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DENDROCHRONOLOGICAL SCOTS PINE STANDARD (1110 – 1460 AD) FOR NORTH-EASTERN POLAND

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Abstract: The study presents preliminary results of investigations on construction of the regional dendrochronological standard for Scots pine *(Pinus sylvestris* L.) for NE Poland. The produced standard 2NPINA is 351 years long, spanning the period 1110-1460 AD. It is based on three local chronologies established from wood samples from Gdańsk (2GDAA1A; 1116 – 1460 AD), Ostróda (2OST1B; 1251 – 1411 AD), and Pułtusk (2PUAA1A; 1110 – 1408 AD). The chronologies presented display relatively high mutual similarities. The highest similarity was noted for the Gdańsk and Ostróda chronologies (t=6.36), somewhat lower for the Pułtusk and Ostróda (t=5.0), and the lowest one for the Pułtusk and Gdańsk patterns (t=4.67). Construction of the standard 2NPINA is the first step in establishing a several-hundred-year pine chronology for this region, hitherto beyond the extent of dendrochronological signal, which rendered unsuccessful any attempt of dating historical wood of pine.

1. INTRODUCTION

Dendrochronology is one of the most accurate methods of absolute dating applied to the Holocene period. Thank to analysis of annual growth sequences of trees the exact calendar year may be determined. Prerequisite is, however, a dating tool, the so-called dendrochronological standard, i.e. an absolutely dated pattern obtained by averaging local chronologies determined for a given tree genus or species. The construction of a standard requires arduous and patient collecting of wood samples from among others:

- living trees,
- historical wood from old buildings, wooden tools etc.,
- wood explored at archaeological excavations,
- subfossil wood lifted from river alluvia or peat.

It is of crucial importance that the collected samples represent trees which grew within an area of relatively uniform climatic conditions. The uniform rhythm of changes of annual growth widths, depending on year-to-year changes of weather conditions, in the analysed population of trees allows for construction of local and, subsequently, regional standards. The latter are established separately for individual tree species, most often for species of wide geographical extent, e.g. oak (Krąpiec, 1998; Ważny, 1999), pine (Szychowska-Krąpiec, 1997; Zielski 1997), fir (Feliksik, 1994; Szychowska-Krąpiec, 2000), or spruce (Bednarz *et al.*, 1998-1999; Koprowski, 2003; Szychowska-Krąpiec, 1998).

One of the most important constituents of forests in central and eastern Europe (including Poland), now and in the past, has been Scots pine. Because of high content of pine in the composition of Polish forests in historic times, wood of this species was in common usage, especially in northern Poland where it is quite often encountered in old buildings. Frequent presence of pine in architectural objects as well as in explored archaeological sites offers a good opportunity for construction of a several-hundred-year dendrochronological standard for NE Poland. This study presents results of the first stage of the construction of such a standard.

2. ANALYSED MATERIAL AND METHODS

The analysed material was wood lifted at archaeological excavations in Gdańsk, Ostróda, and Pułtusk. Altogether 117 wood samples of Scots pine (*Pinus sylvestris* L.) were taken in the form of slices and cuttings. This way of sampling is the most convenient because relatively large surfaces may be investigated, which in turn enables to analyse growth patterns along several measured radii. The highest number of samples (72) represented wood from Pułtusk where archaeological excavations were led in the years 1976-85 (Gołembnik, 1987; Pela, 1997). 25 samples came from *in situ* preserved elements of wooden walls and abutment of the so-called Koga Bridge in the area of Green Gate (Zielona Brama) in Gdańsk, explored by the researchers from the Archaeological Museum in Gdańsk in the years 2000 and 2001 (Kościński, 2003). The last 20 samples were lifted at excavations led in the last few years in Ostróda (sites I and II) by Adam Mackiewicz (Mackiewicz and Mackiewicz, 1998; 2000 and 2001).

Preliminary treatment and preparation of samples in the Dendrochronological Laboratory of the AGH – University of Science and Technology, Cracow permitted to select samples suitable for dendrochronological analysis. Measurements of annual growth rings with 0.01 mm accuracy were carried out on samples with legible, undisturbed sequences of at least 25 growth rings. Computations were made with the computer programs Tree-Rings (Krawczyk and Krąpiec, 1995) and the DPL set (Holmes, 1994). In the first step of the analysis individual sequences from a given site were mutually compared in order to identify contemporaneous patterns. This procedure was based on statistical parameters: Pearson's coefficient of linear correlation ***r*** and modified ***t***-value (Baillie and Pilcher, 1973). Significant values of the parameter ***t*** (usually higher than 4) together with high convergence of the compared dendrochronological curves allowed the identification of contemporaneous sequences. Averaging of these sequences resulted in the construction of local chronologies and the regional master.

3. RESULTS AND DISCUSSION

As a result of the performed analyses three local chronologies were produced:

– 2GDAA1A (1116-1460 AD) for Gdańsk,
– 2PUAA1A (1110-1408 AD) for Pułtusk,
– 2OST1B (1251-1411AD) for Ostróda.

The longest of them is the 345-year master pattern for Gdańsk. It is based on the 16 best correlating individual patterns, of which the longest contained 239 annual growth rings, and the shortest one - 86 rings (**Fig. 1**).

The local chronology 2PUAA1A for Pułtusk is 298 years long. 14 sequences defining the chronology are shorter, i.e. they contain less growth rings than the above presented Gdańsk patterns. Only in five cases the sequences from Pułtusk contain more than 100 tree rings (114, 117, 132, 171, and 207, **Fig. 2**).

The 160-year chronology 2OST1B, produced from archaeological wood from Ostróda, consists of six individual patterns. The longest sequences contain 135-140 growth rings, whereas the shorter ones 72-87 rings (**Fig. 3**).

The discussed local chronologies display relatively high mutual similarity. The highest values of the convergence parameters have been noted for the Gdańsk and Ostróda chronologies (t=6.36, r=0.45), somewhat lower for Pułtusk and Ostróda (t=5.38, r=0.44) and for the Pułtusk and Gdańsk average patterns (t=4.67, r=0.36). These differences may be explained by slightly different climatic conditions in these regions. The regions of Gdańsk and Ostróda, situated in the neighbouring climate regions of Lower Vistula and Western Mazury (according to climatic regionalisation by Woś, 1999), are highly uniform as to the climatic conditions. The Pułtusk chronology (Central Mazovia region), displaying somewhat lower similarity to

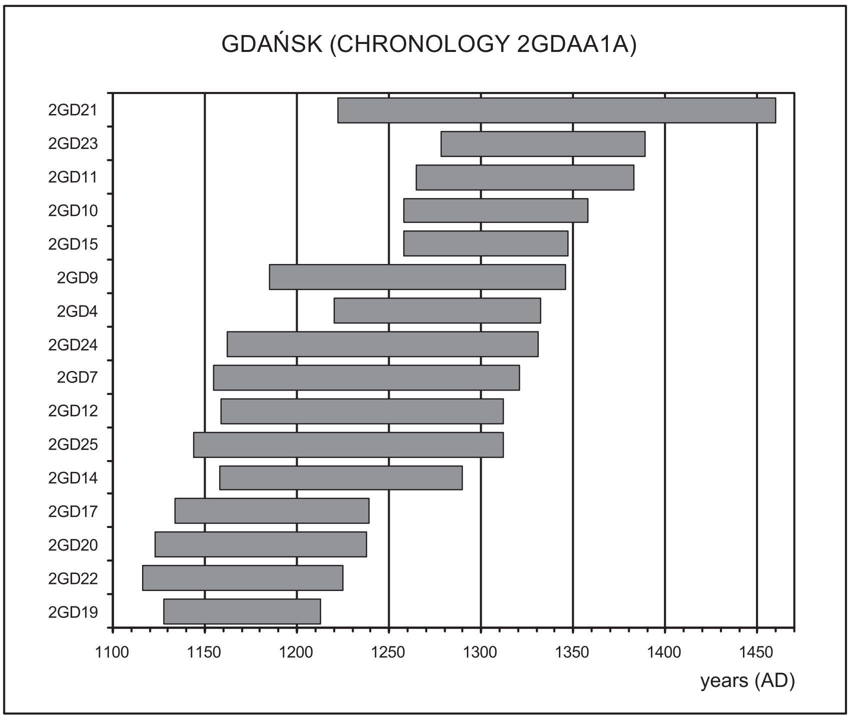

Fig. 1. *Dendrochronological dating of growth sequences sampled from Gdańsk, forming the local chronology 2GDAA1A.*

the other chronologies, is the southern- and easternmostly situated area, with the highest influence of the continental climate. This is presumably the reason of somewhat different growth reaction of pine trees.

The annual growth sequences defining the three local chronologies were also used for construction of the Scots pine regional chronology for NE Poland 2NPINA. The 351-year long chronology was produced from 30 individual growth sequences.

The newly created chronology was teleconnected with absolute pine standards from neighbouring areas: the North Germany chronology, covering the years 924-1995 AD (Heußner, 1996), the Northern Poland standard - 1106-1991 AD (Zielski, 1997), and the Swedish one, established for Gotland 1124-1987 AD (Bartholin, 1987). In all cases the similarity values proved to be significant and relatively high (t above 4.5). The highest convergence values were noted at comparison with the N Germany (t=6.57) and N Poland (t=6.08) chronologies, and somewhat lower value (t=4.68) in case of the Swedish one (**Fig. 4**). The fact of lower similarity of the chronology 2NPINA to the Gotland standard should be explained by peculiar climatic conditions of the island.

The teleconnection carried out not only confirmed the correctness of the construction of the chronology 2NPINA dated to the years 1110-1460 AD, but also demonstrated the large extent of the dendrochronological signal in that period, especially in the direction W-E. It is worth noting the higher convergence of the newly constructed chronology to the North Germany standard than to the chronology determined for the region of Lower Vistula Pomerania (Northern Poland). Perhaps it is because the North Germany chronology was produced from a more abundant (several hundreds) set of samples, representing the whole of Branderburgia.

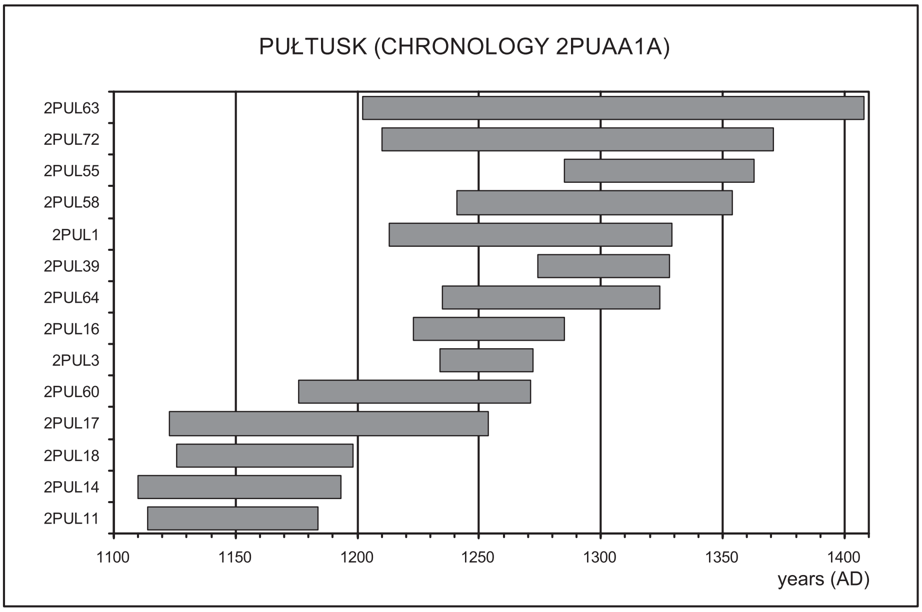

Fig. 2. *Dendrochronological dating of growth sequences sampled from Pułtusk, forming the local chronology 2PUAA1A.*

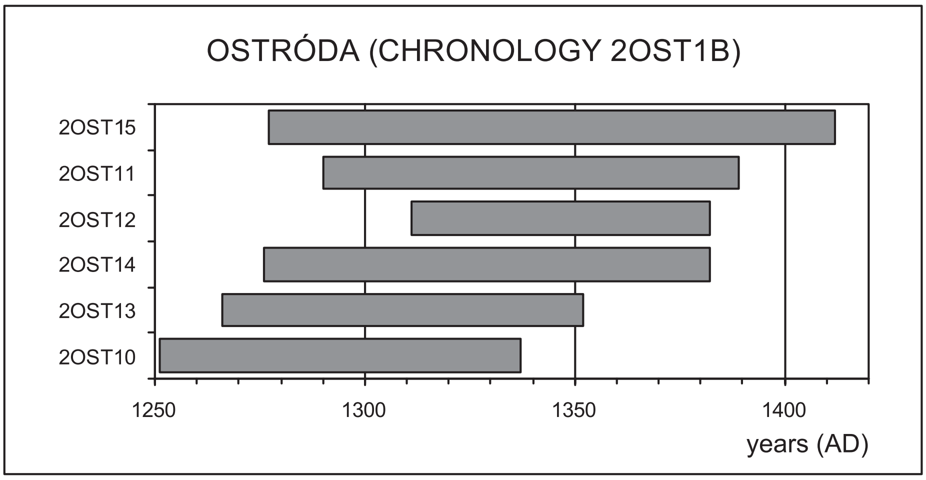

Fig. 3. *Dendrochronological dating of growth sequences sampled from Ostróda, forming the local chronology 2OST1B.*

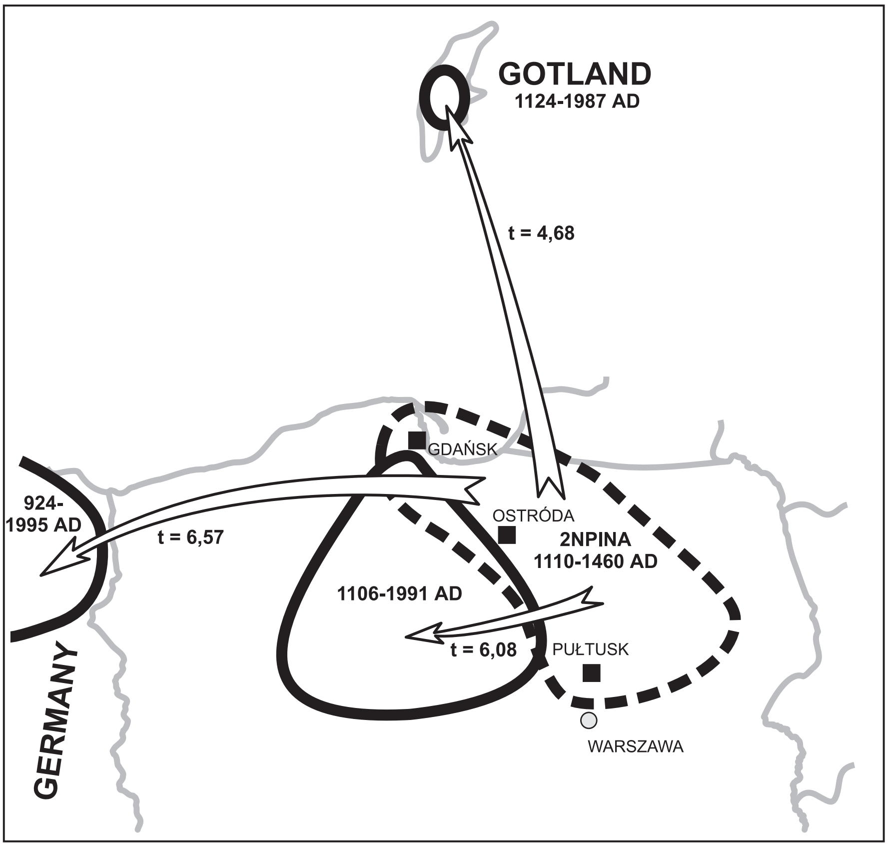

Fig. 4. *Correlation of 2NPINA chronology with chronologies from neighbouring area.*

CONCLUSIONS

The presented regional chronology 2NPINA is, after the N Poland chronology constructed by A. Zielski (1997), the next growth standard for mediaeval pine wood from Northern Poland. It is a significant completion of the first Polish pine standard, because the sites where the investigated samples were collected are situated further to the east than the samples defining the Zielski's chronology. The standard 2NPINA allows to date historic wood from north-eastern Poland as well as to analyse the extent of the dendrochronological signal of pine in the Baltic region. Further research will be aimed at extension of the chronology on the basis of all collected materials, including samples from the UMK Laboratory in Toruń.

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