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Dendroecological research of *Salix fragilis* L. in the Nevėžis Botanical-landscape Reserve

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Dendroecological research has revealed that tree rings of *Salix fragilis* L. are suitable for dendrochronological investigations. The tree ring series synchronise among themselves, and dendroclimatological research has shown that the low air temperature during the previous December, abundant precipitation in previous October and in current July stimulate the annual radial increment of *Salix fragilis* L. trees in Nevėžis Reserve.

Key words: climate, dendroecology, Nevėžis, radial increment, *Salix fragilis* L.

INTRODUCTION

The climate of the Earth is under increasing pressure of anthropogenic activities and likely to provoke the climate warming and forest decline (Lamb, 1995). Research of the impact of changing climate on forest ecosystems has acquired importance (Joo, Wright, 2000). For the analysis of climate changes, a dendrochronological research could be used (Cherubini, 2000).

The Nevėžis Botanical-landscape Reserve is situated 10 km from Kaunas, on the floodplain of the River Nevėžis. The Reserve was founded in 1974 and occupies a 90-ha territory. *Salix fragilis* L. are one of the dominating tree species in the floodplain of the river.

The dendrochronological research of *Salix fragilis* L. was carried out for the first time in Lithuania. The author of this research is also familiar with research on tree rings of willows in the neighbouring countries. The aim of the current study was to compile the tree ring width chronology and to determine the main climatic factors affecting the radial increment of *Salix fragilis* L.

MATERIALS AND METHODS

For the study purposes, 35 *Salix fragilis* L. trees growing in the Nevėžis Botanical-Landscape Reserve were selected. The research plot is situated close to Raudondvaris, on the right bank of the River Nevėžis. The geographical coordinates of the location of trees established using the GPS (geographical position system) unit MAGELLAN 315 are 54°56'51"–54°57'03" latitude and 23°47'35"–23°47'70" longitude.

The field-work was carried out during May and November in 1999. Using an increment borer, samples were taken at the breast height, one sample from each tree.

The surface of the samples was prepared using 100–1000 grid emery paper. Tree ring widths of 31 samples were measured using an MBS-9 stereomicroscope. The accuracy of measuring was 0.05 mm. The measuring of the remaining 4 samples failed due to an indistinct latewood-earlywood structure, despite treating the samples by common techniques used in dendrochronology (Stravinskienė, 1994).

Both the visual and statistical synchronisation of the samples was performed (Eckstein, 1987; Kienast, 1985; Lovelius, 1997; Wendland, 1975). Statistical characteristics such as the coefficient of correlation and similarity were also used. The coefficients were counted using the TSAP 3.14 computer program developed by F. Rinn and S. Jäkel (Heidelberg) and the COFECHA 3.00P program compiled by R. Holmes.

Each tree-ring series obtained from an individual tree was indexed separately. The indexing was carried out using a negative exponential curve and linear regression, and the mean chronology was constructed as biweight robust means (Cook et al., 1990; Rütters, 1990).

For the modelling of tree growth and climatic factors (air temperature and precipitation) the modern method, multivariate regression techniques – a response function was used (Fritts, 1987; 1991; Serre-Bachet, Tessier, 1990). Calculations using data of average monthly air temperatures and the monthly amount of precipitation from the September of the previous year to the current September in the period 1957–1999 were carried out. The PRECON 5.17B computer program developed in the University of Arizona by H. C. Fritts in 1999 for this purpose was used. The compiled chronology of the annual radial increment in the indices of *Salix fragilis* L. was used during the analysis. Climatic data from the nearest Kaunas Meteorological Station were selected.

Analysis of multivariate regression was based on the statistical comparison of long-term climate and radial increment series. Such analysis expresses the average link between climate and tree growth, but does not explain tree ring information in particular years (Schweingruber et al., 1990; Serre-Bachet, Tessier, 1990). Such analysis is known as a pointer year analysis, *i.e.* analysis of years with extremely narrow or wide tree rings (Schweingruber, 1993; Schweingruber et al., 1990). Pointer years of the radial increment were accepted if the increment increased or decreased in 75% or more trees. For this purpose indexed series of an individual tree were used.

RESULTS AND DISCUSSION

Each analysed sample contained on average 28 rings. The longest of them had a time span of 55 years and the youngest 10 rings. The mentioned number of rings did not indicate the age of trees, because most of the samples were injured by stem decay and some of the rings near the pith were missing and could not be measured. Series of the asynchronous radial growth and with possible missing rings were eliminated from the further steps of the analysis. The constructed 43-year chronology (1957–1999) encompassed tree rings with series from 18 trees with the average inter-correlation among the series +0.52 and the average time span of a series 32 years (Fig. 1).

The mean sensitivity of the compiled chronology was 0.15. Comparing with the widely researched conifers in Lithuania (Vitas, 2002), tree ring series of *Salix fragilis* L. are more sensitive, but generally correspond with the sensitivity of tree radial increment in the moderate climate (Феклистов и др., 1997).

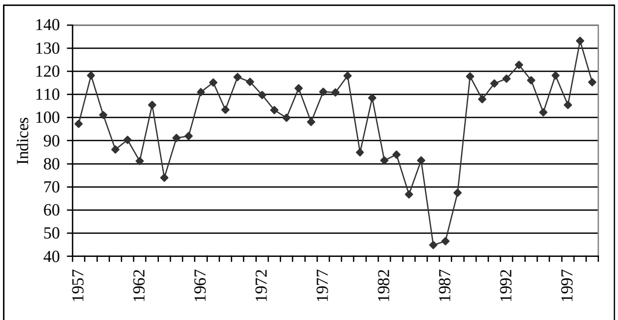

Fig. 1. Chronology of annual radial increment of *Salix fragilis* L. compiled from 18 trees growing in Nevėžis Botanical-landscape Reserve
1 pav. Trapiojo gluosnio (*Salix fragilis* L.) metinio radialiojo prieaugio dendroskalė sudaryta iš 18 medžių, augančių Nevėžio botaniniame kraštovaizdžio draustinyje

The calculated coefficients of response function between the annual radial increment of *Salix fragilis* L. and climate factors (air temperature and precipitation) are presented in Fig. 2. The analysis revealed several unexpected results: all significant coefficients were established between the increment and climate factors of the previous year (October and December), and the second peculiarity was a different reaction (positive) to precipitation in July as compared with other summer months (June, August).

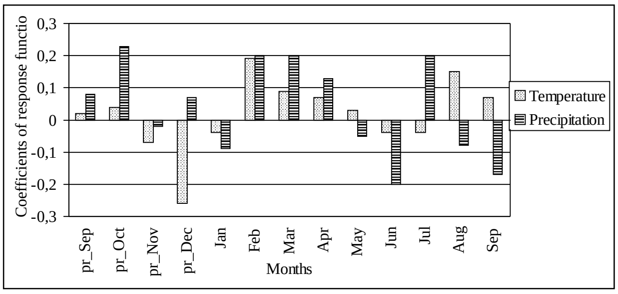

Fig. 2. Coefficients of the response function between radial increment of *Salix fragilis* L., air temperature and precipitation from September (pr_Sep) of previous year to September (Sep) of current year. Asterisk (*) indicates significance, $p \leq 0.05$
2 pav. Atsako funkcijos koeficientai tarp trapiojo gluosnio (*Salix fragilis* L.) radialiojo prieaugio, oro temperatūros ir kritulių nuo praėjusių metų rugsėjo (pr_Sep) iki einamųjų metų rugsėjo (Sep). Žvaigždutė (*) rodo patikimumą, $p \leq$ $\leq 0{,}05$

According to the obtained results, the radial increment is favoured by humid October and cold December of the previous year. A positive link, despite the statistically insignificant February, March and April air temperature and precipitation, was ascertained. The already mentioned positive link with precipitation in July was confirmed.

The positive influence of precipitation in July could be connected with the minimal water flow rates in the Nevėžis in June–July and as an outcome with the fluctuations of groundwater level. For example, water flow rates in the Nevėžis River during the least and the most watery months per year vary almost 20–25 times (Basalykas, 1958) and this could be connected with the abatement of the groundwater and as a result with the positive impact of precipitation in July. The positive impact of a warmer winter could be explained by a higher level of precipitation in winter – a thicker snow cover, which protects the roots of trees. However, to find a satisfactory and clear explanation of the link with air temperature of the previous December is not easy. A direct connection between the radial growth of trees and the temperature of previous December has been not revealed, but it seems that such link points to the necessary rest period of trees in winter (Vitas, 2002).

Negative pointer years were found in 1980, 1984–1988 and positive in 1970, 1979, 1989, 1993 and 1998 (Fig. 3). For the interpretation of pointer years, climate data of Kaunas Meteorological Station were used. The coefficients of the response function pointed to an inverse link between the ring increment and the temperature in previous December. The same tendency was established by the analysis of pointer years. During the negative pointer years (1980, 1984–1988) the average air temperature of December in a previous year was –4.92 °C and in the positive pointer years –1.67 °C. Precipitation in July of a current year was found to be one of the main factors stimulating the radial growth of *Salix fragilis.* During the negative pointer years the average amount of precipitation in July was 72.5 mm and during the positive pointer years 117.6 mm, *i.e*. considerably more than the long-term mean of precipitation in July in Kaunas (83.7 mm). Even very abundant precipitation in July in separate years (*e.g*., in 1993) had no noticeable negative influence on the radial growth of trees and only played a positive role.

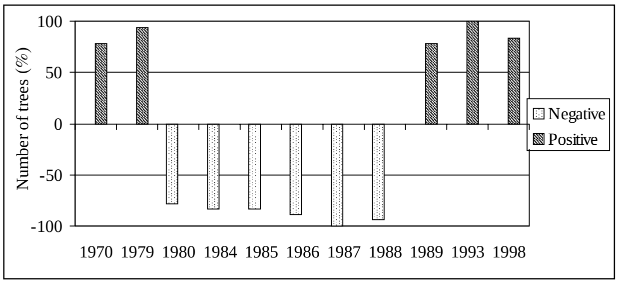

Fig. 3. Pointer years of the annual radial increment of *Salix fragilis* L. in 1970–1998. Abscissa – pointer years, ordinate – number of trees (%) with increment increase or decrease

3 pav. Trapiojo gluosnio (*Salix fragilis* L.) metinio radialiojo prieaugio reperiniai metai 1970–1998 m. Abscisių ašyje – reperiniai metai, ordinačių – medžių su padidėjusiu ar sumažėjusiu prieaugiu skaičius (%)

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DENDROEKOLOGINIAI TRAPIOJO GLUOSNIO (*Salix fragilis* L.) TYRIMAI NEVĖŽIO BOTANINIAME KRAŠTOVAIZDŽIO DRAUSTINYJE

S a n t r a u k a

Trapiojo gluosnio (*Salix fragilis* L.) tyrimai atskleidė šios medžio rūšies metinių rievių naudojimo dendrochronologiniuose tyrimuose galimybes. Nustatyta, kad atskirų medžių radialiojo prieaugio eilutės tarpusavyje sinchronizuojasi, o dendroklimatologiniai tyrimai parodė, kad praėjusių metų žema gruodžio oro temperatūra ir spalio krituliai bei einamųjų metų didelis liepos kritulių kiekis skatina gluosnių radialųjį prieaugį Nevėžio draustinyje.

Raktažodžiai: dendroekologija, klimatas, Nevėžis, radialusis prieaugis, trapusis gluosnis