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THE SCOTS PINE CHRONOLOGY (1582-2004 AD) FOR THE SUWAŁKI REGION, NE POLAND

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Abstract: The presented dendrochronological research resulted in the construction of a pine standard for the Suwałki region, spanning the years 1582 – 2004 AD. The chronology was produced from 80 samples representing historical timbers and living trees. The historical timbers came from wooden structures of the churches in Sejny, Berżniki, Krasnopol, and Wieliczki, as well as from a few buildings in Suwałki, whereas the living-tree samples were taken in the Wigry National Park. The established chronology was compared with other regional standards for the neighbouring areas. The *t*-value for the compared standards fell in the range 6.2-18.9. Additionally, positive and negative signature years were defined. The over-four-hundred-year chronology opening possibilities of dating relevant timbers from architectural objects and archaeological excavations is a succeeding step in constructing of a multi-century pine standard for that region of Poland.

1. INTRODUCTION

Dendrochronological studies have been dynamically developing in Poland for over 20 years. They resulted in the construction of absolute regional standards, used as tools for absolute dating with one-year accuracy. Master chronologies spanning over 1000 years were constructed for three tree species: Scots pine *(Pinus sylvestris*) (Zielski, 1997), oak (*Quercus sp.)* (Ważny, 1990; Krąpiec, 1998), and fir (*Abies alba*) (Szychowska-Krąpiec, 2000). Because of climatic diversification of Poland, possibilities of application of these standards are restricted for individual regions of the country, the exception being the fir chronology of an over-regional extent with a strong dendrochronological signal, which is due to the low genetic variability of this tree species. Up to now the Suwałki region has been among the so-called 'white spots', i.e. regions for which there has not been any long regional chronology constructed so far.

Climatically, the Suwałki region substantially differs from other regions of Poland. Apart from the mountain areas, it is the coldest part of the country with an average annual temperature around 7°C. The climate there displays the most continental features, with predominance of air masses flowing from eastern and north-eastern Europe. The winters are long and frosty, with long-lasting snow and ice cover (between 90 and 110 days in a year), and the number of days with average temperatures below the freezing point (0°C) amounts to 108-119 in a year. The vegetation season in the region is shorter than in other parts of the Polish Lowland and the yearly rainfall is relatively low (Kondracki, 1998; Woś, 1999). Different climatic conditions are reflected, among others, in annual growth rings in trees, whose growth patterns are markedly different than in trees from the adjacent areas. Such an individual character of the Suwałki region brings about serious problems at any attempt of dating wood from this area. Therefore, in the Dendrochronological Laboratory of AGH-UST in Cracow, research on the construction of an absolute chronology for this region has been undertaken in order to enable absolute dating of timbers from historical objects and archaeological excavations. As the most commonly used tree species in the region was Scots pine, the attempted dendrochronological scale is based on this species.

2. MATERIAL AND METHODS

Material

Dendrochronological research was carried out on wood sampled from living trees and from wooden structures of both sacral and secular objects from towns and villages situated not further than 40 km from Suwałki. The analyses were made on wood from the following sacral objects: the church in Wieliczki, the monastery complex and basilica in Sejny, the church in Berżniki, and the church in Krasnopol. Apart from that, the samples were taken from two buildings in Suwałki, namely the Grammar School at 126 Kościuszki Str. and a dwelling house, undergoing repairs in the sampling time, at 74 Kościuszki Str. Additionally, samples were taken from living trees growing in the Wigry National Park (WPN). The location of the sampling sites is presented in **Fig. 1**. Altogether, 179 wood samples were collected.

Sejny

The town situated 36 km to the east from Suwałki is renown from its beautiful late-renaissance sacral complex: the monastery and basilica. These were the objects of the research. Samples for analyses were taken from roof structures of the monastery complex and the monumental church, presently Basilica of St. Lady Mary's Visit. The basilica, older than the monastery, was constructed in the years 1610-1632 by Dominican monks who arrived from Vilnius. In 1760 the basilica was reconstructed and today it represents the Vilnius Baroque style. Eight samples were taken from vertical posts above the main nave and three others from horizontal tie-beams, also over the main nave. The structure supporting the bell was sampled with six samples. In all the above cases the collected samples represented pinewood. An additional sample, of oak wood, was taken from the bed of the bell.

The two-storey monastery, adjacent to the basilica, of rectangular shape, somehow resembling a fortified castle with corner towers, was built in 1730. Nineteen wood samples were taken from the following elements of the roof structure: horizontal tie-beams, vertical posts, and truss-posts reinforcing the whole structure. All the collected samples represented pinewood.

Berżniki

The village, situated off the main roads, near the Lithuanian border, is the oldest settlement in the Suwałki region, established on the Magdeburg law by the Queen Bona in the sixteenth century. There is a wooden church of Assumption of St. Lady Mary from 1819, a wooden belfry from the mid-nineteenth century, and the whole is surrounded by a wall with a gate and two wooden and brick chapels, also from the middle of the nineteenth century. Near the church, on the opposite site of the road there is a wooden presbytery, dated to the end of the eighteenth or the beginning of the nineteenth century. Dendrochronological samples were taken from ceiling beams in the living room of the presbytery (3 samples) and two beams from the outer and inner walls. All five samples represented pinewood. In the second object, the belfry, three vertical posts were sampled. Most samples were taken, however, from the roof structure of the church; from the beams lying over the vault of the nave, beams over the aisles, the second and third framework, and a framework near the altar. Altogether 32 samples were taken from wooden elements of the presbytery, the belfry, and the church in Berżniki.

Wieliczki

In Wieliczki, a village existing since 1540, attention should be paid to the wooden church of Nativity of St. Lady Mary from 1676/77, renovated in 1925 – 1927, up to now considered to be of larch. Samples were taken from

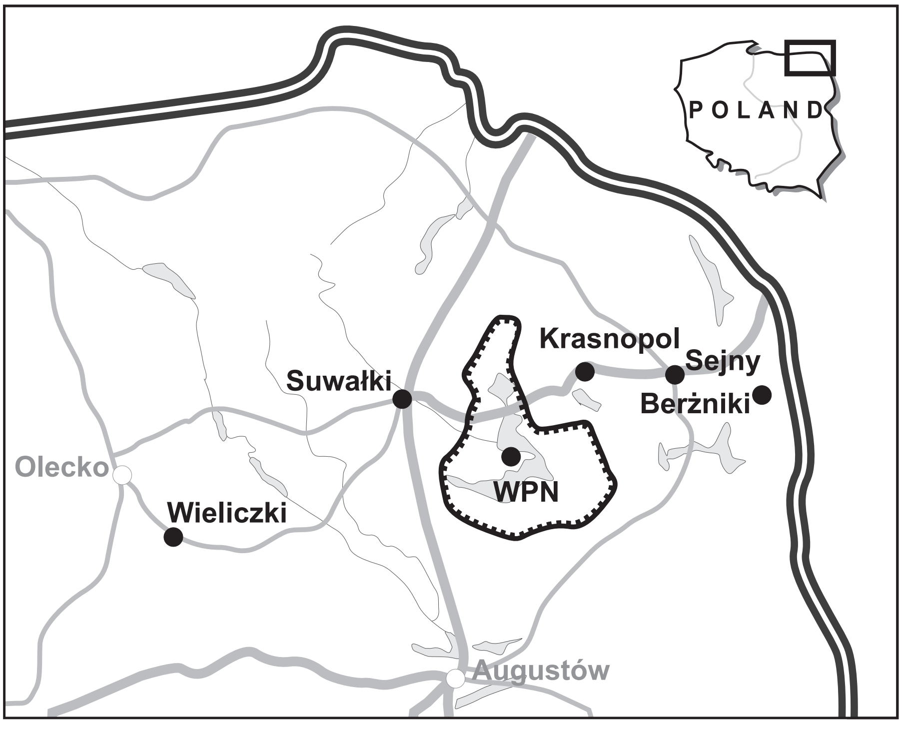

Fig. 1. Location of sites of sampling wood used for the construction of the regional standard for the Suwałki region.

both storeys of the roof structure of the church and from the tower. Fifteen samples were taken from vertical posts and horizontal beams of the higher storey, seven from posts and truss-posts of the church tower, and nine others from the lower storey. In all cases the collected samples represented pinewood.

Krasnopol

The village church of Lord's Transfiguration, dating back to the nineteenth century, was built in the classicistic style. All seven samples taken from the roof structure of the church represented the same tree species; Scots pine.

Suwałki

Dendrochronological research there was made in two buildings situated at the Kościuszki Street. The first one is the Grammar School no 1 (126 Kościuszki Str.), where twelve wood samples were taken from floor beams, vertical posts supporting the whole structure, and planks fastening the structure of the roof. All the collected samples represented pinewood. The second object in which the research was carried out was a dwelling house (74 Kościuszki Str.), having been renovated just at the time of sampling. Easy access to all wooden elements of the structure resulted in a large number (49) of taken samples; all of them turned out to represent pinewood.

Wigry National Park

Samples for the analyses were taken in the northern part of the Park, from huge, predominating trees with fully developed canopies, devoid of any symptoms of illness or damages. In all cases the investigated trees were over 100 years old; such trees most accurately reflect their characteristic physiological features in dimensions of annual growth rings.

Methods

The samples were taken in various forms. Most of them were in the form of cores, taken from both living trees as well as historic timbers. The living trees were sampled with a Pressler increment borer, 0.5 cm in diameter. In cases of historic timbers cores were taken with a mechanical borer coupled with an electric, high-power drill, and where possible, samples were taken in the form of slices, cut out with a hand or electric saw. All samples were subjected to preparation, consisting in cutting the outermost layer of wood, 2-3 mm in thickness, in order to obtain legible anatomical structure enabling the identification of borders between tree rings in cross-sections. Measurements of tree-ring widths, with 0.01mm accuracy, were performed in the Dendrochronological Laboratory, Faculty of Geology, Geophysics and Environmental Protection AGH-UST in Cracow, with an apparatus DENDROLAB 1.0 and computer registration of the results. A set of computer programs TREE-RINGS (Krawczyk and Krąpiec, 1995) was used for the treatment of the measured sequences of annual growth rings. A local average pattern was established for each of the investigated sites. The absolute dendrochronological standard for the Suwałki region was produced from the components of these mean patterns, after averaging the individual sequences and checking the correctness of the synchronization of annual growths and the degree of their homogeneity with the computer program COFECHA (Holmes, 1994).

3. RESULTS

Altogether 179 wood samples were measured. In the first step of the research, based on individual samples, site chronologies for all the investigated objects were constructed.

Site chronologies

The site chronologies were produced from such individual sequences which displayed the highest mutual similarities and convergent shapes of the dendrograms. As a result, eight site chronologies were established for the following objects:

– the basilica and monastery in Sejny (2)
– the church in Berżniki (1)
– the church in Wieliczki (1)
– the church in Krasnopol (1)
– the Grammar School no 1 in Suwałki (1)
– the dwelling house in Suwałki (1)
– the Wigry National Park (1)

Sejny

Two separate chronologies were constructed for the monastery complex and for the basilica, respectively. The chronology for the monastery, encompassing the years 1581 – 1693 AD, was produced from ten mutually best correlating samples (**Fig. 2**). The individual sequences contained between 50 and 112 increments. Out of twenty collected samples, ten were absolutely dated; nine from horizontal tie-beams and one from a vertical post. The data obtained fell into the range 1638 – 1693 AD. However, as none of the analysed samples retained the last sapwood ring, it was impossible to determine the exact year of felling the trees, from which the timbers were used for the construction of the monastery. It may be only stated that the wood used for construction of the roof proved to be older than the time of building the monastery (1730). The second average pattern, based on samples taken from the basilica, covers the period 1633 – 1770 AD. It was produced from ten samples, of which individual sequences contained from 51 to 90 growth rings (**Fig. 3**). All of them were devoid of the last sapwood ring which could have indicated the date of felling the trees. The results obtained fell into the range 1698 – 1770 AD. The oldest date (after 1698 AD) was noted for a horizontal tie-beam from the wooden structure over the arch vault of the basilica. Somewhat younger data (1733 – 1757 AD) were obtained for timbers forming the structure supporting the bell. Taking into account the renovation of the basilica in 1760, the timbers of the bell support were supposedly replaced in that time. Vertical posts forming the structure over the arch vault of the nave mostly came from trees cut down in the second half of the eighteenth century, so they had to have been introduced into the structure of the roof already after having finished the renovation in 1760. Unfortunately, none of the analysed wood samples repre-

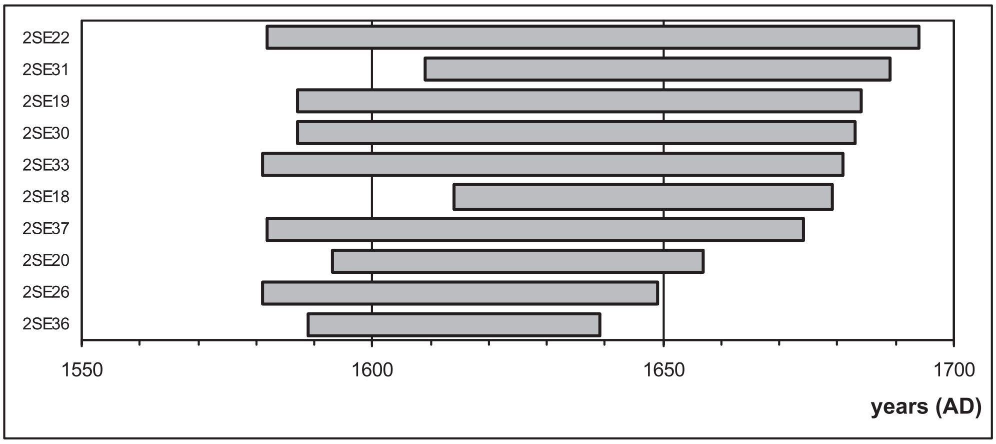

Fig. 2. Growth sequences from the monastery complex in Sejny forming the site chronology, spanning the years 1581-1693 AD.

sented the oldest wood, from the time of building the basilica.

Berżniki

Based on wood from the church and the presbytery, a site chronology, covering the years 1665 – 1885, was produced from 19 samples. Individual sequences contained from 54 to 134 tree rings. Samples of timbers from the presbytery represent two time intervals: the eighteenth (2BER1, 2, 3) and the nineteenth century (2BER4) (**Fig. 4**). Ceiling beams in the presbytery were made of pine trees cut down in the second half of the eighteenth century (after 1765 and after 1770 AD), which might indicate that the building could have been constructed at the end of the eighteenth century. On the other hand, a nineteenth-century beam in the outer wall of the presbytery is apparently a testimony of a renovation at the end of the century. In the case of timbers from the church the date range is rather broad – from 1772 to 1891 AD. The oldest dating was obtained for wood from the third framework over the right aisle (1772 AD) and for the framework near the altar (1787 AD). Because of lack of the last sapwood rings it is impossible to precisely determine the period of felling the trees these elements were made of. The other dates are younger; the beginning as well as the end of the nineteenth century. These from the beginning of the century (1801 and 1806 AD) correspond to building of the church in 1819, whereas the younger ones (1825 – 1832 AD and 1885 – 1891 AD) – two phases of its renovation. The dendrochronological analysis confirms that the rectory is older, built as early as at the end of the eighteenth century. Subsequently, in the beginning of the nineteenth century, the church was constructed, partly from older timbers, apparently at hand after demolition of an earlier existing sacral building.

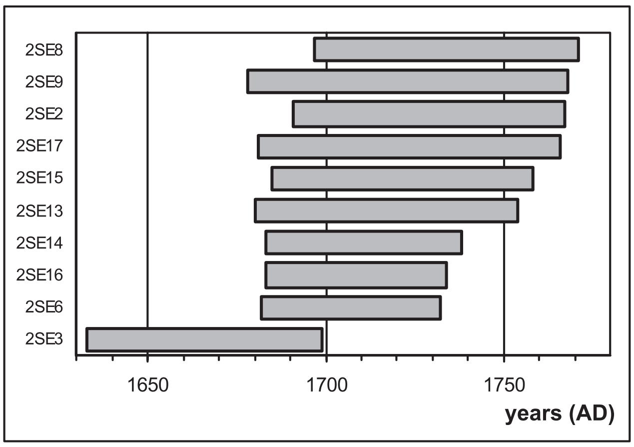

Fig. 3. Dendrochronological dating of growth sequences of samples from the basilica in Sejny.

Wieliczki

Using the best correlating individual sequences of timbers sampled from the church, the 101-year-long site chronology, covering the period 1592 – 1692 AD, was constructed (**Fig. 5**). The length of the individual patterns was diversified, from 44 to 91 annual growth rings. The wood from the structure of the roof over the main nave was dated to the years 1675 – 1677; the youngest sapwood rings retained in some samples enabled precise dating with one-year accuracy. These data coincide with the historic date of building the church in 1677. The timbers from the structure of the tower and from the higher storey of the church roof turned out to be younger, from the 1690s (1692 AD). This may indicate that both, the tower and the second storey were built several years later than the principal structure of the church. There has been common opinion that the church in Wieliczki was built from the larch wood. In any of the wooden elements sampled, however, wood of this species has not been recognised. All the analysed timbers were made of wood of Scots pine.

Krasnopol

Samples from the structure of the church roof enabled to construct the 156-year site chronology, covering the period 1703 – 1858 AD. It consists of six samples, of which individual sequences contained from 81 to 151 increments (**Fig. 6**). As in three samples the youngest dating rings were preserved, they could be precisely dated to 1858. The remaining samples represent timbers dated to a few years earlier, but taking into account the lack of some sapwood rings, these timbers apparently also came from trees cut down in the same year, i.e. in 1858. Allowing for the time necessary for seasoning the wood, it is worth to note that the result of dating is in perfect agreement with historic data on building the church in 1862.

Suwałki

Analysis was made for twelve samples of wood coming from floor beams, vertical posts, and planks support-

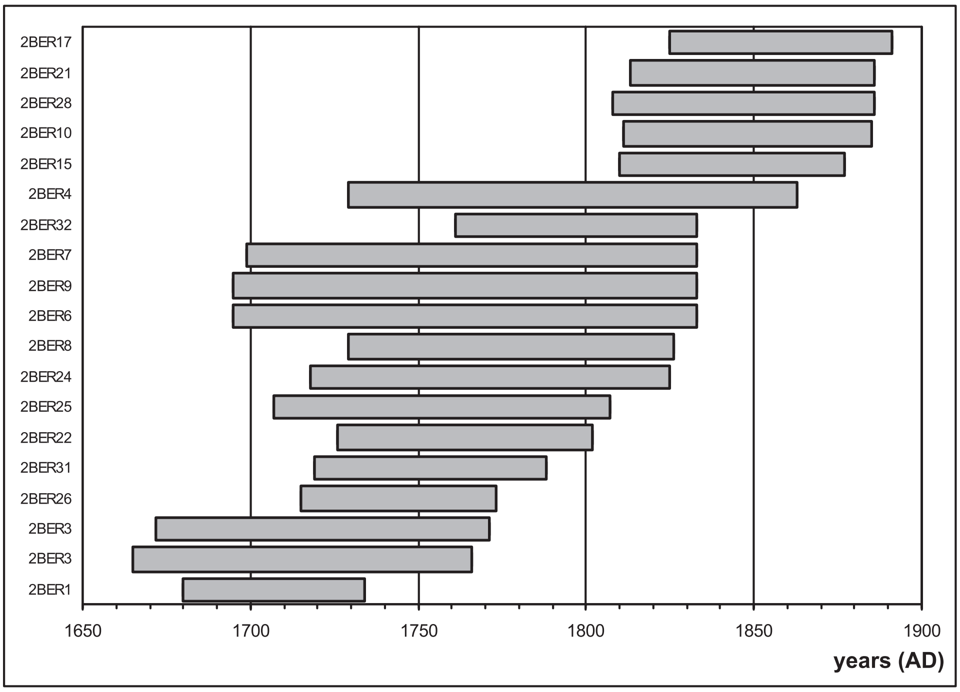

Fig. 4. *Growth sequences from the church and the presbytery in Berżniki forming the site chronology, spanning the years 1665-1885 AD.*

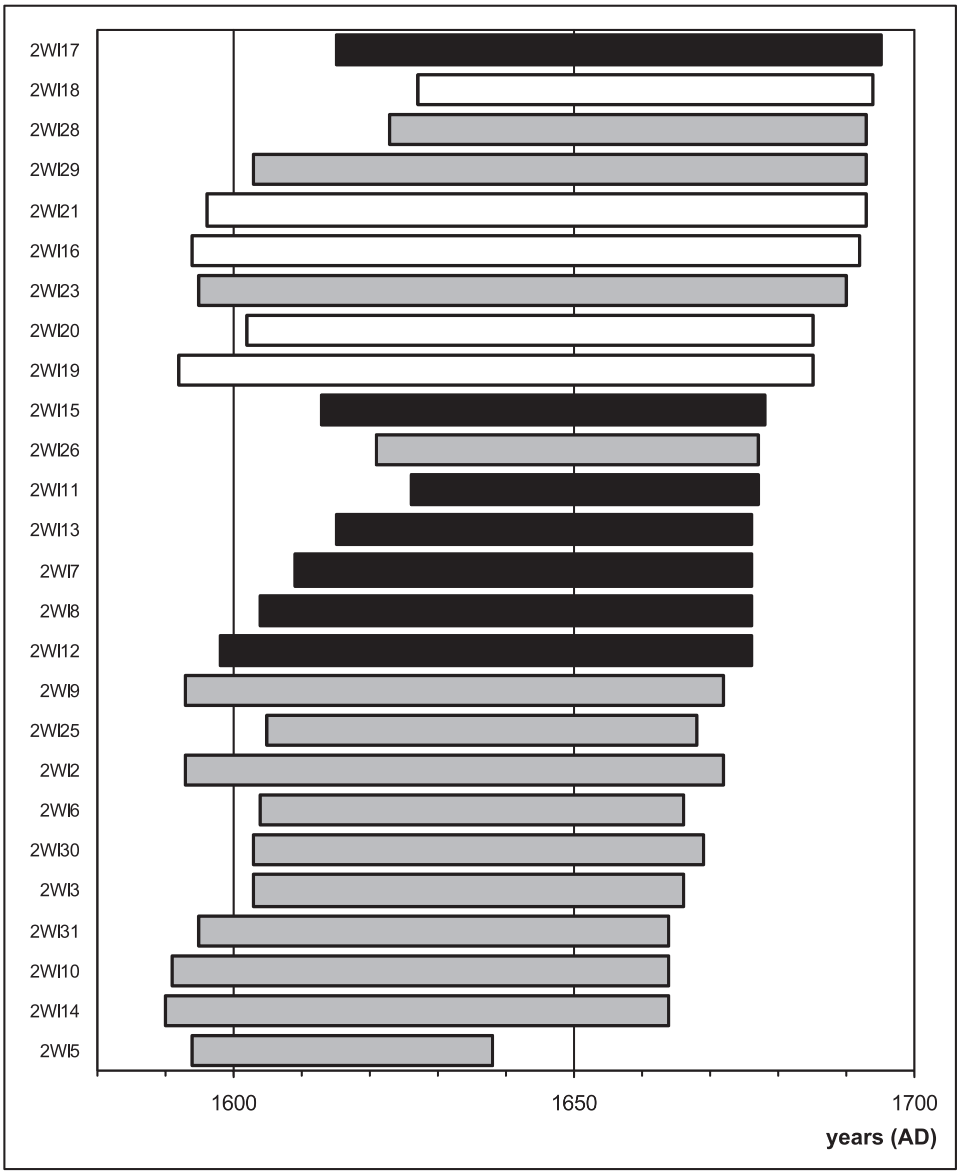

Fig. 5. *Growth sequences from the church in Wieliczki forming the site chronology, spanning the years 1592 -1692 AD (black colour – samples with the youngest sapwood ring;. white colour – samples from the structure of the tower).*

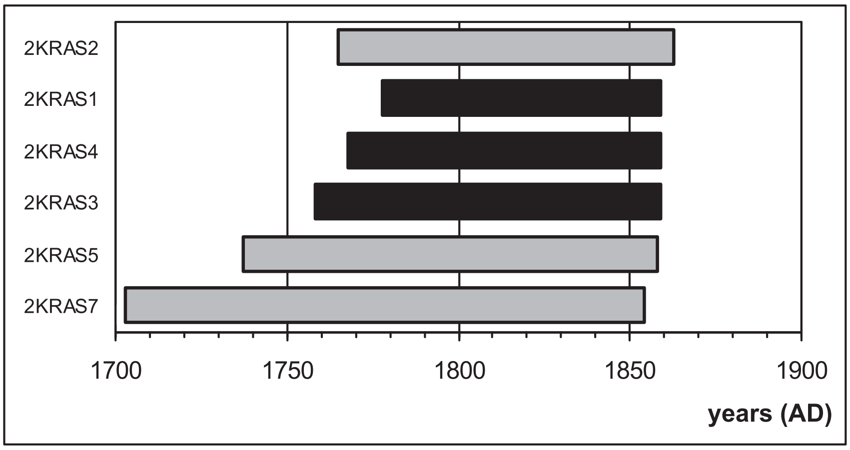

Fig. 6. *Correlation diagram of samples from the roof structure of the church in Krasnopol (black colour – samples with the youngest sapwood ring).*

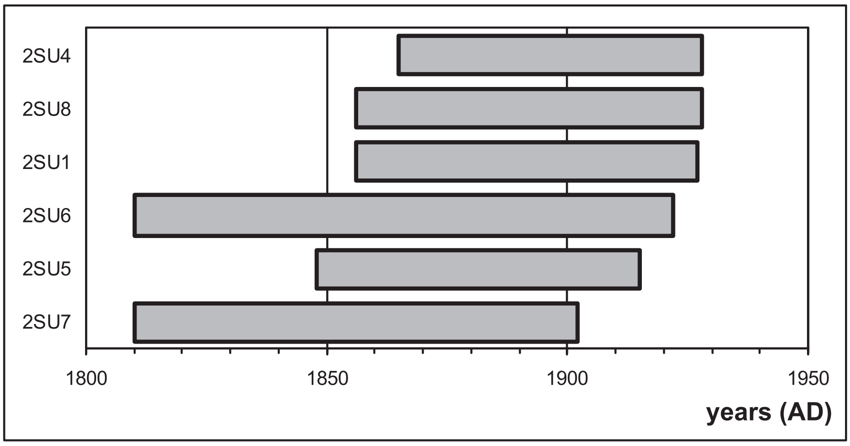

Fig. 7. *Correlation diagram of samples from floor beams in the Grammar School in Suwałki.*

ing the roof structure of the building of the Grammar School no 1. Six elements of this structure were absolutely dated; the youngest annual growth rings preserved corresponded to the range 1901-1927 (**Fig. 7**). As all the analysed timbers were devoid of the last sapwood rings, more exact dating of cutting down the trees these elements were made of, with a one-year accuracy, was impossible. The analysis carried out allows assuming that the roof structure of the building was built of wood from trees felled in the beginning of the 1930s.

The second object from Suwałki subjected to dendrochronological studies was a renovated dwelling house at 74 Kościuszki Street. The renovation works considerably facilitated the access to wooden structures of all storeys of the building, enabling detailed sampling in the form of slices and cores. The samples were taken from ceiling planks of the first storey, wooden structure of the roof, as well as from spare timbers, removed from the building and gathered at hand. Abundance of the material enabled to compile the 257-year-long site chronology spanning the period 1596-1852 AD (**Fig. 8**). The length of the individual sequences was highly diversified, from 48 to 222 rings; in some samples the outermost sapwood ring was observed. Most of the samples with completely preserved ring patterns were dated to 1817, which could indicate that the building had been constructed at the end of the 1810s, in a period of fast development of the town after having located there the seat of the authorities of the Augustów voivodeship in 1816. In that time, construction of wooden houses in the centre of the town was banned, so they were built, among others, along the Kościuszki street. The older timbers, from the 1760s, could have been re-used for the construction of the house, whereas the younger ones, from mid-1850s, might suggest mending or renovation of the building.

Wigry National Park

Fourteen samples were taken in the Krusznik forest district, branch no 248. All sampled trees were over 100-year-old pine trees of ages between 124 and 231 years. The trees around 150-year-old were prevailing, only two were older than 200 years (212 and 231 increments). The established average pattern, 231 years in length, covers the period 1774-2004 AD.

Regional chronology

Based on the constructed site chronologies for individual objects and sites, the regional standard for the Suwałki region was established; 423 years in length and covering the period 1582-2004 AD. It was produced from 80 absolutely dated samples coming from historic wood from various objects and living trees. **Table 1** presents characteristics of individual samples included into the standard: correlation with master (correlation coefficient r and *t*-value), mean width ring, standard deviation, autocorrelation, and mean sensitivity. After mutual synchronisation of the individual sequences and testing them with the program COFECHA, the standard chronology was established, multiply replicated on its whole

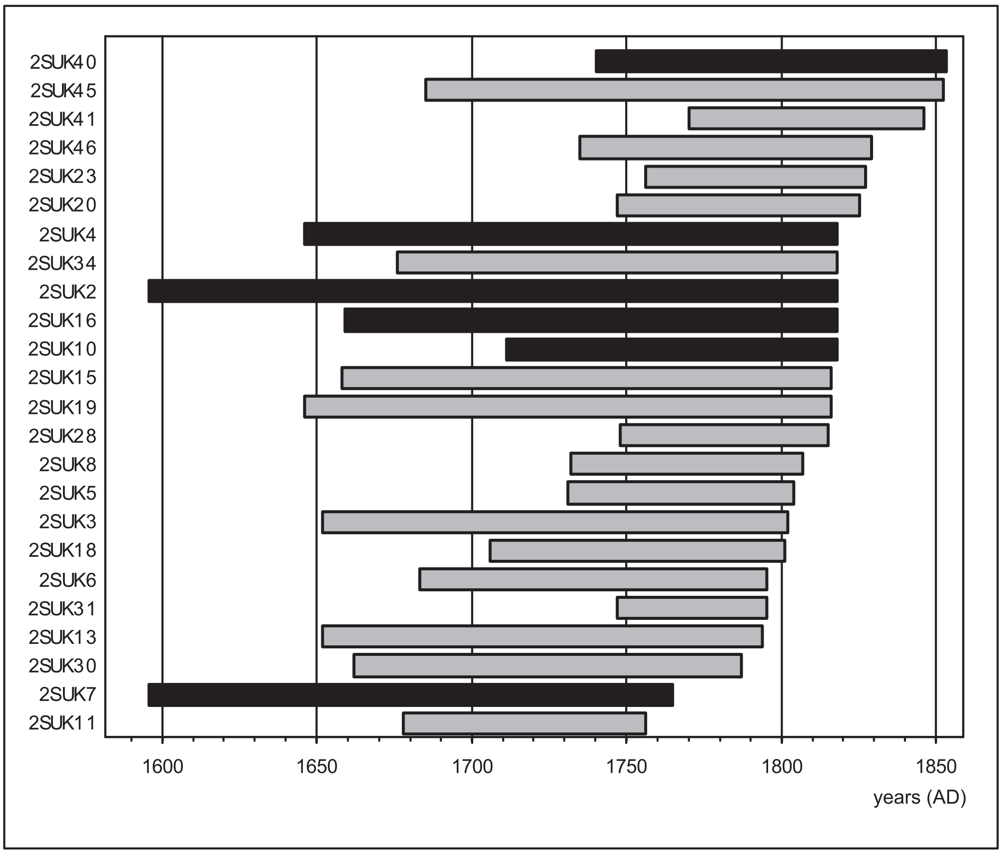

Fig. 8. *Growth sequences from the dwelling house in Suwałki forming the site chronology, spanning the years 1596-1852 AD (black colour – samples with the youngest sapwood ring).*

length, except the first 20 years, where it is based on less than ten samples. For the period between 1600 and 2004 the minimal number of samples amounts to twelve. Covering of subsequent periods with samples is, however, not uniform. The maximal replication, expressed by the highest number of samples (over 30) takes place in the years 1731-1801; whereas twenty and more samples form the standard in the intervals: 1652-1665, 1680-1730, 1802-1832, 1861-1862, and 1865-1901 (**Fig. 9**).

A starting point for the construction of the absolute standard was the local chronology established from living trees growing in the Wigry National Park, where the youngest analysed increments corresponded to the year 2004 on the time scale. With older and older site chronologies produced from historic wood samples, starting from the average pattern for the Grammar School in Suwałki and finishing with the master for the monastery in Sejny, the 423-year-long standard was established.

In order to verify accuracy and correctness of the standard construction, signature years were determined; positive in the case of larger increments than in the previous year, and negative, when the increments for a given year are narrower than a year earlier. The commonly assumed criterion for determination of signature years is a one-direction change observed at over 90% of the analysed annual growth sequences and at a population of at least ten trees. Scots pine is a species that reacts on unfavourable climatic conditions (temperature and rainfall) with variations in size of cambial increments. Particularly remarkable relationships concern low temperatures in January, February, and March, which are manifested by reductions of tree-ring widths in a given year. Also the amount of rainfall in the spring-summer season (April-August) affects the size of annual increments (Zielski, 1996; Feliksik *et al*., 2000). In the newly established chronology for the Suwałki region twenty-five negative signature years were determined, in eight of them 100% of the analysed trees reacted in the same way. The highest numbers of negative signatures (seven) occurred in the eighteenth and the twentieth centuries, whereas the lowest number (only two) – in the nineteenth century. Reliable explanation of the causes of formation of all negative signature years is impossible, but in numerous cases narrow increments were brought about by very frosty winters, e.g. the winter of 1739/40, persisting from October till May and considered as one of the three most frosty and longest in the last 400 years. Frosty and cold winters are also responsible for narrow tree rings in the years 1928, 1931, and 1940 (Inglod, 1968). Moreover, dry summers, with a shortage of rainfall, might bring about negative years; it was the case of the summer of 1689 (Inglod, 1968), which affected the annual increments in 1690. A combination of unfavourable climatic factors, like a dry summer followed by a frosty winter, also negatively affects radial growths, as e.g. in 1616.

Opposite combinations of climatic elements result in positive signature years, e.g. 1965 or 1972, when mild winters and higher than yearly average summer precipitations (Janowska, 1977) triggered formation of wide increments. Abundant summer rainfall, even combined with floodings, also positively affects the size of annual growths, which may be indicated by the year 1772, proved to be a posi-

Tabela 1. *Samples forming regional chronology of pine for the Suwałki region.*

Lp.	Laboratory code	Dating of sequences	No of years	Correlation with master (r)	Mean width deviation	Standard ring (mm)	Autocorrelation	Mean sensitivity
1	2BER10	1805-1878	74	0.514	1.93	1.165	0.896	0.176
2	2BER17	1825-1890	66	0.404	1.71	0.466	0.543	0.205
3	2BER22	1726-1801	76	0.433	2.22	0.837	0.850	0.149
4	2BER25	1707-1806	100	0.616	1.99	0.800	0.768	0.222
5	2BER26	1715-1772	58	0.583	3.02	1.669	0.889	0.200
6	2BER31	1719-1787	69	0.447	1.88	0.971	0.735	0.288
7	2BER32	1761-1832	72	0.669	1.19	0.541	0.822	0.217
8	2BER4	1729-1862	134	0.385	1.25	0.745	0.855	0.253
9	2BER6	1695-1832	138	0.435	0.98	0.541	0.867	0.208
10	2BER7	1699-1832	134	0.582	1.12	0.673	0.871	0.212
11	2BER9	1695-1832	138	0.538	0.93	0.795	0.917	0.196
12	2KRAS3	1758-1858	101	0.508	1.40	1.345	0.894	0.307
13	2SE13	1680-1753	74	0.503	1.89	1.069	0.856	0.202
14	2SE15	1685-1757	73	0.554	1.61	0.643	0.806	0.225
15	2SE17	1681-1765	85	0.613	2.17	1.275	0.899	0.192
16	2SE2	1691-1766	76	0.575	1.92	1.423	0.955	0.188
17	2SE22	1582-1693	112	0.460	1.09	0.779	0.904	0.273
18	2SE23	1731-1790	60	0.671	2.27	0.668	0.623	0.219
19	2SE3	1633-1698	66	0.473	2.76	1.898	0.881	0.235
20	2SE30	1587-1682	96	0.500	1.37	0.471	0.792	0.167
21	2SE31	1609-1688	80	0.583	1.87	0.834	0.803	0.217
22	2SE36	1589-1638	50	0.505	2.57	1.145	0.851	0.205
23	2SE6	1682-1731	50	0.496	2.24	1.607	0.934	0.176
24	2SE8	1697-1770	74	0.516	1.80	0.860	0.789	0.262
25	2SE9	1678-1767	90	0.621	1.70	1.093	0.923	0.213
26	2SU04	1865-1927	63	0.616	1.71	0.733	0.789	0.213
27	2SU05	1848-1914	67	0.596	1.85	0.674	0.815	0.180
28	2SU06	1810-1921	112	0.521	1.08	0.595	0.661	0.219
29	2SU07	1810-1901	92	0.473	1.40	0.620	0.841	0.173
30	2SU08	1856-1927	72	0.342	1.54	0.778	0.884	0.188
31	2SU1	1856-1926	71	0.592	2.24	1.121	0.838	0.218
32	2SUK10	1711-1817	107	0.732	2.12	1.182	0.824	0.213
33	2SUK11	1678-1755	78	0.643	2.06	1.010	0.835	0.169
34	2SUK12	1790-1852	63	0.534	2.30	1.112	0.731	0.254
35	2SUK13	1652-1793	142	0.619	1.54	1.054	0.920	0.236
36	2SUK14	1752-1852	101	0.390	1.72	1.452	0.954	0.186
37	2SUK15	1658-1815	158	0.606	1.23	0.930	0.948	0.198
38	2SUK16	1659-1817	159	0.629	1.52	0.671	0.887	0.170
39	2SUK19	1646-1815	170	0.606	1.22	0.502	0.787	0.206
40	2SUK2	1596-1817	222	0.503	1.01	0.552	0.769	0.250
41	2SUK20	1747-1824	78	0.467	1.17	0.451	0.793	0.199
42	2SUK21	1639-1733	95	0.315	1.25	0.490	0.766	0.217
43	2SUK28	1748-1814	67	0.479	1.23	0.349	0.579	0.193
44	2SUK3	1652-1801	150	0.639	1.45	0.801	0.891	0.196
45	2SUK34	1676-1817	142	0.601	1.43	1.133	0.928	0.223
46	2SUK36	1613-1714	102	0.411	1.47	0.687	0.841	0.204
47	2SUK38	1793-1849	57	0.623	2.04	0.549	0.516	0.210
48	2SUK4	1646-1817	172	0.554	1.41	0.872	0.874	0.209
49	2SUK40	1740-1852	113	0.507	0.81	0.447	0.898	0.215
50	2SUK41	1770-1845	76	0.671	1.41	0.948	0.929	0.205
51	2SUK45	1685-1851	167	0.585	0.66	0.564	0.942	0.181
52	2SUK46	1735-1828	94	0.618	1.49	0.829	0.837	0.244
53	2SUK5	1731-1803	73	0.526	2.99	1.289	0.881	0.174
54	2SUK6	1683-1795	113	0.519	1.73	0.937	0.942	0.161
55	2SUK7	1646-1814	169	0.633	1.22	0.501	0.811	0.190

Lp.	Laboratory code	Dating of sequences	No of years	Correlation with master (r)	Mean width deviation	Standard ring (mm)	Autocorrelation	Mean sensitivity
56	2SUK8	1732-1806	75	0.556	2.82	1.327	0.896	0.163
57	2WI12	1598-1675	78	0.443	1.55	0.950	0.853	0.202
58	2WI14	1590-1663	74	0.512	1.95	0.894	0.835	0.208
59	2WI16	1594-1691	98	0.585	1.90	1.137	0.866	0.239
60	2WI2	1593-1671	79	0.467	2.39	1.044	0.812	0.183
61	2WI21	1596-1692	97	0.544	1.53	0.902	0.854	0.263
62	2WI3	1603-1665	63	0.531	1.65	0.665	0.726	0.257
63	2WI31	1595-1663	69	0.497	2.34	0.986	0.831	0.175
64	2WI5	1594-1637	44	0.597	3.14	0.764	0.663	0.161
65	2WI6	1604-1665	62	0.521	2.45	0.690	0.486	0.220
66	2WI8	1594-1665	72	0.621	1.83	0.813	0.601	0.258
67	2WPN11	1793-2004	212	0.564	1.72	1.240	0.909	0.231
68	2WPN20	1774-2004	231	0.547	1.48	0.697	0.820	0.243
69	2WPN25	1827-2004	178	0.603	1.18	0.619	0.783	0.267
70	2WPN46	1822-2004	183	0.579	1.32	1.006	0.893	0.278
71	2WPN50	1857-2004	148	0.466	3.08	2.045	0.915	0.211
27	2WPN56	1809-2004	196	0.472	1.36	1.053	0.890	0.268
73	2WPN63	1855-2004	150	0.635	1.25	0.926	0.894	0.290
74	2WPN64	1856-2004	149	0.590	1.50	0.902	0.892	0.230
75	2WPN70	1874-2004	131	0.514	1.84	0.752	0.813	0.221
76	2WPN65	1850-2004	155	0.428	1.24	0.642	0.780	0.270
77	2WPN66	1861-2004	144	0.537	1.20	0.683	0.809	0.264
78	2WPN67	1853-2004	152	0.640	1.23	0.557	0.741	0.263
79	2WPN68	1881-2004	124	0.589	1.71	0.707	0.718	0.256
80	2WPN69	1853-2004	152	0.672	1.47	0.610	0.591	0.312

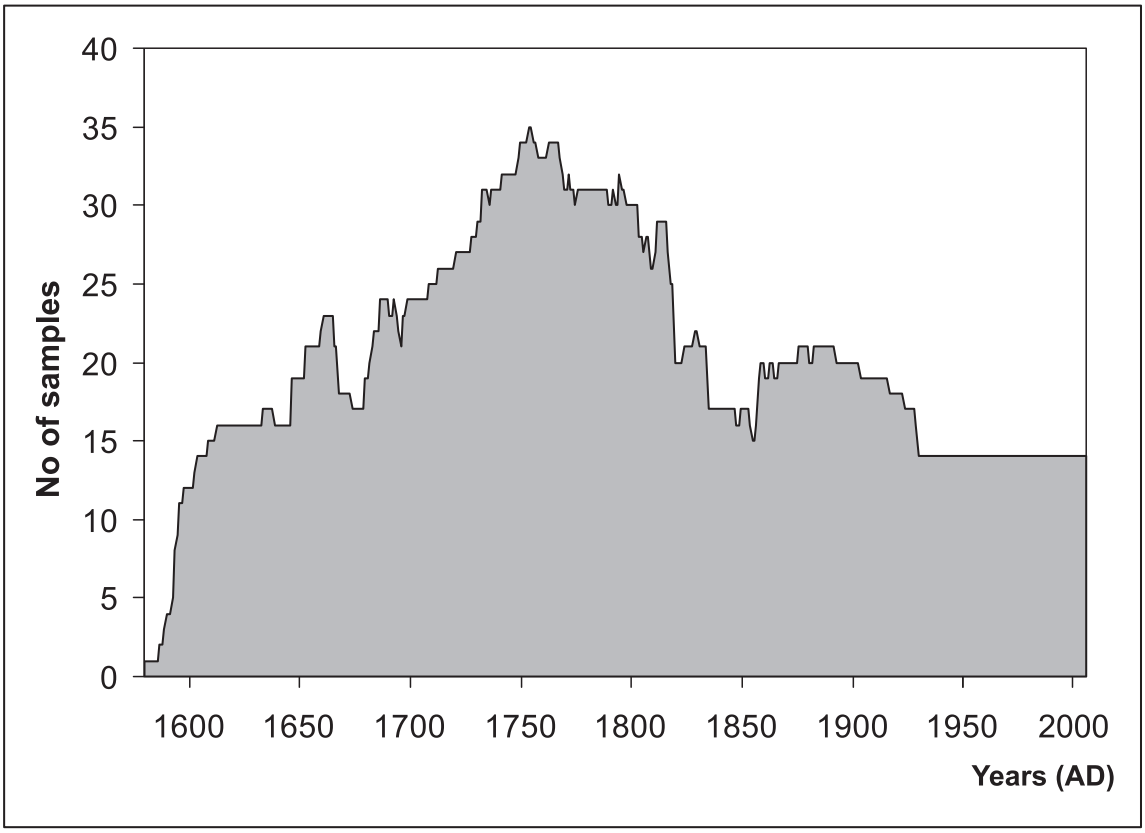

Fig. 9. *Replication of the tree-ring sequences in the Suwałki regional chronology in the period 1582-2004.*

tive signature not only at pine trees but in the fir population as well. The signature years are an important indicator, displaying the responses of trees growing in various habitats on extreme climatic conditions. The latter, influencing the annual increments, are reflected by a uniform reaction of trees, either positive or negative.

Another method of checking the correctness of the construction of the standard is teleconnecting it with chronologies established for the adjacent areas. Two factors decide about positive effect of teleconnection: a distance and similar climatic conditions. The standard established for the Suwałki region was compared with the following absolutely dated dendrochronological standards:

– N Poland (1106 - 1991 AD) – (Zielski, 1997)
– Pomerania - Kujawy region (1168 - 1987 AD) – (Krąpiec *et al*., in print)
– Gotland (1124 - 1987 AD) - (Bartholin, 1987)
– Mazury 2MAZ_0X (1518 - 2004) – (Szychowska-Krąpiec and Krąpiec, unpublished)
– Małopolska 2STAND 3 (1622 - 1996 AD) – (Szychowska-Krąpiec, 1997)
– central Deutschland (924 - 1995 AD) – (Heußner, 1996)

The highest similarity, expressed by the *t*-value of 18.9, was noted for the Suwałki standard and the regional chronology for the neighbouring Mazury region (Szychowska-Krąpiec, Krąpiec, unpublished) **(Fig. 10)**. Such a high convergence value is due to relatively low distance between the areas in which the pine-tree populations defining both standards grew and to relatively uniform dendrochronological signal, created by similar climatic factors. The latter is confirmed by dendroclimatical studies, indicating that the regions of Mazury and Suwałki lie in the same dendroclimatical region (Wilczyński *et al*., 2001). Somewhat lower similarity (*t*-values around 11-13) was noted in the comparison with two chronologies, both of them almost thousand-year long, for N Poland and the Kujawy-Pomerania region. Higher convergence with the N Poland regional standard ($t=13.6$) is apparently caused by its stronger dendrochronological signal, of larger extent than the chronology established for the Kujawy-Pomerania region (lower *t*-value of 11.5). Teleconnection with chronologies constructed for more distant areas indicated lower similarity (*t*-values below 10). Among these chronologies the attention should be paid to relatively high similarity of the Suwałki standard with the Gotland chronology ($t=9.1$), in spite of the fact that Gotland is an island. Convergence with the two remaining standards, for central Germany and Małopolska is similar, with *t*-values around 6. In case of the German chronology ($t=6.8$), the similarity is relatively low, which is apparently due to large distance between these two regions, over 1000 km. The lowest similarity was noted between the Suwałki and Małopolska chronologies ($t=6.2$), which is related to different climatic conditions in southern and northern

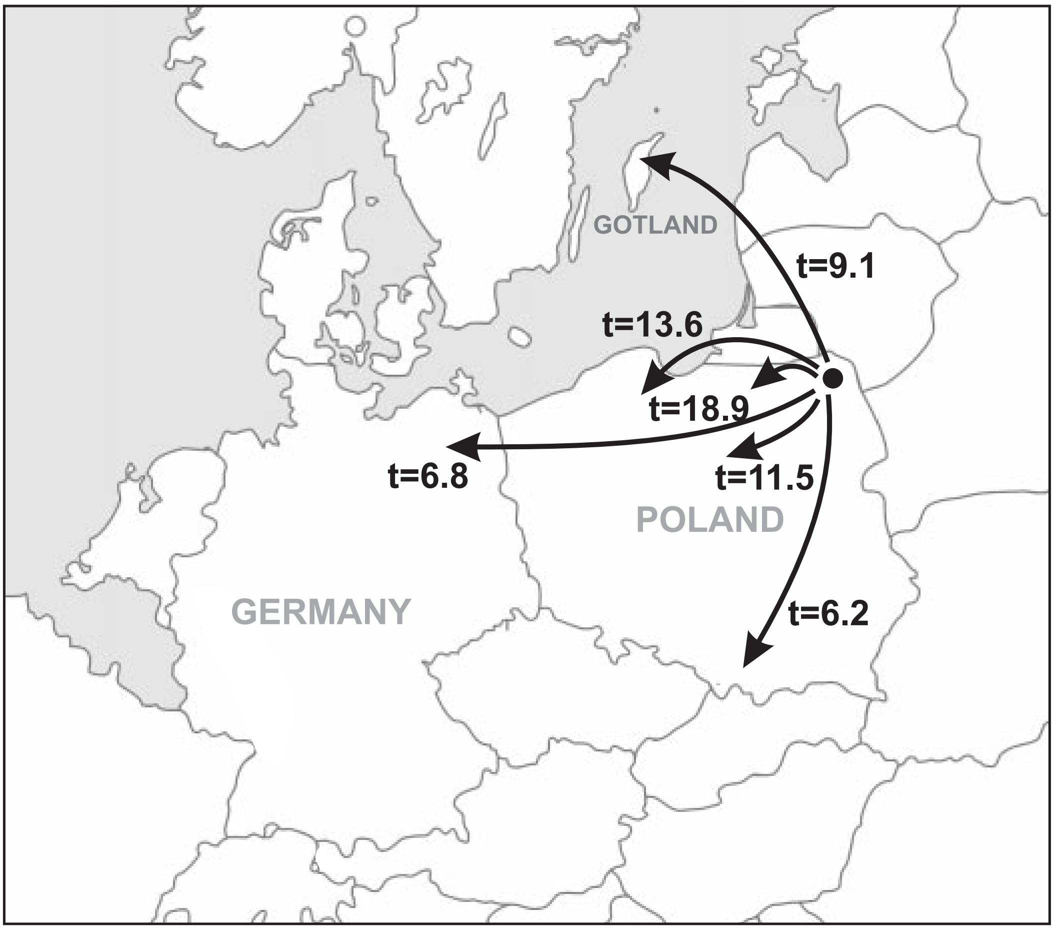

Fig.10. *Teleconnection of the chronology from the Suwałki region with other pine standards.*

Poland. This is confirmed by dendroclimatical studies performed on recent populations of pine trees in Poland, resulting in distinguishing of nine dendroclimatical regions on the basis of tree-ring width sequences. The principal factors differentiating the chronologies in the direction north-south are thermal and pluvial conditions in the summer (Wilczyński *et al.,* 2001).

The teleconnection carried out confirms the correctness of the construction of the Suwałki chronology and, at the same time, displays the pattern of similarity to some other selected chronologies. Apart from the most similar Mazury chronology (representing the same dendroclimatical region), the highest convergence is noted at the teleconnection with the N Poland, Kujawy-Pomerania, and Gotland chronologies. This proves similar relationships between the size of cambial increments and climatic factors.

4. CONCLUSIONS

1. Dendrochronological research carried out resulted in the construction of the absolute pine standard for the Suwałki region, spanning the years 1582-2004 AD. Performed analysis of signature years and teleconnection with regional chronologies for the neighbouring areas confirmed correctness of the construction of the standard.
2. The standard produced enabled dating of timbers from the investigated region, hitherto causing serious problems at absolute dating because of different growth patterns. The established pine chronology will find practical use in dating of wood from architectural objects and archaeological excavations.
3. Elaborating of an over four-hundred-year growth standard for this part of Poland opens possibilities for using it in paleoclimatical studies, attempting reconstruction of past climatic changes, cooling phases of the Little Ice Age, and particular years with extreme anomalies of the temperature.

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