*Palaeobotanist* 50 (2001) 95-99
0031-0174/2001/95-99 $2.00

# Specifics of tree growth in Lithuania and its dependence on various factors

JONAS KARPAVICIUS

*Laboratory of Dendroclimatochronology, Kaunas Botanical Garden of Vytautas Magnus University, Z.E. Zilibero - 2, LT-3018, Kaunas, Lithuania.*
*Email: BS@bs.vdu.lt*

(Received 17 January 2001; revised version accepted 22 November 2001)

## ABSTRACT

Karpavicius 2001. Specifics of tree growth in Lithuania and its dependence on various factors. Palaeobotanist 50(1) : 95-99.

Due to a great diversity of tree stand conditions and climate in Lithuania, the response of tree growth to environmental changes differs considerably across the country. It causes difficulties in compiling long dated tree ring records from sub fossil and archaeological wood through cross matching of modern woods.

It was found that changes in long-term radial growth and the recurrence of biennial growth rhythm are the basic features, which distinguish tree stand conditions in Lithuania.

**Key-words**—Tree-rings, Radial growth, Climatic factors, Geohydrological conditions, Lithuania.

## लिथुआनिया में वृक्ष वृद्धि की विशिष्टताएँ एवं विभिन्न कारकों पर इसकी निर्भरता

योनस कार्पाविचस

## सारांश

लिथुआनिया में वृक्ष खड़ स्थितियों तथा जलवायु में विविधता के कारण सम्पूर्ण देश के पर्यावरणीय परिवर्तन भिन्न-भिन्न हैं। इस कारण जब पुरातात्विक काष्ठ की उपअश्मीय एवं अरीय वृद्धि के आंकड़े प्रयुक्त किए जाते हैं, तो दीर्घावधिक वृक्ष वलयों की श्रेणी निर्मित करने में अनेक असुविधाओं का सामना करना पड़ता है।

यह पाया गया है कि दीर्घावधिक अरीय वृद्धि में परिवर्तन तथा द्विवार्षिक वृद्धि चक्र ही वे प्रमुख अभिलक्षण हैं, जिनसे लिथुआनिया की वृक्ष खड़ स्थितियाँ अभिनिर्धारित की जा सकती हैं।

**संकेत शब्द**—वृक्ष वलय, अरीय वृद्धि, जलवायुविक कारक, भूजलीय स्थितियाँ, लिथुआनिया.

## INTRODUCTION

SEVERAL tree ring features, such as ring width, wood density and chemical properties are being increasingly applied in various applications of dendroclimatology and dendrochronology. The details of tree ring and its relationship to environmental changes including methodology of such analyses are thoroughly described by Bitvinskas (1974), Fritts (1976), Schweingruber (1988), Cook & Kairiukstis (1989), Lovelius (1979) and others. The works of these authors and others showed, that the radial increments of trees are influenced by a number of factors of both climatic and non-climatic.

It has been recorded that even in such a small territory (65·2 thousand km²) as Lithuania, there is considerable diversity in responses to tree growth to environment. These differences might be related to soil types and changes of ground water level (Kairaitis & Karpavicius, 1996). Moreover, it has also been established that changes in radial growth are also influenced by several climatic factors (Karpavicius *et al.*, 1996).

Due to the relatively short age of trees in Lithuania (200–300 years), it is very difficult to establish reliable tree ring records longer than 300 years. The data could be extended by cross matching with the long tree ring series using subfossil and archaeological wood. However for the building of long tree-ring series of a site and tree species needs the knowledge of peculiarities of tree radial growth of trees of this region. In this paper an attempt has been made to overview the factors influencing the tree growths in Lithuania.

## MATERIAL AND METHODS

A dense network of dendrochronological materials from Lithuania has been collected by several workers and these samples are stored our in Dendrochronology Laboratory (Fig. 1).

The species investigated mainly are pine (*Pinus sylvestris* L.), spruce (*Picea abies* (L.) Karst.), oak (*Quercus robur* L.) and larch (*Larix* sp.). For the tree-ring analysis not less than 10 increment cores, one from each tree, at breast height in each experimental plot was collected through increment borer. In some cases samples were taken from more than 100 trees. These large number of tree ring samples were analysed to evaluate which trees are more sensitive to climatic, whether there are missing and false rings and does the growth reduction depend on concurrent conditions in the stand. The investigation has shown that most trees of average and normal selection categories have such qualities (Karpavicius, 1986). The biggest amount of samples for the investigation from trees of selective categories have been taken since then.

After the mounting and processing the samples for tree ring analysis, ring width of all these samples were measured using the stereomicroscope and measuring machine. Pine, spruce and larch samples were measured to 0·05 mm and oak to 0·1 mm accuracy. Each early and late wood width was measured separately. The data from individual samples in each stand were averaged and the prepared tree-ring series were used for the further analysis. During analysis of radial growth it has been recorded that, the data provided earlier in the reports of the National forestry assessment, for the description of local growth condition are inadequate. With the support of the geological bore in stands growing in conditions of normal

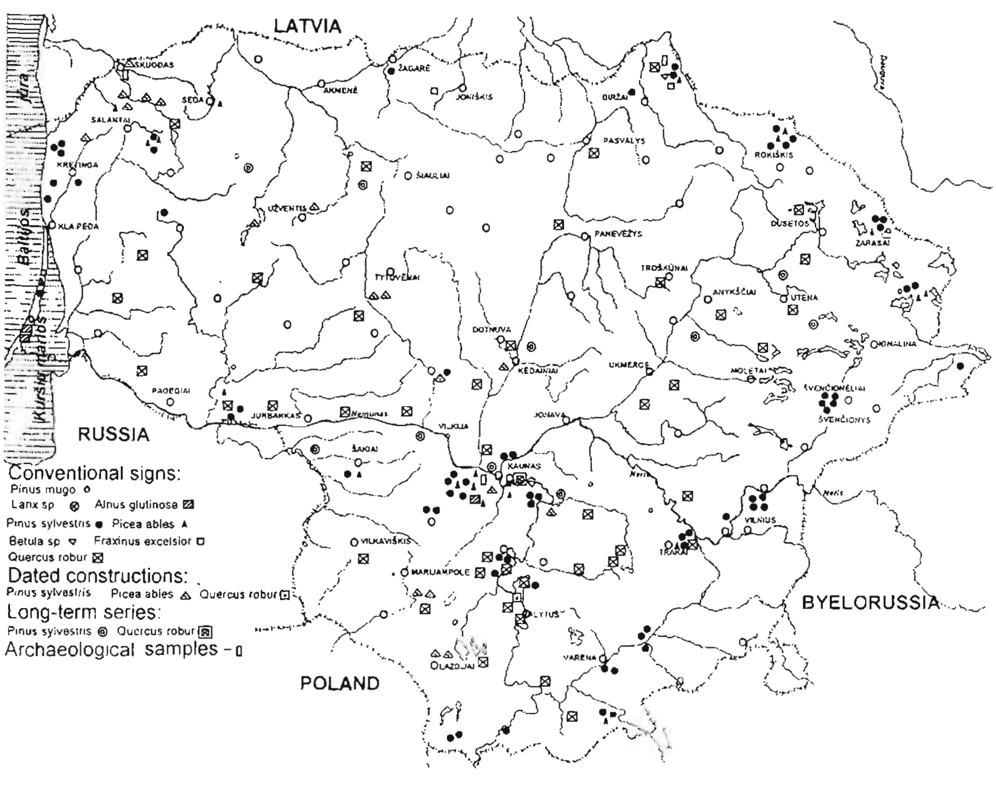


Fig. 1—Location of the experimental plots in Lithuania.

humidity, samples of soil for the supplementary analysis were taken. Attention on the examination of soil composition and ground water level was focused. Where ever possible, the examination was lowered to a depth of 6 m.

Experimental plots, located in bogs, in different localities were selected with regard to the distance from the water reservoirs (river, lake) and from the border of the bog, the thickness of the peat layer, etc., representing different hydrological conditions and forest sites (according to grass cover). These samples were taken from different age groups of trees in order to evaluate the impact of age, to facilitate identification of missing tree rings and also to compare the reaction to climatic factors.

As mentioned earlier, it is not possible to analyse trees covering time span of hundreds or more years, growing in Lithuania. However, one long tree ring series (2200 years), using the series of the radial growth from pine wood, found in "Uzpelkiu tyrelis" has been established (Pukiene, 1997). Dendroscale of subfossil oak, taken out from the ground of river Neris at Smurgainiai (Byelorussia) for 6000 years (Kairaitis, unpubl.) is nearly finished. Dendroscale for about 1000 years of the radial growth of pine wood, found in peat bog "Aukstoji plynia" (Karpavicius, 1998) is also nearly finished. It should be mentioned that all these long-term scales have gaps in certain periods.

While compiling long-term series, one has to face a number of problems. One of these is that, trees growing in different conditions of the geohydrological regime, react to the changes of climatic conditions differently. Therefore, the data of radial growth could not be used for joint ring-series through cross dating.

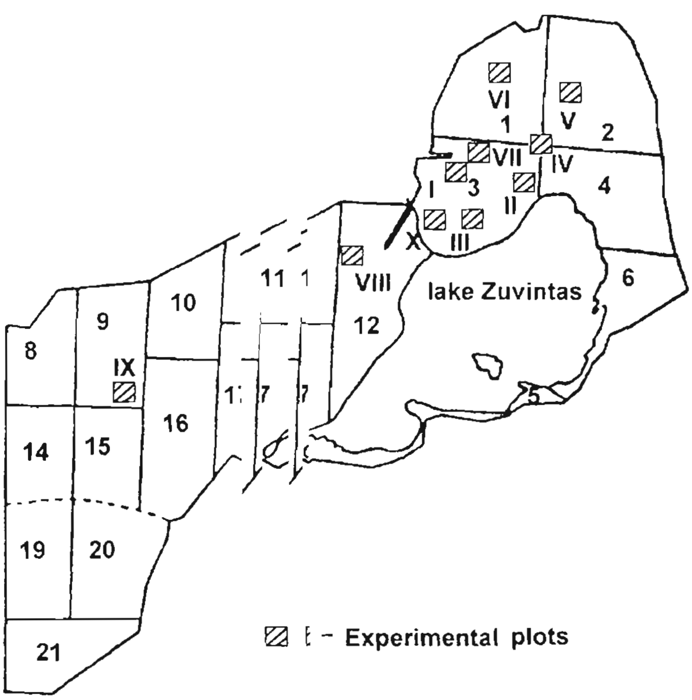


Fig. 2—Scheme of the expɾ esrireɛnental plots in Zuvintas reservation.

Consequently, one of the main goals of our laboratory is to find out the explanation about peculiarities of radial growth of trees, growing in different conditions of the geohydrological regimes and their dependence on the climatic factors. The possibility to identify conditions of the growing site was investigated according to the radial growth patterns of samples from 43 oak stands and over 20 experimental plots, located in the pine forest bogs in Lithuania. The biggest parts of experimental plots (10) from peat bog of the Zuvintas strict reservation were chosen (Fig. 2).

For this investigation, several statistical methods were used. These will be described briefly in the discussion below.

## RESULTS AND DISCUSSION

Lithuania, being in the centre of Europe, could be described as a country with great diversity in climate and vegetation. For example, during the period of 1893-1997 average precipitation was 618 mm, ranging from 407 mm in 1911 to 915 mm in 1950 and the average temperature being 6·4 °C. Moreover, a great range of temperature and precipitation comparing the data of different months has been observed. For example, the average winter temperature has varied from –0·1°C in 1925 to –10·3°C in 1940 and the average air temperature of March from +5·2°C in 1921 to –9·0°C in 1952, while the June precipitation from 158 mm in 1901 to 6 mm in 1940.

During the study of radial growth-climate relationships of various tree species more similar responses with climatic factors were found: positive growth-climatic relationships were found with mean annual temperature, temperature of September, October, March and precipitation of June. On the other hand, negative relationships were found with precipitation of September, October, May and temperature of June. The growth – climate relationships with other months are different and depend on various factors. For example, after extremely cold winters radial growth of trees become similar, e.g., after cold winters in 1940-41 and 1979-80 years decrease in radial growth is common as for oaks and pine growing in the soil of normal humidity.

The greatest dependency of growth on climatic factors is associated with soil composition and the depth of ground water. These factors influence not only growth-climatic relationships, but also the tree growth dynamics. Four types of growth-climate responses in Lithuania oak stands have been established (Kairaitis & Karpavicius, 1996): (1) insensitive to both temperature and precipitation; (2) more sensitive to the temperature regime (3) more sensitive to precipitation and (4) sensitive to temperature and precipitation.

Some of oak stands can not be assigned to any of these types. They belong to one type based on coefficients of

| Period | Experimental Plot | | | |
|---|---|---|---|---|
| | M – 2 | M – 3 | M – 4 | M – 5 |
| until 1943 | 64·1 | 64·2 | 88·3 | 68·2 |
| 1943-1980 | 50·0 | 63·2 | 73·6 | 39·5 |
| 1981-1994 | 76·9 | 100 | 100 | 92·3 |

Fig. 3—Percentage of similarity of radial growth patterns of trees from different experimental plots (Minciagires forestry of Aukstaitija National Park).

correlation with meteorological factors during one period, and to another type based on results in another period.

Characteristic of type 1 oak stands is that they grow in sandy or loamy soils, have average or thick soil layers (about 40 cm) with humus, and ground water at the depth of 1·2 to 1·5 m.

Type 2 stands grow in soils characterized by a thin layer of loam or sand at the surface, leading into loam which then graduates in to clay. At some stands, sand is again found below the clay, or sand intermixed with clay. The ground water level is at a depth of 1·2 to 3 m.

Stands with the third type of response, growing in sandy or gravel soil with a deep ground water level.

Type 4 responses characterize oak stands which grow in soils of either pure loam or clay or which have a thin horizontal strip of sand at the surface. Ground water levels of over 6 m are common to the stands.

As it has already been mentioned, for tree growth not only are different types of climatic response common, but the course of growth dynamic as well. The most distinct dynamic of radial growth is found for oaks and pines, which grow in bogs settings closely related with hydrological conditions.

Similar percentage among tree groups, growing in the same bog, reflects the dynamics of radial growth (Fig. 3).

As Fig. 3 shows, the largest percentage of similarity with the growth of pines in the centre of the bog (depth of peat 1·8 m) have pines, growing in such places, where the depth of peat fluctuates from 1 to 1·5 m (e.p. Nr. M – 3 and M – 4), though e.p. Nr. M – 3 trees grow approximately 10 m from peat edge. Moreover, trees growing at the border (e.p. Nr. M – 2), or no less than 10 m away from the edge, but the depth of peat reaching only 0·6 m (e.p. Nr. M – 5) have less synchronisation than those growing in the centre.

It proves once again, that it is not possible to combine tree ring from different hydrological settings. The question arises, is it possible to define the stands where trees grew on the basis of radial growth features?

Research carried out at the laboratory shows that in addition to previously mentioned differences, some radial growth features typical for specific growth conditions exist. These regularities are well investigated for oaks (Kairaitis & Karpavicius, 1996; Kairaitis, 1998) and pines growing in bogs (Karpavicius, 1993, 1998). As pines growing in Zuvintas reservation, radial growth illustrate one of these features is the trend of long- term radial growth (Fig. 4).

As seen in Fig. 4, in 1936-1979 the average amount of precipitation has decreased and the average radial growth of pines has increased in nearly all-experimental plot, compared to the 1893-1935 period. This increase in pine increment varies in different bog localities, due to different hydrological conditions. The radial growth increase of pines was lowest in the most humid forest sites (e.p. Nr. Z-1, Z-7, Z-8) and in one of central peak site of the bog (e.p. Nr. Z-4). Meanwhile, in the e.p. Nr. Z-2, Z-3 and Z-10, which are not far from lake Zuvintas and the River Dovine, the increment was doubled, as the excess water was drained to the lake-river (Fig. 2). On the other hand, the lowest amount of precipitation in e.p. Nr. Z-6, which is located on a sloping area 200 m from the spruce stand located near the border of the bog, had a negative impact.

Although the decrease of precipitation from the mean of 627·2 mm in the period of 1893-1935 to 607·9 mm in the period of 1936-1979 had a positive impact on the radial growth in nearly all experimental plots located in the Zuvintas reservation, in the other bogs impact is negative, except for the pines growing in the central part of the bogs. This can be explained by the distance from the border of the bog and the peat layer thickness.

Such phenomena of radial growth were also found for subfossil wood of pines, excavated from various depths from the peat bog "Aukstoji Plynia" (Karpavicius, 1998).

Another feature of radial growth studies is the two-years rhythm in which the increment of one year is bigger than that of the previous two years. This pattern is mainly characteristic for periods when rainy years were followed by drier years (Karpavicius, 1993). In the 1954-1963 period, in even years the average of precipitation was 600·8 mm and in uneven years it was only 503 mm. This pattern creates different humidity

| Period | Experimental Plot | | | | | | | | | Precipitation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Z – 1 | Z – 2 | Z – 3 | Z – 4 | Z – 6 | Z – 7 | Z – 8 | Z – 9 | Z – 10 | |
| 1893-1935 | 0·54 | 0·46 | 0·54 | 0·52 | 0·63 | 0·50 | 0·44 | — | 0·63 | 627·2 |
| 1936-1979 | 0·68 | 0·93 | 1·04 | 0·63 | 0·58 | 0·51 | 0·58 | 0·66 | 1·35 | 607·9 |

Fig. 4—The average radial increment and precipitation of different periods (in mm).

and nutritional conditions in different areas of the bog. If the increase in precipitation in experimental plot Nr. Z-4 and Z-6 results in decrease in increment growth, in the experimental plot Nr. Z-9 the precipitation had a positive impact on growth. It is important to note that this two years pattern is less common for pines growing near the border of the bog where thin layer of peat dominate.

To summarise, the width of radial increment in separate time periods and a characteristic two years rhythm/pattern are reliable indicators that allow us to evaluate the geohydrological conditions of the tree growth.

One more growth features for the pines growing in bogs is that radial growth of young pines reflect the climatic fluctuation the same way like older trees but the absolute values of their increment depend on the climatic conditions in the period the trees started to growth (Karpavicius, 1994). This feature is common not only for the pines growing in Zuvintas reservation, but also for those stands in other bogs, where the depth of peat is more than 1 m and that grow further from the border of the bog.

This feature of young tree radial increment is most characteristic for oaks (Kairaitis, 1998) and pines growing in bogs. That is why, for the formation of long-time series, use of tree-ring data from subfossil wood, is recommended to use absolute quantities. If separate individual increment indices are used for the joining of long-term tree ring series, much information developing hundred-year-old cycle is lost.

## CONCLUSIONS

The dynamics of radial growth of trees in Lithuania discussed in this paper has been found to have correlation with diversified environmental variables viz., meteorological factors, soil composition and depth of ground water, moisture regime and a host of other factors. Due to these differences, it is essential to use data from more or less analogous habitats as possible when compiling long-time series of tree growth in Lithuania. It has been recorded that extremely cold winters are one of the basic factors for which different tree species growing in locations of normal humidity react similarly (negatively). Moreover, long-term radial increment changes and constant two-years increment rhythm recurring no less than every 10 years of oaks and pines growing in bogs are basic features, which allow us to distinguish the growing conditions.

***Acknowledgements***—*The author is grateful to R. D'Arrigo, Tree-Ring Lab., Lamont Doherthy Earth Observatory, New York and Amalava Bhattacharyya, Birbal Sahni Institute of Palaeobotany, Lucknow for critically going through the paper and providing suggestions to improve this paper.*

## REFERENCES

Bitvinskas TT 1974. Dendroclimatic investigations. Leningrad: Gidrometeoizdat Publishers (in Russian).

Cook ER & Kairiukstis LA 1989. Methods of Dendrochronology. Applications in the Environmental Sciences. The Netherlands: Kluwer Academic Publishers.

Fritts HC 1976. Tree Rings and Climate. London, New York, San Francisko: Academic Press.

Kairaitis J 1998. Biological aspects of long-term scales of oak (*Quercus robur* L.) in Lithuania. *In:* Dendrochronology and environmental trends. Kaunas : 250-253.

Kairaitis J & Karpavicius J 1996. Radial growth peculiarities of oak (*Quercus robur* L.) in Lithuania. Ecology 4: 12-19.

Karpavicius J 1986. Radial growth of Scot pine changes and relation with morphological features. *In:* Dendrochronology and dendroclimatology. Novosibirsk: Nauka : 86-90 (in Russian).

Karpavicius J 1993. Dendroclimatochronological investigations. *In:* The Zuvintas reservation. Vilnius: Academia : 233-241 (in Russian).

Karpavicius J 1994. Some problems of compiling long-term series of yearly tree–rings. Ecology 3 : 3-12 (in Russian).

Karpavicius J 1998. Some bioecological aspects in compiling long-term dendroscales in Lithuania. *In:* Dendrochronology and environmental trends. Kaunas 254-263.

Karpavicius J, Yadav R & Kairaitis J 1996. Radial growth responses of pine (*Pinus sylvestris* L.) and spruce (*Picea abies* L. Karst.) to climate and geohydrological factors. Palaeobotanist 45 : 148-151.

Lovelius NV 1979. Change of tree growth. Leningrad: Nauka (in Russian).

Pukiene R 1997. Pinewood growth dynamics in Uzpelkiu experimental plot oligothrophic bog during the subatlantic period. Summary of doctoral dissertation. Vilnius.

Schweingruber FH 1988. Tree ring – Basics and applications of dendrochronology. Netherlands: The Kluwer Academic Publishers.