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Dendrochronological studies of *Juniperus communis* dying out population in the "Jałowce" reserve (Pomerania)

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Abstract: The aim of undertaken research was recognition the reasons of dying out the common juniper *Juniperus communis* L. ssp. *communis* population in the forest nature reserve "Jałowce" (Pomerania). Applied methods of dendrochronological analysis let to determine the age of juniper-stand in the reserve and describe the influence of climatic conditions on its growth. Obtained results testify to *Juniperus communis* chronology with signature WIE collected from 17 individual sequences which numbered 102 tree ring width and represented a time span 1903 to 2004. Such results described the juniper-stand in the reserve as ageing population with the oldest specimen at age 98 years. However, the last several years were characterised by the lack of strong growth depressions typical for earlier time periods with tree ring width ranged 0.7–1.0 mm (the mean annual tree ring width amounted to 0.85 mm), but the visible symptoms of degeneration and dying out of protected common juniper population intensified probably because of its age.

Additional key words: tree ring width, dendroclimatological analysis, meteorological conditions

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Introduction

The forest nature reserve "Jałowce" (17°17'E, 54°38'N) was set up in 1984 and the aim of protection was concentration of 149 woody specimens of common juniper *Juniperus communis* L. ssp. *communis* with different habit forms (columnar, pyramidal, conical, club-shaped) reaching 4–10 m height. The reserve (1,29 ha) is situated on the south-east side of the moraine slope on a small fallplace and surrounded by a pine-stand. The reserve includes forest lands situated 12 km to the south of the Baltic shoreline (Fig. 1).

Since years the progressive dying out of protected common juniper population in the reserve has been observed as well as numerous juniper-stand damages like frost injures, blowed down trees and branches broken by falling caps of snow. In total only 25% of all juniper specimens were living, 26% were dead and dying ones predominated (49%). The reserve lost its natural values because of the visible symptomps of degeneration and dying out the protected common juniper population (Fig.2). One of the reasons for such situation might be the age of the common juniper population in the reserve and as a consequence prob-

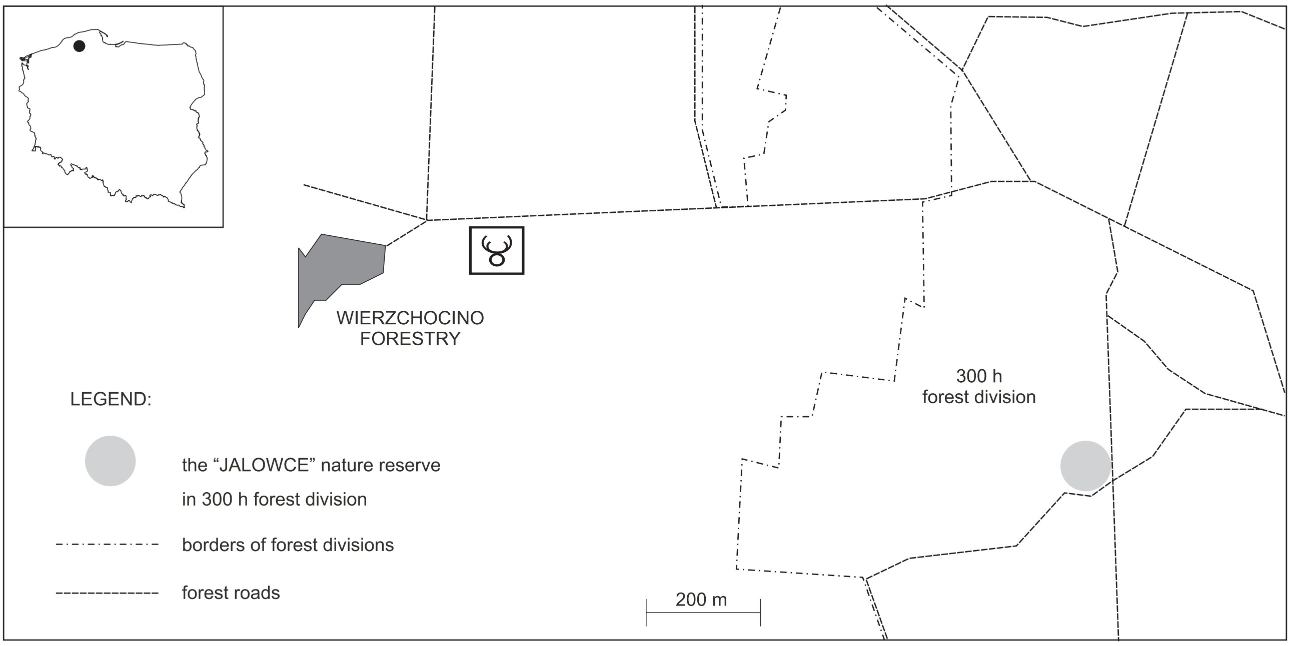

Fig. 1. Localization of the “Jałowce” reserve in the Wierzchocino forestry

lems with generative propagation, disease susceptibility and low weather-resistant. Also partial shading the commmon juniper population by surroundig pine-stand reduced regeneration capacity of the juniper specimens becuse of the high light requirements of this species.

Fig. 2. Dying out specimen of *Juniperus communis* in the “Jałowce” reserve

Methods

Juniper and pine tree ring width cores and discs were collected in June 2005 preceded by the prior obtainment of consent of the Pomeranian Nature Conservation Officer and the Damnica Forest Inspectorate. The tree ring width cores were sampled at height of 1.3 m above ground level from living trees using Pressler borers, securing the drilled holes with a fungi- and germicide and wooden pins, whereas the discs were cut out at height of 0.4 – 0.5 m above ground level from trunks of dried junipers found in the reserve (Fig. 3).

The samples from 42 trees were taken in total, among them from 30 junipers (23 living – signatures J and 7 dead – signatures JK) and 12 pines (signatures JS).

The basis for dendroclimatological examination were established chronologies (i.e. dated series of mean annual tree ring width for a given tree group). In order to establish these chronologies, standard procedures used in dendrochronological studies were applied: measuring annual tree ring width (exact to 0.01 mm), dating and its verification of individual dendrograms (Cofecha programme, Holmes 1983) and indexation (Arstan programme, Holmes 1983; Holmes 1994). In case of discs, about 3–5 measurement radiuses were determined, among them the measurement characterized by the highest values of statistic indicators (t-Student test value, coefficient of convergence value GL) was selected.

Established chronologies including sequences of annual tree ring width were the basis for dendrochronological examination: the analysis of signature years and the analysis of response function.

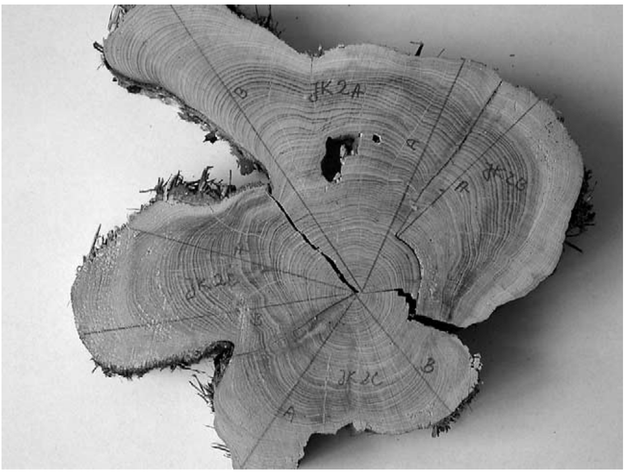

Fig. 3. Tree ring width disc cut out from a dried juniper found in the reserve

The analysis of signature years consisted in determining years, when majority of trees of a given species were characterised by the same growth trend. The years, when over 90% trees showed positive growth trends were regarded as positive years, while those with a narrower tree-ring in relation to the previous one in 90% examined specimens were determined as negative years (Kaennel and Schweingruber 1995; Meyer 1997–1998; Cedro 2004). The analysis of meteorological conditions, setting up the type of factor (temperature, precipitation) and the time period of the strongest tree ring width - climate relation, was determined for signature years (TCS programme, Walanus 2002).

The next dendroclimatological method applied was response function analysis, which relays on multiple regression analysis (Blasing et al. 1984; Cook and Kairiukstis 1992; Holmes 1983; Holmes 1994; RESPO programme; Zielski and Krąpiec 2004). The independent variables were mean monthly air temperatures and monthly precipitation, while the dependent ones – the values of juniper and pine tree ring width after indexation. In the analysis, meteorological data of last 53 years were used (1948–2000), from the Institute of Meteorology and Water Management (IMGW) station in Ustka located 28 km to the WSW from the reserve. In the study, previous vegetation season was allowed for (since July), as well as present growth season (up to September), 16 months in total.

Results

Chronologies

Juniperus communis L. trees are represented by the chronology with WIE signature collected from 17 individual dendrograms (12 coming from living specimens and 5 from discs from 53 measured growth sequences). The chronology numbers 102 tree rings width and represents a time span 1903 to 2004 (2005 year was not regarded during the measurements because of the persisting vegetation season). The longest growth sequence was obtained for disc JK2, with a measurement radius JK2AA of 98 years (1903–2000), while the shortest one for increment core J2 – 32 tree ring width (Fig. 4). The mean annual tree ring width is very small and amounts to 0.85 mm, rarely exceeding 2 mm.

In WIE chronology, one can distinguish years and time periods which are characterised by growth depressions: 1921, 1926, 1932, 1958–59, 1964, 1988 and 1991 as well as those with annual growth width above the average: 1922–23, 1931, 1943, 1945, 1960–62, 1965–68, 1973 and 1993. The last several years are characterised by the lack of strong growth depressions typical for earlier time periods and by growth increments at a balanced level ranging 0.7–1.0 mm (Table1, Fig.4).

The Scotch pines, forming the main tree stand of the reserve, are the base of chronology JSS. According to the forest inspectorate statement, these trees are about 65 years old (Gromadzki 1990) and the set up chronology is long for 104 year (1901–2004), (Fig. 4). Eight dendrograms, being a part of it, correspond to the age given in the statements (they have 22 to 51 growth increments – samples were collected at a height of 1.3 m above ground.

However, two trees, JS4 and JS8, have their tree rings width measured, to 79 and 104 ones respectively. Since the area of the reservation is post-agricultural in its character (soil profile structure, undergrowth species composition, heavy branching of pine tree stand) (Gromadzki 1990), these trees are probably the remnants of field woods, being at the same time seeding specimens for younger pine trees. The average width of radial tree ring width in pine trees is over two times bigger than that in junipers and amounts to 1.87 mm/year (Table1).

Table 1. Statistical data for the tree-ring measurements and for the index chronologies of *Juniperus communis* and *Pinus sylvestris*

Lab. code	No. of years	Time span	No. of samples	Mean width ring [mm]	Std. Deviation [mm]	Mean sensitivity	1st order autocorrelation	Index chronology			
								Median	Mean sensitivity	Std. Deviation	1st order autocorrelation
WIE	102	1903–2004	17	0,85	0,57	0,41	0,09	0,97	0,28	0,24	-0,03
JSS	104	1901–2004	10	1,87	0,98	0,23	0,79	0,99	0,25	0,23	0,02

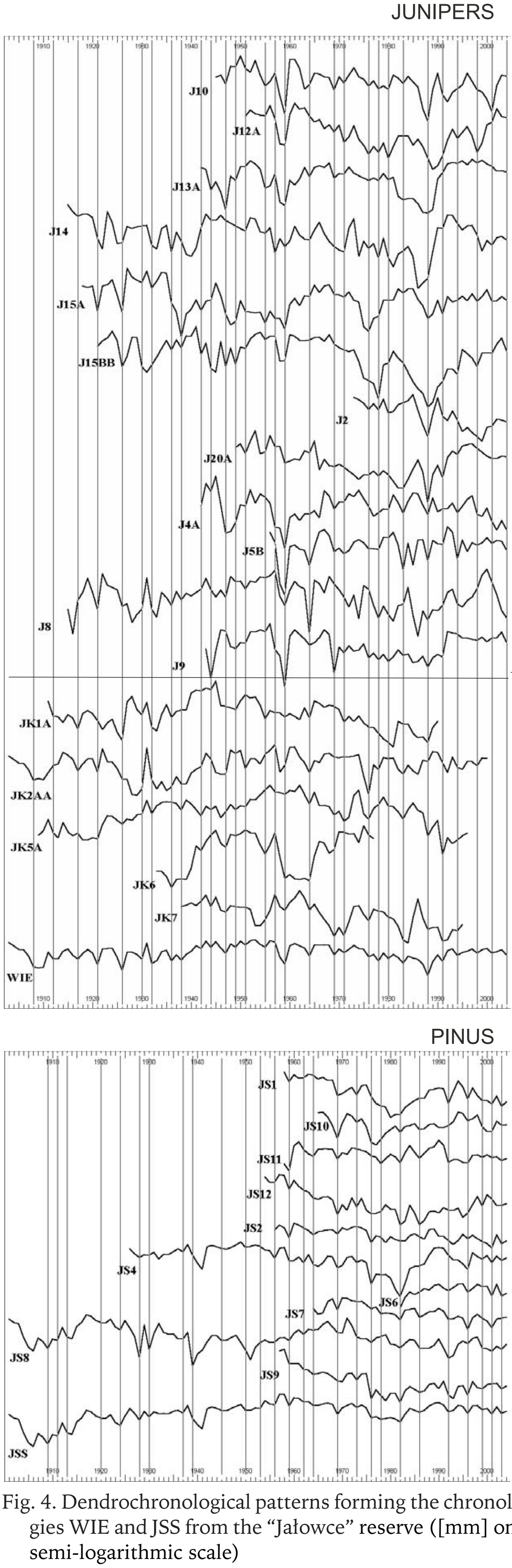

Fig. 4. Dendrochronological patterns forming the chronologies WIE and JSS from the "Jałowce" reserve ([mm] on a semi-logarithmic scale)

The comparison of both chronologies points to a small graphic conformity of dendrograms and low values of statistical indices (t-Student test value: 2.69; coefficient of convergence value GL = 49.5%).

The set up chronologies were the base for further dendroclimatological studies: the analysis of signature years and the response function analysis.

Dendroclimatological analysis

The analysis of signature years showed the presence of 9 years with the same growth trends in junipers (5 positive years and 4 negative years) and of 8 indicator years in pine chronology (5 years with an upward growth trend and 3 years with a downward growth trend) (Fig. 5).

The analysis of meteorological conditions within the set of signature years for chronology WIE showed a connection between positive years and precipitation in summer. The sum of annual precipitation above a long-term standard and large precipitation events in summer months favour tree growth. In negative years, there were precipitation deficiencies and drought events in summer. An additional factor, that caused growth depressions, was low temperatures in June. Thermal conditions in winter months do not have a significant effect on the shaping of annual growth values in junipers (years with both positive and negative growth trends occur in the years characterised by frosty winters). A prevailing factor that determines the activity of *Pinus sylvestris* L. tree cambium is thermal conditions in the winter period. Positive signature years occur in the years characterised by mild winters and warm spring, while negative ones are those with a temperature in winter months (espe-

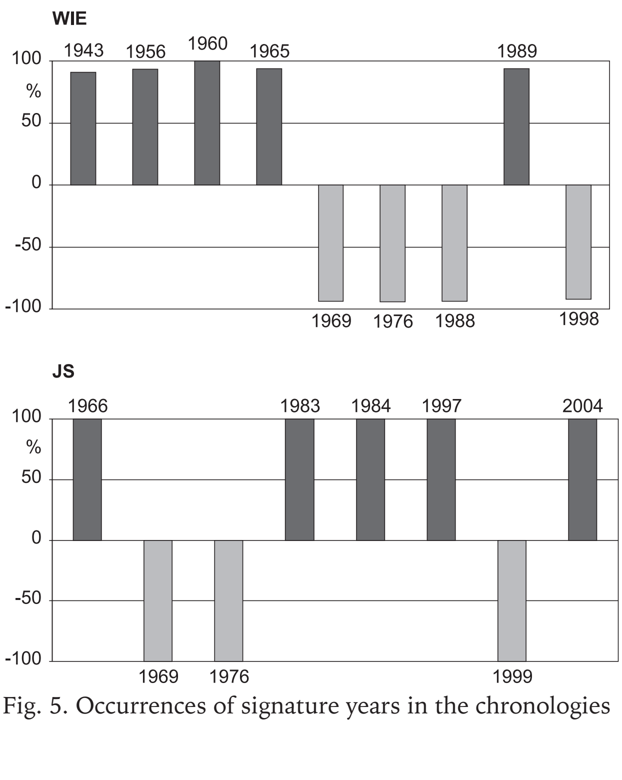

Fig. 5. Occurrences of signature years in the chronologies

cially February) below mean temperature value. Two negative signature years occur simultaneously in both chronologies: 1969 and 1976 (Fig. 5). These years are distinguished at the same year by the occurrence of strong winter, the sum of annual precipitation below the average and the drought in summer.

The results of response function analysis are presented in Fig. 6. The coefficient of determination (r^2), describing the strength of relationship between the analysed meteorological factors and the width of annual tree ring width, is 52% (for common juniper chronology). The coefficients of correlation and regression show a strong effect of air thermal conditions in summer season (in June and July) on the shaping of cambium activity. However, opposite relationships are obtained in both these months – high temperatures in June affect positively development of the examined trees, whereas on the contrary in July, with temperatures below mean value having the same effect. Such different relationships in the adjacent months are difficult to explain with ecological requirements of the examined species, therefore there is a need for broader studies on the juniper population within the area of the Polish Lowlands. In addition, positive regression values were stated in the previous summer season. The requirements with respect to precipitation in the present growth season appear in February and May. High precipitation sums in these months favour high growth dynamics. In the course of precipitation in the analysed time period, the effect of pluvial conditions was also stated in July of the previous vegetation season.

In the pine chronology (JJS), 48% of variation in the width of tree-rings can be explained by the analysed meteorological factors. The effect of temperature in February is predominant; regression is also stated at the end of the present vegetation season, as well as negative correlation and regression values in the previous vegetation season (especially in autumn). Precipitation has also a strong effect on cambium activity of Scots pine. In summer months, high precipitation sums favours thickness growth in pine trees, whereas regression acquire negative values in the time period from October of the previous year to January of the present year.

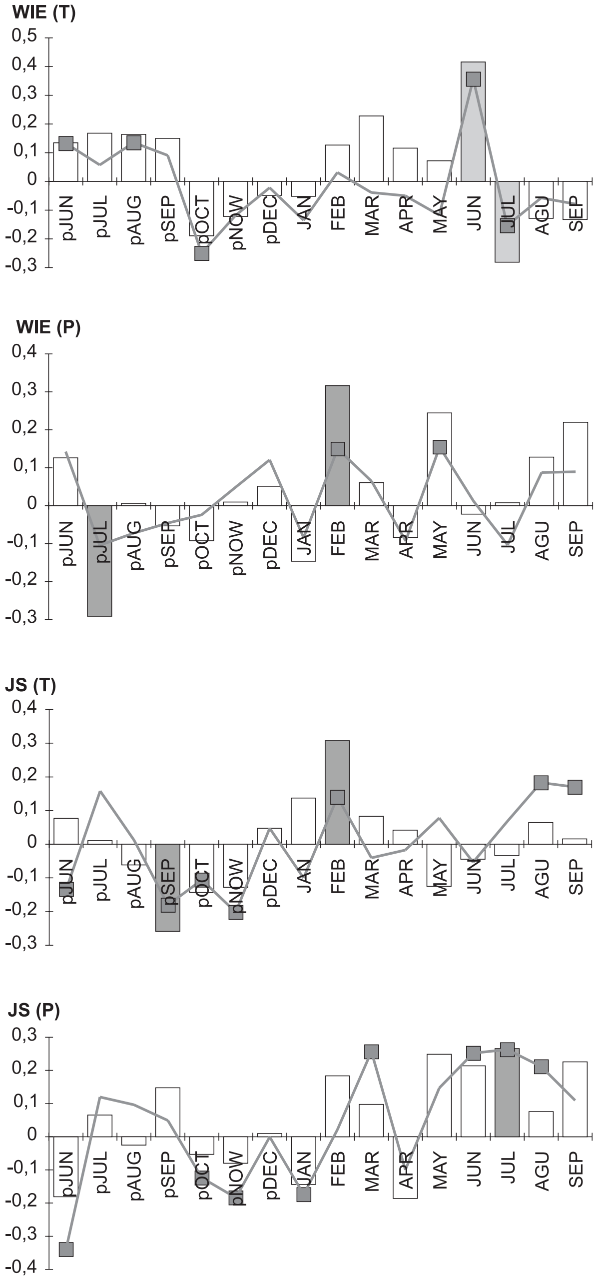

Fig. 6. Results of response function and correlation coefficients for temperature (T) and precipitation (P); bars show simple correlation coefficients, lines represent regression coefficients, determination coefficient for WIE is $r^2 = 52\%$, for JS is $r^2 = 48\%$. Values statistically significant for $\alpha = 0.05$ – gray bars and gray squares

Discussion

The papers concerning the common juniper in Poland are few whereas a dendrochronological analysis of this species have not been carried out yet (Andrzejczyk 1988; Bobiński 1974; Bobiński 1979; Grześkowiak and Bednorz 2002; Bugała 2000; Seneta and Dolatowski 2004; Okuniewska-Nowaczyk et al. 2004; Surmiński 2004). Also in Europe this species was not the object of dendrochronological studies. However, the other species from Juniperus genus were used for climatic reconstructions concerning mostly the high-mountain regions of Asia (Esper 2000; Treydte et al. 2001; Poutahmasi and ParsaPajouh 2001; Shao et al. 2002), North America or Near East (Hantemirov et al. 2000a; Hantemirov et al. 2001b; Gorlanova et al. 2001; Grissino-Mayer et al. 2001; Touchan et al. 2001). Considering the quite different habitat and climatic conditions as well as the separate juniper species examined in mentioned papers, there was not possible to make the comparision of the obtained results concerning the influence of climate on annual increaments of common juniper trees within the area of investigations. Viability evaluation of the juniper-stand in the “Jałowce” nature reserve explained the visible damages and dying out the majority of specimens there. Such symptoms are observed in senile common juniper populations at age over 70–80 year (Bobiński 1974; Bobiński 1979). In order to save the dying out population protected in the nature reserve, immediately should be undertaken action of active protection which enable the rest of living specimens vegetative propagation by offshoots (Hrynkiewicz-Sudnik et al. 1991). Also the thinning out of the high pine-stand surrounding the reserve and clearing the undergrowth in the reserve improve the light access to photophilous junipers.

But presented tree ring width – climate relation as well as the problem of protecion of dying out plant population within the areas under law protection, pointed to the necessity of continuation of initiated investigations and their widening on the other sites of *Juniperus communis* in lowland areas of Poland.

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