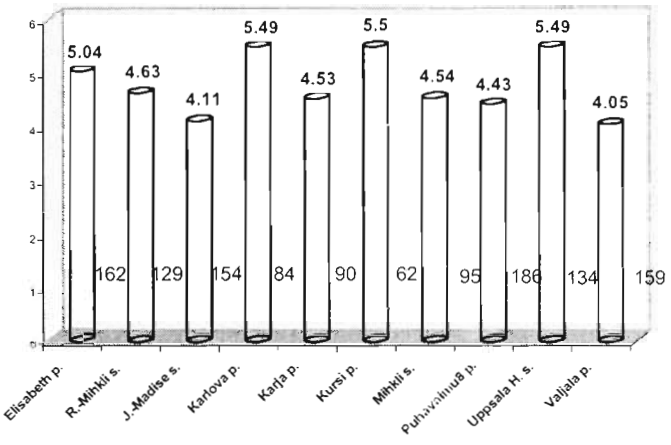

Fig. 4—Student's t-values of Estonian average pine series with Gravsten pine chronology (Bartholin, personal commun, 1998). Ordinate: Student's t-values. Abscissa: names (toponymes) of the average tree ring series. Numbers next to the bars show overlapping of the series in years, at the top of the bars - t-value; p. = pines, s. = spruces. All Estonian tree ring series refer to the construction wood

(overlapping 115 years) with Elisabeth Church pine series of Pärnu being the highest. A general Latvian pine chronology of modern trees dating from 1723-1972 AD (Špalte, 1979) showed significant correlation with series of growing pines in Vormsi, north-western Estonia (t = 8·22), Karepa, northern Estonia (t = 7·19) and Kiidjärve, south-eastern Estonia (t = 6·17), whereas the correlation with the tree ring series of construction timber was more modest (reaching t = 4·79 in case of Martna Church).

As to the Polish pine chronologies (Zielski, personal commun, 1989, 1992a, b, c, 1995), the Torun modern pines gave the highest t-value, 5·01, for growing pines in Vormsi, northwestern Estonia. Modern pines in the Valley of Wisla yielded also high t-value, 4·97, with the Vormsi pines, as well as the Polish chronology POLPINUS (t = 4·99). The northern Poland pine chronology yields somewhat lower t-values with some Estonian object series. It has to be mentioned that Bartholin and Zielski (1992) have found a high correlation between some church chronologies from northern Poland and several other chronologies from Sweden.

DISCUSSION

The fact that the t-values of the foreign reference chronologies are often higher with average series of growing pines than with the series of construction wood in Estonia make one suggest that the higher correlation may be caused to a certain extent by the preserved age trend of the trees both in the last end of the reference chronologies and in the Estonian modern tree ring series. As the average Estonian series of construction wood mainly consist of roughly even-aged tree

series, the average series also preserve their age trend. While correlated with a long reference chronology, the Estonian object series that contain age trend match with the middle part of the reference chronology built up by series of various ages and with suppressed age trend. Therefore, their correlation is lower than in the case of the two series that both contain age trend. The next task is to suppress the age trend in Estonian tree ring series by composing longer chronologies of uneven-aged tree ring series.

The relatively high t-values of the foreign reference chronologies with the series of growing pines in Estonia still allows to disprove the suggestion that the construction wood of some Estonian buildings was imported from Sweden. Apparently, the construction wood of the studied church roofs is of local origin. It does not eliminate the possibility of wood import to Estonia for other purposes during the past centuries.

As to the directions of the world, the Estonian tree ring series show generally better similarity with westward chronologies than with northern and southern ones (some available chronologies from Russia in the east did not yield considerable correlation with Estonian series). While attributing the similarity of the tree ring series to the climate, we can note that in the Baltic region the zone of similar climate extends mainly in the west-east direction. As there were no remarkable differences established in the correlation with foreign chronologies between the tree ring series from western and eastern Estonia, we can consider that the whole Estonia belongs to the same dendroclimatologically uniform region as other northern European countries. Tree ring chronologies from southern Finland and especially from Sweden that are situated on the same latitudes as Estonia can be successfully used for dating Estonian object series.

CONCLUSIONS

1. Tree ring chronologies of pine from the central part of Sweden, especially the Gotland pine chronology, correlate well with tree ring series from all over Estonia.
2. Tree ring chronologies of pine from southern and southeastern Finland correlate well with tree ring series from eastern Estonia.
3. Tree ring chronologies of pine from Poland correlate with some tree ring series from western Estonia.
4. The comparison of Estonian tree ring series with Lithuanian and neighbouring Russian tree ring chronologies should be carried out in the future.
5. The correlations allow to conclude that the area of Estonia belongs to the same dendroclimatological region as northern European countries, and the tree ring chronologies from close neighbouring areas, especially from western Sweden, can be used for dendrochronological comparisons and dating of Estonian tree ring series.

Acknowledgements—*This study was partly funded by the INCO Copernicus Project No. IC15-CT98-0123 of the European Union. I was able to carry out this comparative study only due to my kind colleagues T. Bartholin from Denmark, D. Eckstein from Germany, Ó. Eggertsson from Sweden, M. Lindholm and P. Zetterberg from Finland, M. Zunde from Latvia and A. Zielski from Poland, who gave their tree ring chronologies at my disposal. I wish to express my sincere thanks to all of them.*

REFERENCES

Bartholin T personal commun 1991. Chronology of Åland *Pinus* 1091-1777 AD.

Bartholin T 1993. Dendrochronology in building investigations in Sweden. *In*: Storsletten O & Thun T (Editors)—Dendrochronology and the Investigation of Buildings. Proceedings of an International Seminar at the Academy of Science and Letters, Oslo, 1st-2nd November 1991 : 14-17. Riksantikvarens Rapporter 22, Oslo.

Bartholin T personal commun 1998. Chronology of Gotland *Pinus* 1124-1987 AD.

Bartholin T personal commun 1998. Chronology of Gravsten *Pinus* 1469-1840 AD.

Bartholin T & Zielski A 1992. Dendrochronology of Pine (*Pinus sylvestris*) in Northern Poland. *In*: Bohr R *et al.* (Editors)—Some ecological processes of the biological systems in North Poland : 187-197. Nicholas Copernicus University Press, Torun.

Läänelaid A 1998. A network of tree-ring series in Estonia. *In*: Stravinskiene V & Juknys R (Editors)—Proceedings of the International Conference Dendrochronology and Environmental Trends, 17-21 June 1998, Kaunas, Lithuania, Kaunas : 264-270.

Läänelaid A 1999a. Juurdekasvupuuriga kirikusse... Eesti Loodus 1 : 12-15. (In Estonian, with English Summary: Boring for tree-ring chronology in churches.).

Läänelaid A 1999b. Aastarõngad ajaloouurimise teenistuses. Akadeemia 2 (119) : 362-370. (In Estonian: Tree rings in the service of history).

Lindholm M personal commun 1998. Chronology of SE Finland pines 1635-1765 AD.

Špalte EP 1979. Dendroshkaly sosnovykh drevostoev Latvijskoj SSR. Dendroklimatologicheskie shkaly Sovetskogo Soyuza. Kaunas, : 45-51. (In Russian: Dendro-scales of pine stands of Latvian SSR).

Zetterberg P personal commun 1998. Tree-ring chronology of pine of S Finland.

Zielski A personal commun 1989. Chronology of northern part of Poland (PL280039) 1558-1988 AD.

Zielski A personal commun 1992a. Chronology Polska srodkowa i polnocna (POLPINUS) 1168-1991 AD (In Polish).

Zielski A 1992b. Long-term chronology of Scots pine (*Pinus sylvestris* L.) in the northern part of Poland. Dendrochronologia 10 : 77-90.

Zielski A personal commun 1992c. Chronology of Polska - rejon dolnej Wisly (PLPINUS5), 1106-1991 AD (In Polish: A Polish chronology - region of the valley of Wisla).

Zielski A 1995. Współczesna chronologia sosny zwyczajnej (*Pinus sylvestris* L.) w rejonie Torunia. - Acta Universitatis Nicolai Copernici, Biologia 48, Nauki Matematyczno-Przyrodnicze - Zeszyt 93 : 203-222 (In Polish, with English Summary).

Zunde M personal commun 1998. Chronology of Bauska church, 129 years.