DENDROCLIMATOECOLOGICAL RESEARCH OF SPRUCE FORESTS IN LITHUANIA

Adomas Vitas
Vytautas Magnus University Kaunas Botanical Gardens Dendroclimatochronology Lab.,
Z.E.Zilibero 6, LT-3018 Kaunas, LITHUANIA

Abstract

The results of the dendroclimatoecological research conducted in 1995-1997 have been discussed. The research has been carried out in 48 experimental plots in Lithuania on different forest sites. Carrying out the research, the impact of climate (air temperature and precipitation) on the annual radial increment of Spruce has been analyzed. Using living Spruce trees, the reconstruction of the past climate was carried out. The dynamics of the annual radial increment have been analyzed in the period 1810-1997 on different forest types. Carrying out the analysis of the pointer years of the annual radial increment of Spruce, the decline of the Spruce forests ecosystem in Lithuania since the seventh decade of the 20th century was estimated and detailed also with the analysis of extreme ecoclimatic conditions at the same time.

Keywords: annual radial increment, dendroclimatology, Spruce, extreme ecoclimatic conditions, pointer year

INTRODUCTION

Many scientific works, conducted by foreign and Lithuanian researchers on dendroclimatology demonstrates, that the annual rings of Spruce are an excellent indicator of the conditions of the environment in particular (Eckstein, 1989; Schweingruber, 1993; Stravinskiene, 1997; Bitvinskas, 1974 etc). Using methods and information of dendrochronology (width of the annual (late and early increment) tree rings), status of tree, stand and forest ecosystem could be evaluated, e.g. impact of extreme ecoclimatic conditions on the tree radial increment and the stability of the forest ecosystem. The dynamic of tree annual radial increment is closely related to fluctuations of the climatic conditions, pollution and other ecological and anthropogenic factors, which encompasses "Dendroecology" (Schweingruber, 1993). Other ecological factors (often hardly controlled), which come across the dendrochronological and dendroclimatoecological research and must be eliminated, e.g. tree age impact to tree ring widths, felling of trees etc. This impact is often combined.

Results of my first scientific work - dendroclimatoecological research of Norway Spruce (*Picea abies* (L.) Karst.) in Lithuania - was firstly presented in the International conference on dendrochronology and dendroclimatology.

MATERIALS AND METHODS

The dendroclimatological research has been carried out since 1995. In 1995-1996 Spruce in Kazlu Ruda forests were researched. In 1996-1998 Spruce forests of the Central and

Western parts of Lithuania were researched. Since 1997, the research of the Spruce forests in the South and East of Lithuania was begun.

Aims of the research were:

- Research the dynamics of the annual radial increment of Spruce.
- Evaluate impact of climate on the annual radial increment of Spruce.
- Evaluate the possibilities to use living Spruce trees in the reconstruction of climate.
- Establish the impact of extreme ecoclimatic conditions (pointer year analysis).

The main objectives of the research have been achieved as follows:

- For the purpose of the research, 48 experimental plots in all regions of the territory of Lithuania were selected.
- Experimental plots were described using the taxation characteristics of the forest inventory (forest types were established according to the Prof. S. Karazija typology) (Karazija, 1988).
- Thirty samples have been taken from tree stems (at the height of 1.3 meters) of each experimental plot by inserting an increment borer. Totally more than 1500 trees and about 100.000 annual rings were measured. The late, early and annual increment of the tree ring was measured to within 0.01 accuracy.
- PC analysis. Individual series of each tree in experimental plot were averaged into a joint chronology. Using a computer program "Arstan 40", the negative exponential function and linear regression, the long-term age trends were eliminated. Meteorological (monthly and yearly precipitation and air temperature) data was interpolated to each experimental plot. Counting the correlation coefficients (PC "Excel-5.0"), the climate impact on the annual radial increment was evaluated.

RESULTS AND DISCUSSION

Spruce forests in Lithuania do not predominates at present (Spruce forests occupies about 24% of the forest area) but they corresponds best to the climate of Lithuania and from the point of view of geography they are the most important (Basalykas, 1958). The most characteristic forest types of Spruce stands are *Piceetum myrtillosum, Piceetum myrtillo-oxalidosum, Piceetum oxalidosum* (Kairiukstis, 1962). Spruce forests dominate in the Western part of Lithuania, because more heavy clay and fertile soils dominates there. In the South and East of Lithuania dominates infertile sandy soils and Spruce could be found only in more wet and fertile sites, e.g. near bogs.

Climate of Lithuania is moderately wet and moderately warm. The averaged air temperature in the Southwest of Lithuania is +6.6 and in the Northeast +5.4 °C. In the Eastern part manifests the warmest summers and coldest winters. The biggest amount of

precipitation (about 750 millimeters) falls in the Western part of Lithuania. The Baltic Sea greatly affects the climate of Lithuania: cools summers and warmers winters, lengthens spring and autumn.

Evaluating the climatic impact on the annual radial increment of Spruce, correlation coefficients were used. For the purpose of the research, the monthly and yearly data of precipitation from 1887 and air temperature from 1777 years was used. Using interpolation, they were adapted to each experimental plot. Reliable correlation coefficients are bigger than 0.15 (time span more 100 years) (Kolemaev V., Staroverov O., Turundaevski, 1991).

The impact of climate on the annual radial increment of Spruce was researched in dry (*Piceetum vaccinio-myrtillosum*, *Piceetum hepatico-oxalidosum*, *Piceetum myrtillosum etc.*), moderately wet (*Piceetum myrtillo-oxalidosum, Piceetum myrtillosum*) and wet (*Piceetum oxalidosum, Piceetum oxalido-nemorosum etc.)* forest types.

Positive correlation coefficients between the annual radial increment of Spruce and air temperature of January, March, April, September and year and precipitation of June, year and not reliable with April are characteristic on all forest sites.

As an example, the correlation coefficients between the annual radial increment of Spruce on moderately wet forest types and climate (air temperature and precipitation) will be analyzed more detail (fig. 1, 2).

Impact of air temperature is opposite comparing to precipitation during the year. In winter from December up to March positive impact of air temperature increases and of precipitation decreases. Fluctuations of the impact of air temperature and precipitation of the spring and summer are more closely related to each other, but the impact of air temperature of autumn increases from September up to November and impact of precipitation decreases little by little. Impact of yearly air temperature is greatly more positive comparing with precipitation. Peculiarities of climatic impact obtained in this research corresponds with the conclusions of researchers in other European countries, e.g. Prof. D. Eckstein affirms that Spruce positively responds to wet and cool summer (Schweingruber, 1993).

Climatic conditions of Lithuania (moderately wet and warm) are not a permanently limiting factor for Spruce growth. The fluctuations of correlation coefficients in separate periods were detected. It produces difficulties on climate reconstruction. For example, correlation coefficients counted every ten years between yearly precipitation and annual radial increment of Spruce in experimental plot of Bebrujai from 1887 untill 1997 are positive, however in periods 1917-1927, 1937-1947 and 1977-1987 they are negative.

Chronologies of Spruce annual radial increment with the time span more than 150 years were used for the reconstruction of past climatic conditions. The climate was reconstructed only these months, which climate reliably correlates (>0.15) with

the annual radial increment of Spruce. For the reconstruction, models of the linear regression were used. Error of the reconstruction, comparing the results of the twelve years of the reconstructed climate with the real data was evaluated. Errors of the reconstructed climate fluctuates from 40 % up to 59 % (average 49 %).

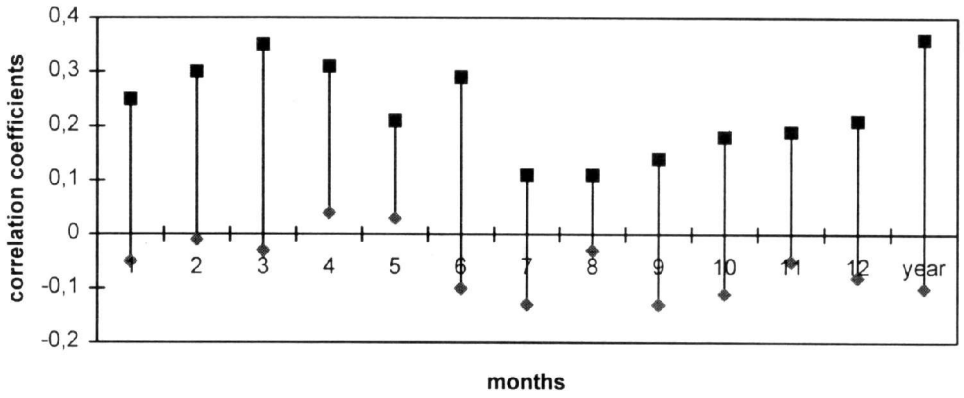

Figure 1. Fluctuations of correlation coefficients between air temperature and annual radial increment of Spruce on moderately wet forest types

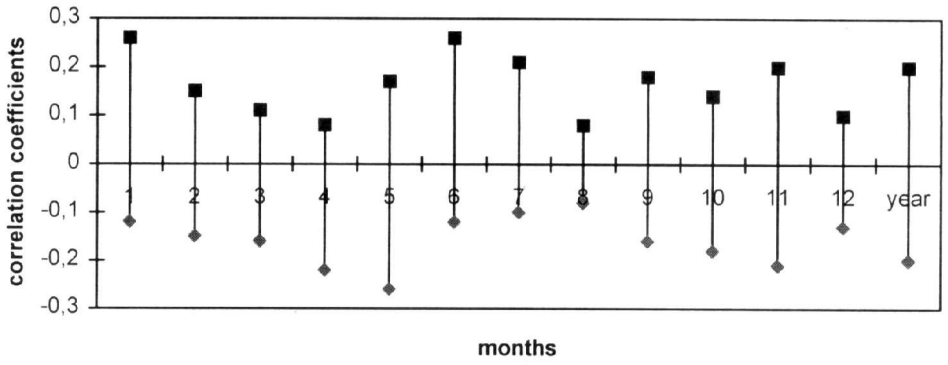

Figure 2. Fluctuations of the correlation coefficients between precipitation and annual radial increment of Spruce on moderately wet forest types

Impact of extreme ecoclimatic conditions could be established applying to pointer year analysis on the annual radial increment. Pointer years of Spruce annual radial increment with the decrease of the annual radial increment more than 15 %, according to the data of the research, were in: 1815, 1817-1818, 1826, 1828, 1835, 1849, 1852, 1858-1860, 1875, 1897, 1941-1942, 1954-1955, 1979-1980, 1992, 1993-1994. The increase of the radial increment more than 15 % were in: 1820, 1822, 1824, 1829, 1831, 1843, 1846, 1853, 1854, 1856, 1862, 1863, 1874, 1879, 1889, 1903, 1946, 1947, 1948, 1950, 1974, 1983, 1990,

1997. The pointer year (minimum) of 1992-1993 was one of the biggest during the period of the last two centuries (the biggest was in 1828). According to the figure 3, a minimum of two years duration was only two times: in 1941-1942 and 1992-1993. These two minimums must be analyzed more deeply. Analyzing the data of the climate (air temperature and precipitation, it is easy to come to a conclusion, that the reduction of the annual radial increment of Spruce was under the limit of:

- In 1941 of dry summer of 1941 (perhaps also of dry beginning of summer of 1940) and cold winter of 1940 and 1941.
- In 1942 of dryish beginning and end of summer of 1942 and cold winter of 1942.
- In 1992 drought of 1992 summer.
- In 1993 the impact of the long-term ecoclimatic extremes (impact of 1992 summer drought) manifests.

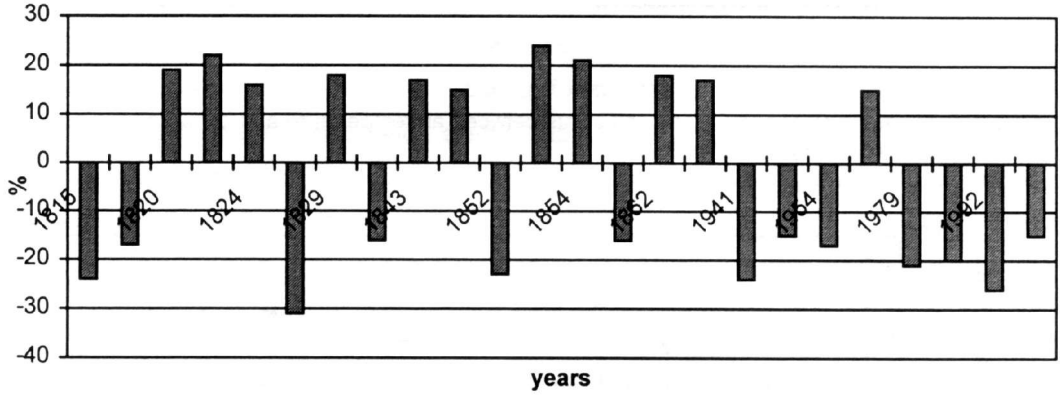

Figure 3. Pointer years of Spruce annual radial increment increase or decrease (more than 15 %)

Minimum of 1992-1993 depends also on forest site wetness. In dry sites the minimum of the increment lasts from 1992 up to 1996 years, on wet the minimum was only in 1992 years. It indicates also, that the negative phenomena under which impact formed these years were summer ecoclimatic extremes. Because the minimum of the increment of Spruce in 1992-1993 was the biggest during the two last centuries, the climate of the 1992-1997 was analyzed in essence.

At the end of the 20th century summer droughts and heats acquired the bigger impact (in the middle of this century bigger impact had cold winters). From 1990 predominates drought and hot summers.

Especially negative impact caused summers of 1992 and 1994. These summers have been distinguished for its extremes. June, July, August and September were warmer than the average air temperature. May-August was very dry. Summer of the 1994 was the hottest during the last three centuries (t>30°C was in 15 days) (Buitkuviene, 1998). The

average air temperature of July of 1994 was about 20 degrees (long-term average is 17.8). In this month precipitation in some regions felt in 5-10 millimeters and in some there was not precipitation at all, when normally July is the wettest month of Lithuania (about 70-80 millimeters). Precipitation of July of the ninth decade of the 20th century in figure 4 is presented. After the last minimum of the annual radial increment of Spruce in 1992-1993, the catastrophic out break of *Ips typographus* (L.) in 1994-1996 began.

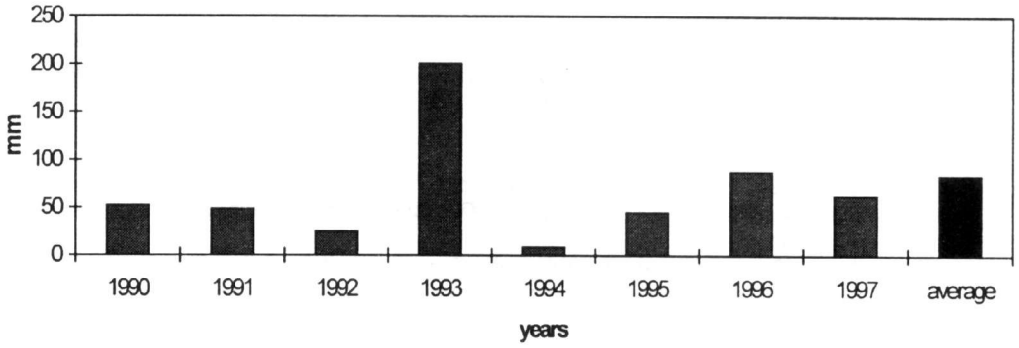

Figure 4. Precipitation (mm) of July since 1990 until 1997 (according to data of Kaunas meteorological station). In solid - long-term averages of the July precipitation

After 1974 - years with the maximums of the annual radial increment of Spruce more than 15% - was not found out. It points at the decline of Spruce forests ecosystem from the middle of the seventh decade of the 20th century. It could be related not only with impact of extreme ecoclimatic conditions and as a result- the reduction of the radial increment of Spruce, but also with an increase of the technogenic atmospheric pollution.

According to results of Stravinskiene investigations the progressive decrease of annual radial increment, early and late parts of Spruce tree rings has begun since 1981. This indicates that the state of Spruce forest stands grew worse and they became weak. Master chronology of Spruce (*Picea abies* (L.) Karsten) growing in *oxalydosum* and *myrtilloso-oxalidosum* forest types was constructed and can be used as a control for indication of Spruce forest stands and environmental changes (Stravinskiene, 1997).

CONCLUSIONS

1. Air temperature of spring (March, April), autumn (September) and year and precipitation of summer (June) and year positively affects the annual radial increment of Spruce on all forest types.
2. Climatic reconstruction using living Spruce trees is complicated in Lithuania, due to a short chronologies (200-300 years) and because in moderately warm and wet climate of Lithuania climatic factors limiting the increment of trees are changing permanently.

3. Maximums of the pointer years of the annual radial increment of Spruce were not registered from the seventh decade. It indicates at the decline of the Spruce forest ecosystem of Lithuania. The last and greatest minimums of the annual radial increment of Spruce were in 1992-1993. Analyzing the pointer years of the increment of Spruce, the degradation of the forest ecosystem and the insect outbreaks is possible to prognoses. Pointer years of the increment could be easily explained to climatic extremes.

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