

DEPENDENCE OF RADIAL GROWTH OF *PINUS SYLVESTRIS* L. FROM WESTERN POMERANIA ON THE RAINFALL AND TEMPERATURE CONDITIONS

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Abstract: The paper deals with the influence of varying climatic conditions on radial growth of Scots Pine in the area of Western Pomerania. The research was aimed to evaluate the influence of air temperature and precipitation on dimensions of radial growth of the analysed tree species. The investigations demonstrated high dependence of the annual growth width upon temperature in winter and the beginning of spring. Precipitation influenced the annual growth in summer months, particularly in June and July. In the site with high level of ground water (very humid forest habitat) the rainfall had a negative effect on the annual growth width – contrary to the other analysed sites.

1. INTRODUCTION

Scots Pine is the most important, predominating species forming forests in Poland. In the area of Western Pomerania, this species composes up to 70 % of the forests. Pine has been the object of dendroclimatical research for several years (Krapiec and Ważny, 1994).

In Poland, first studies on relationships between the climatic conditions and radial growth of pine were carried out by Zienkiewicz (1946) and Ermich (1953). Since then many studies appeared, dealing with pine from various areas of the country. In the area of Western Pomerania the research within high peat areas was led by Jasnowska (1977). Zielski (1996, 1997) analysed the influence of the climate on growth of trees, and Szychowska-Krapiec and Wiśniowski (1996) investigated the effect of pollution on the radial growth of pine from the area of Police.

This paper is aimed to evaluate the influence of air temperature and rainfall on formation of radial growths of Scots Pine. There was a question also analysed in which season of the year the climatic parameters are of major importance for the annual growth of this species. The produced local chronologies may be used for palaeoclimatic reconstructions, determination of pointer years, as well as comparison of reactions of tree groups growing in various habitats on the same changes of climatic conditions.

The influence of climatic conditions provokes similar reactions of almost all trees of the same species in a given area. The trees, however, are affected first by one factor, then by another, and each of these factors may act two-fold – limiting or stimulating the growth of trees (Kaennel and Schweingruber, 1990; Karpavichius *et al.*, 1996).

Habitat conditions, in particular availability of water, also influence growth reactions to a high degree. In min-

eral habitats maximal growths take place in years of abundant watering (high annual rainfall), whereas minimal in dry years, with shortage of water in the soil. In peats, bogs and other habitats with high level of ground water the atmospheric precipitation may have the reverse effect on growth of trees – increased level of water may limit or entirely hinder the growth (Jasnowska, 1968 and 1977).



Fig. 1. The investigated area.

2. MATERIALS AND METHODS

Material for this research was sampled from 55 trees growing in the oldest economic forests in the forest areas of Trzebież, Międzyzdroje and Bierzwnik, forest reservations Bielinek and Dąbrowa Krzymowska, as well as in the area of the Wolin National Park (Fig. 1). The investigated trees were exhaustively described, their photographs were made, and the ground and soil were analysed with drillings and sampled with a soil rod.

The pine trees were sampled with the Pressler increment borer, and where it was possible slices were taken (site Karsibórz). Therefore, cores were the principal research material, as felling of higher number of trees and taking slices was impossible, especially in case of huge, healthy trees, seeding trees, as well as those growing in nature reservations. Sites, in which the cores were taken from trees, were protected with wooden stick of the same diameter as the Pressler borer and with Lac Balsam (antifungal and antibacterial agent).

Measurements of the annual ring widths from the analysed trees were carried out in the Laboratory of Climatology and Marine Meteorology of the University of Szczecin with the apparatus for dendrometric measurements borrowed from the Polish Geological Institute in Szczecin. The data were worked out statistically and graphically (average width of annual growth of trees, standard deviation, mean sensitivity, autocorrelation, correlation r , Student's t -test, percentage convergence) with the set of TREE-RINGS computer programs (Krawczyk and Krapiec, 1995) in the Dendrochronological Laboratory of the Department of Stratigraphy and Regional Geology, University of Mining and Metallurgy in Cracow. Statistical analysis of relationships between the climatic parameters (monthly average temperatures and total monthly rainfall – 14 values for each examined element, from August of the preceding year to September of the given vegetation season) and radial growth of trees was carried out with the set of DPL programs, using the response function method.

Climate characteristics of the investigated area was based on meteorological data (monthly average air temperatures and sums of atmospheric rainfall for 1949-1998 period from the meteorological stations in the Western Pomerania – Świnoujście, Szczecin, Resko and Gorzów Wielkopolski), taken from the IMGW Meteorological Annals and other available sources (Koźmicki *et al.*, 1984; Atmospheric Precipitation 1948-1981).

3. RESULTS

Measurements of width of the annual growth rings and correlation of the obtained data enabled construction of five local chronologies for pine (*Pinus sylvestris*):

1. Trzebież 1757-2000 (244 years);
2. Wiselka 1798-1999 (202 years);
3. Dąbrowa Krzymowska 1796-1997 (202 years);
4. Bierzwnik 1826-1999 (174 years);
5. Karsibórz 1916-2000 (85 years)

They all display high values of the correlation coefficient “ r ” for pairs of them (Table 1). The results of studies on the relationships between the annual growth of wood, air temperature and rainfall together with calculated coefficients “ r^2 ” reflecting the influence of climatic factors on the annual radial growth of the analysed trees are presented in Figs 2 and 3.

Scots Pine belongs to a group of boreal and mountain species, occurring within the temperature range from -60 to $+40$ °C. Broad tolerance of this species on temperature changes was noted by many authors (Białobok *et al.*, 1993; Szeicz and MacDonald, 1995; Zielski, 1990, 1997). In Poland, the period of cambial activity of pine begins in early May and lasts until the end of September (Ermich, 1959; Schweingruber 1993), but the annual growth of wood is also affected by climatic conditions in winter preceding the growth season.

The obtained results point out high sensitivity of pine on low temperatures during winter period. After frosty winters the width of annual growths diminished in the succeeding vegetation season. On the other hand, mild winters (January and February) together with lack of frequent frosts in spring (March and April) positively influenced the ring width. In the site of Dąbrowa Krzymowska similar reactions of trees were observed for May (Fig. 2).

Growth reactions were also related to temperatures in the year preceding the analysed vegetation season: in the northern part of the investigated area (Wiselka and Karsibórz) September temperatures had negative influence on the radial growth, whereas in its southern part (Dąbrowa Krzymowska and Bierzwnik) positive reactions were observed.

Scots Pine exhibits considerable tolerance for another environmental factor *i.e.* atmospheric rainfall. Minimal yearly rainfall at which pine occurs in natural conditions is 200 mm, whereas maximal is over 1000 mm (Jasnowska, 1977; Białobok *et al.*, 1993; Wilczyński, 1999). Total rainfall is, however, only one of the factors influencing water economy of pine; equally important are distribution of rainfall throughout the year and availability of water. Excess of water in soil has a negative effect on the development of trees and growth of wood. In the area of Poland, pine reaches optimal humidity in habitats of young and mixed forests, although it occurs in dry and boggy forests as well (Zielski, 1997; Jasnowska, 1977).

In the investigated sites the influence of atmospheric precipitation on the growth of trees is relatively smaller than the influence of air temperature. Higher precipitation in summer months (June and July), as well as dry September positively affected the growth of trees. Among the months preceding the cambial activity the highest relationship was noted for February; low precipitation in this month had a positive effect on the development of trees (Fig. 3). High dependence of the annual growth on the amount of annual rainfall during most of the year, presumably due to the negative effect of water excess in soil, was noted in the site Karsibórz (habitat of very humid and humid forest). This site is located at the southern edge of the island Uznam (0.5 m a.s.l.) in the vicinity of the Piast Channel and Szczecin Bay, with peat and peat-gley soils

in the ground. In the mid-1990's winter storms brought about an increase of the Baltic Sea level in the Pomerania Bay, inflow of salt water through the Piast Channel into the Szczecin Bay, and subsequent flooding of the south-

ern edge of the island Uznam. As a result of the water level increase many trees died. Intense rainfall also results in saturation of soil with water, which badly affects growth of most of the tree species.

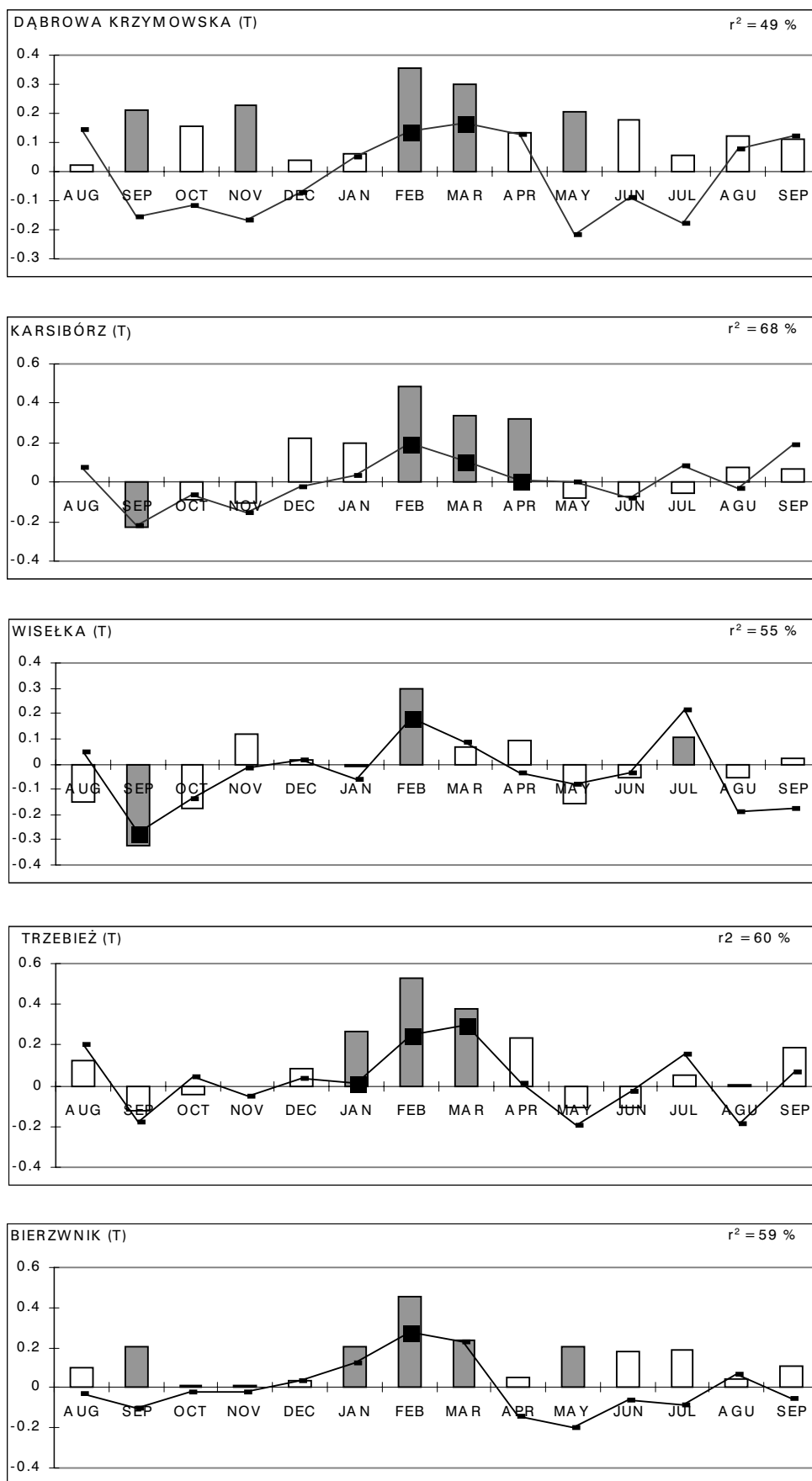


Fig. 2. Results of response function and correlation coefficients for temperature; bars show simple correlation coefficients, lines represent regression coefficients. Values statistically significant for $\alpha = 0.05$ – gray bars and black squares.

Table 1. Comparison of regional chronologies of *Pinus sylvestris* L. with Student's t-test.

Site No	Site	1	2	3	4	5
1	TRZEBIEŻ	X	6.3	6.1	7.4	6.7
2	WISEŁKA		X	5.3	4.3	2.7
3	DĄBROWA KRZYMOWSKA			X	5.2	4.5
4	BIERZWNIK				X	5.5
5	KARSIBÓRZ					X

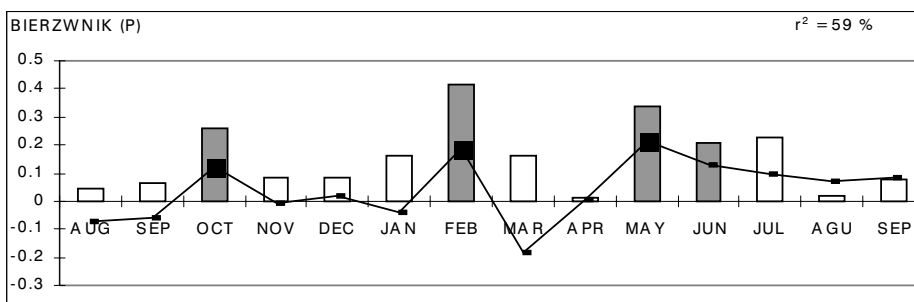
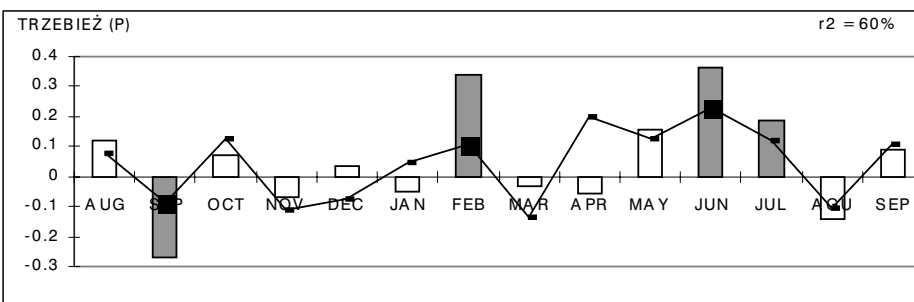
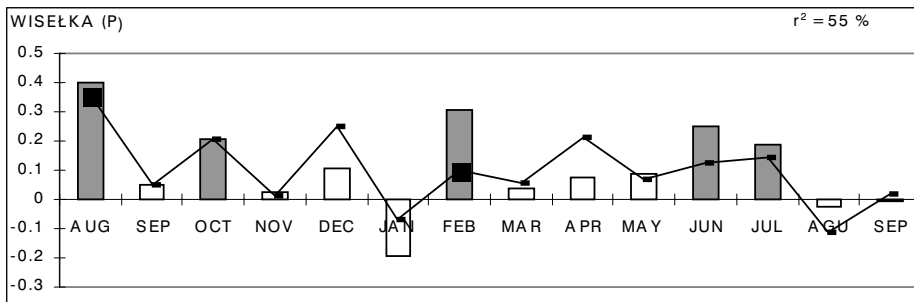
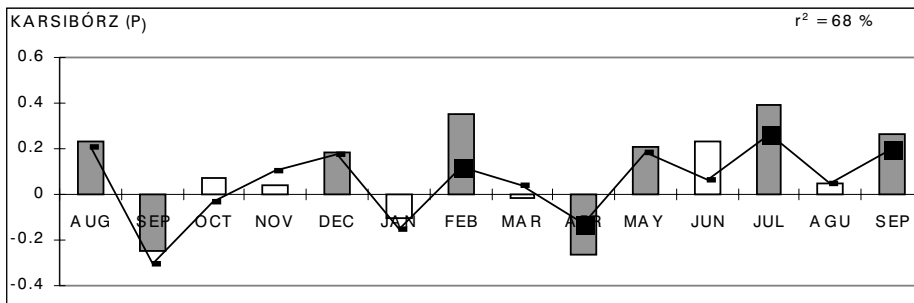
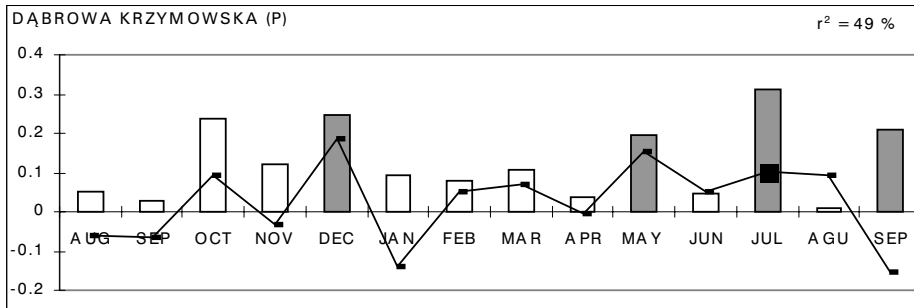


Fig. 3. Results of response function and correlation coefficients for precipitation; bars show simple correlation coefficients, lines represent regression coefficients. Values statistically significant for $\alpha = 0.05$ – gray bars and black squares.

4. CONCLUSIONS

- Five local chronologies for pine were constructed.
- The research carried indicates that thermal conditions in winter and beginning of spring preceding the vegetation season are the deciding factors about the annual growth of pine.
- Frosty winters and cool springs resulted in decrease of width of the annual growths in the succeeding vegetation season.
- The influence of rainfall on the radial growth of trees was lower than that of air temperature.
- Higher rainfall in summer months (June and July), as well as dry September positively affected the growth of trees. Among the months preceding the cambial activity the highest relationship was noted for February, in which low precipitation was convenient for the development of trees.
- In the site Karsibórz strong relationships between the amount of rainfall and the width of annual growth rings were noted, apparently due to excess of water in the ground.

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