# Seasonal Growth Variations of Pine, Spruce, and Birch Recorded by Band Dendrometers in NE Lithuania

**ADOMAS VITAS**
*Vytautas Magnus University, Faculty of Nature Sciences, Centre of Environmental Research, Group of Dendroclimatology and Radiometrics, Ž.E. Žilibero 2, LT-46324 Kaunas, Lithuania; E-mail: a.vitas@gmf.vdu.lt*

**Vitas, A.** 2011. Seasonal Growth Variations of Pine, Spruce, and Birch Recorded by Band Dendrometers in NE Lithuania. *Baltic Forestry* 17(2): 197–204.

*Abstract*

We present the 1976-2010 results of a study on seasonal circumference growth carried out in NE Lithuania. The growth variations were recorded every three days using manual band dendrometers installed on 29 trees: 23 Scots pines (*Pinus sylvestris* L.), 3 Norway spruces (*Picea abies* (L.) Karsten) and 3 silver birches (*Betula pendula* Roth). The average onset of the growth was observed between May 6-10 and the cessation between August 28-30; growth on average lasted for 111-117 days. The growth onset and cessation time were highly variable among individual trees. A tendency for an earlier onset and cessation, and for an increase in growth duration from 1976 to 2010 was observed. Pine and spruce reach their maximum growth in June, while the birch culminated in July. Birch demonstrated much slower growth in April and May in comparison to pine and spruce. Our study has revealed a tendency of an increasing growth rate during April-June and an inverse trend in July and August.

**Key words:** band dendrometer, circumference measurement, Norway spruce, Scots pine, silver birch

## Introduction

The seasonal circumference growth of trees has been widely used investigating the duration of tree vegetation as well as studying the dynamics of growth during the growing season and its relationship with environmental factors (Deslauriers et al. 2007, Detienne et al. 1988, Downes et al. 1999, Dünisch et al. 2002, Marion et al. 2007).

Various methods are used for the investigation of seasonal circumference growth (Mäkinen et al. 2008), such as dendrometers (Deslauriers et al. 2007, Kahle 2005, Pook et al. 1977), pinning (Seo et al. 2007, Wolter 1968), and micro-coring (Marion et al. 2007, Забуга and Забуга 1991). Dendrometers record the intra-annual stem growth including cell division and enlargement of phloem and xylem (irreversible stem reaction) and reversible diurnal stem shrinkage and expansion caused by hydration shifts (Забуга and Забуга 1991). Due to this, dendrometers have been criticized when short-term growth is studied, when the reversible variations are higher than wood growth, inevitably introducing errors in the measured data (Zweifel and Häsler 2001). Pinning and micro-sampling enable a direct assessment of cambial cell division and following wood formation (Marion et al. 2007, Pook et al. 1977, Забуга and Забуга 1991). Taking of micro-samples leaves small wounds on the stem. Hence, repeated sampling should be done from different places around the trunk and thus limits the time for continuous sampling from the same tree.

Therefore, manual band dendrometers were chosen when a long-term study of seasonal growth was started in 1976, expecting to upgrade them to automatic dendrometers in future. Until now, the data from 1976-1980 and 1994-1998 were analyzed (Karpavičius and Vitas 2000, Vitas 2002, Битвинскас et al. 1981, Битвинскас 1984). Hence, the most of the data remains still unpublished.

In this paper, we present the investigation of seasonal circumference growth of pine, spruce, and birch in NE Lithuania. Our objectives were to define the onset, cessation, and duration of growth together with growth rate during the growing season; in particular, we wanted to ascertain the shifts of these growth indicators during the whole monitoring time from 1976 to 2010.

## Material and methods

### *Study area*

The investigation was carried out on an experimental plot located in the Aukštaitija National Park, vicinity of Vaišnoriškė (55°25'33"N 26°01'45"E). The Laboratory of Dendrochronology selected this research plot in 1976 for a continuous monitoring of seasonal growth using band dendrometers. The ter-

rain is located 158-166 m above sea level and slightly uprising from south to north of the plot. The plot of ca. 1 ha in size is overgrown by a mixed pine forest with spruces and birches. The forest type of the stand was determined as *Vaccinio-myrtillo-Pinetum* and the soil as arenosol with insertions of gravel and cobbles. The ground water table is deeper than 5 m (Vitas 2006). According to the inventory of 2001, 198 pines, 35 birches, 23 spruces, and 6 trees of other species grew on the plot. Natural mature forest predominates, while in a small part pines were planted after the Second World War.

In Lithuania, the climate changes from maritime to continental. The study area belongs to the climate region of Aukštaitija (Bukantis 1994), which is characterized by the most continental conditions with coldest winters. The mean monthly air temperature from 1976-2010 ranges from -5.4°C in February to +17.2°C in July (Fig. 1). The average annual temperature is +5.8°C. The monthly amount of precipitation ranges from 38.1 mm in April to 69.8 mm in August and the yearly average is 667.1 mm.

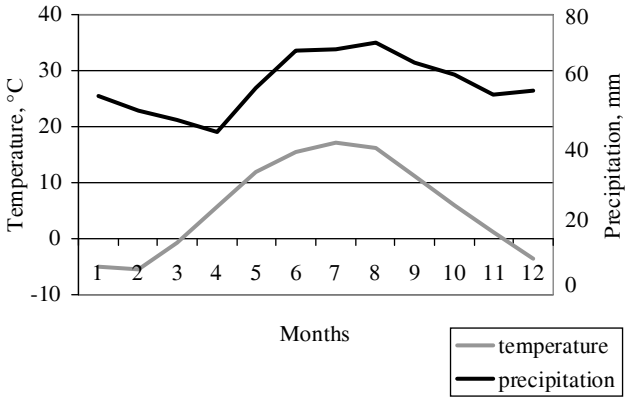


**Figure 1.** Average monthly air temperature and amount of precipitation in Vaišnoriškė 1976-2010

***Methods***

Manual band dendrometers for monitoring seasonal growth were installed on 24 pines, 3 spruces, and 3 birches in 1976. At present, the growth of 23 pines, 3 spruces, and 3 birches of co-dominant and dominant crown categories is measured. It is known that dominant trees start to grow earlier and their growing season lasts longer than that of intermediate trees (Горячев 1981, Кайрюкштис and Юодвалькис 1970). Due to drying-out of trees, mainly caused by *Peridermium pini* (Pers.) Lev. and *Fomitopsis annosa* (Fr.) Karst., the number of investigated pines fluctuated by two to three trees and spruces and birches by one tree (Karpavičius and Vitas 2000). The circumference growth was measured using mechanic or electronic callipers every three days from spring (end of April or beginning of May) until autumn (end of August or beginning of September) within 0.01 mm accuracy (Fig. 2). The radial growth could be easily extracted from original measurements by dividing the data by 2π. The principle and installation of band dendrometers are comprehensively discussed by B. D. Keeland and P. J. Young (available online: http://www.nwrc.usgs.gov/Dendrometer/).

**Figure 2.** Band dendrometer installed on pine tree; arrows show measuring points for the circumference growth

In this article, we analyzed data of seasonal growth from 1976-2010; the data for 1987 and 1992 got lost. The impact of cambium swelling in spring was removed by visual inspection of individual tree growth curves. Slight increase of circumference followed by the plateau phase was removed from the processed growth curves. The growth onset and cessation were determined for individual trees during each growing season and growth duration was calculated. The growth rate percentage from the total annual growth for each month was counted (April-May, June, July, and August-September). The statistical analysis was performed using Statistica 6.0 (StatSoft Inc. Tulsa).

## Results

The average radial growth of pine, spruce, and birch from 1976-2010 was 0.82±0.03, 1.55±0.06, and 1.34±0.06 mm per annum, respectively. The chronologies are presented in Figure 3; pine shows a slightly increasing but birch a slightly decreasing trend (Table 1). Hence, the average growth was highest for spruce, lower for birch and lowest for pine.

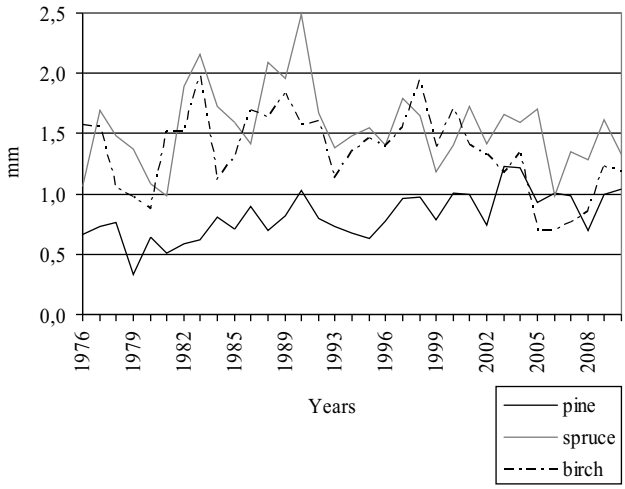


**Figure 3.** Average annual radial growth of pine, spruce, and birch from 1976-2010

**Table 1**. Trend-line characteristics of radial growth; a - slope of the line, $R^2$= coefficient of determination

| Species / Feature | Pine | | Spruce | | Birch | |
|---|---|---|---|---|---|---|
| | a | $R^2$ | a | $R^2$ | a | $R^2$ |
| Average radial growth | 0.01 | 0.45 | 0.00 | 0.01 | -0.01 | 0.11 |
| Onset of the radial growth | -0.57 | 0.43 | -0.61 | 0.50 | -0.40 | 0.18 |
| Cessation of the radial growth | -0.21 | 0.08 | -0.29 | 0.18 | -0.20 | 0.08 |
| Duration of the radial growth | 0.36 | 0.14 | 0.31 | 0.12 | 0.20 | 0.03 |
| Growth rate in April-May | 0.30 | 0.06 | 0.43 | 0.22 | 0.28 | 0.12 |
| Growth rate in June | 0.03 | 0.00 | 0.20 | 0.06 | 0.48 | 0.37 |
| Growth rate in July | -0.46 | 0.19 | -0.48 | 0.29 | -0.55 | 0.35 |
| Growth rate in August-September | 0.09 | 0.01 | -0.24 | 0.08 | -0.41 | 0.27 |

The average onset of the growth of pine, spruce, and birch (Fig. 4, top) was observed on 128.7±1.5, 125.6±1.5, and 130.4±1.6 day of the year (corresponding to 9th, 6th, and 10th of May). The earliest onset of the growth of pine, spruce, and birch occurred in 2000 and 2007 (22nd of April). The latest growth onset of pine was recorded in 1979 (1st of June), spruce in 1976 (24th of May), and birch in 1980 (1st of June).

The growth of pine, spruce, and birch has ceased on average on 240.5±1.2, 242.3±1.2, and 241.6±1.2 day, respectively (that means between 28th and 30th August) (Fig. 4, middle). The earliest cessation of the growth of pine and birch occurred in 1990 (17th and 14th of August) and of spruce in 2000 (14th of August). The latest cessation of the growth was observed in 1997 (13th, 15th, and 12th of September, respectively).

The growth of pine, spruce, and birch on average lasted for 111.8±1.6, 116.8±1.6, and 111.3±2.0 days (Fig. 4, bottom). The shortest growth was noticed in 1979, 1976, and 1980 and lasted for 87, 95, and 87 days, respectively, whereas the longest growth period was observed in 1997 and lasted for 130, 138, and 133 days, respectively.

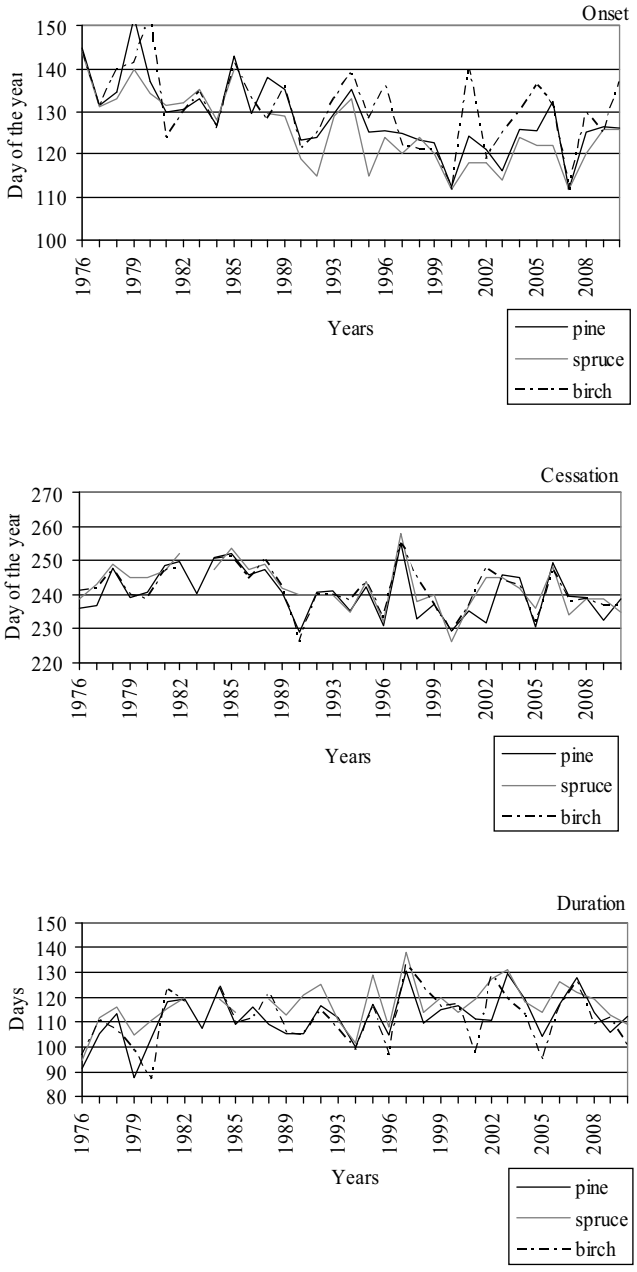


**Figure 4.** Average onset, cessation, and duration of seasonal circumference growth of pine, spruce, and birch. Onset and cessation are shown in days of the year, and duration is expressed in number of days

We have observed a high variability between individual trees in onset, cessation, and duration of growth. The onset is more variable in comparison to the growth cessation (10.5±1.2 and 9.4±0.9, respectively). These differences among pine, spruce, and birch will not be analyzed because of different numbers of investigated trees for each species.

Figure 4 shows highly synchronous growth onsets, cessations and durations of tree species (corre-

lations ranging from 0.69 to 0.90, $p<0.001$). The growth onset curves of pine, spruce, and birch show a pronounced downward trend (slope coefficient a=-0.57, -0.61, and -0.40, respectively) (Table 1). Hence, the growth onset from 1976-2010 tends to start earlier. The cessation of growth tends to finish earlier, but the trends are less pronounced (a=-0.21, -0.29, and -0.20). The duration of growth is slightly increasing (a=0.36, 0.31, and 0.20).

The average seasonal growth characteristics and growth curves of pine, spruce, and birch in April-May, June, July, and August-September from 1976-2010 are presented in Table 2 and Figure 5. It is evident that pine and spruce growth culminates in June (38.2% and 35.5% from the total growth). Spruce shows the more pronounced growth in July in comparison to pine (27.3 and 22.6% accordingly). Birch demonstrates a much slower growth rate in April-May (11.0%) and higher growth rate in July (37.7%).

**Table 2**. Average seasonal growth of pine, spruce, and birch (in % of the entire season) in April-May, June, July, and August-September from 1976-2010

| Tree species / Period | pine | spruce | birch |
|---|---|---|---|
| April-May | 24.1±2.1 | 24.3±1.6 | 11.0±1.3 |
| June | 38.2±1.9 | 35.5±1.4 | 36.0±1.3 |
| July | 22.6±1.8 | 27.3±1.5 | 37.7±1.6 |
| August-September | 16.9±1.8 | 13.6±1.4 | 16.9±1.3 |

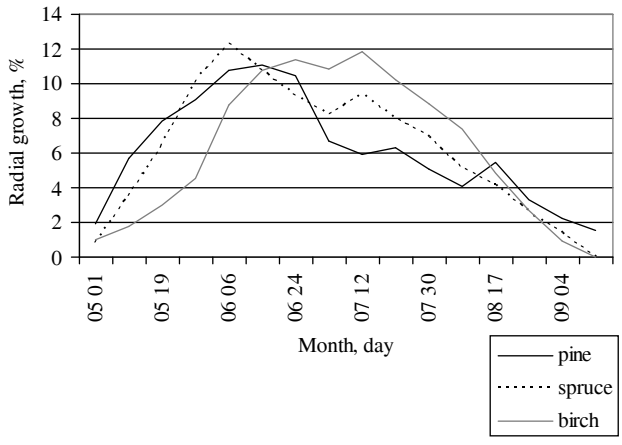


**Figure 5.** The average percentage radial growth of pine, spruce, and birch during every nine days from 1976-2010

The average growth rate curves for pine, spruce, and birch during April-May, June, July, and August-September (Fig. 6) show a tendency among all species for an increase of the growth in April-June and an inverse tendency for July-August, except a slight positive trend of pine in August-September (Table 1).

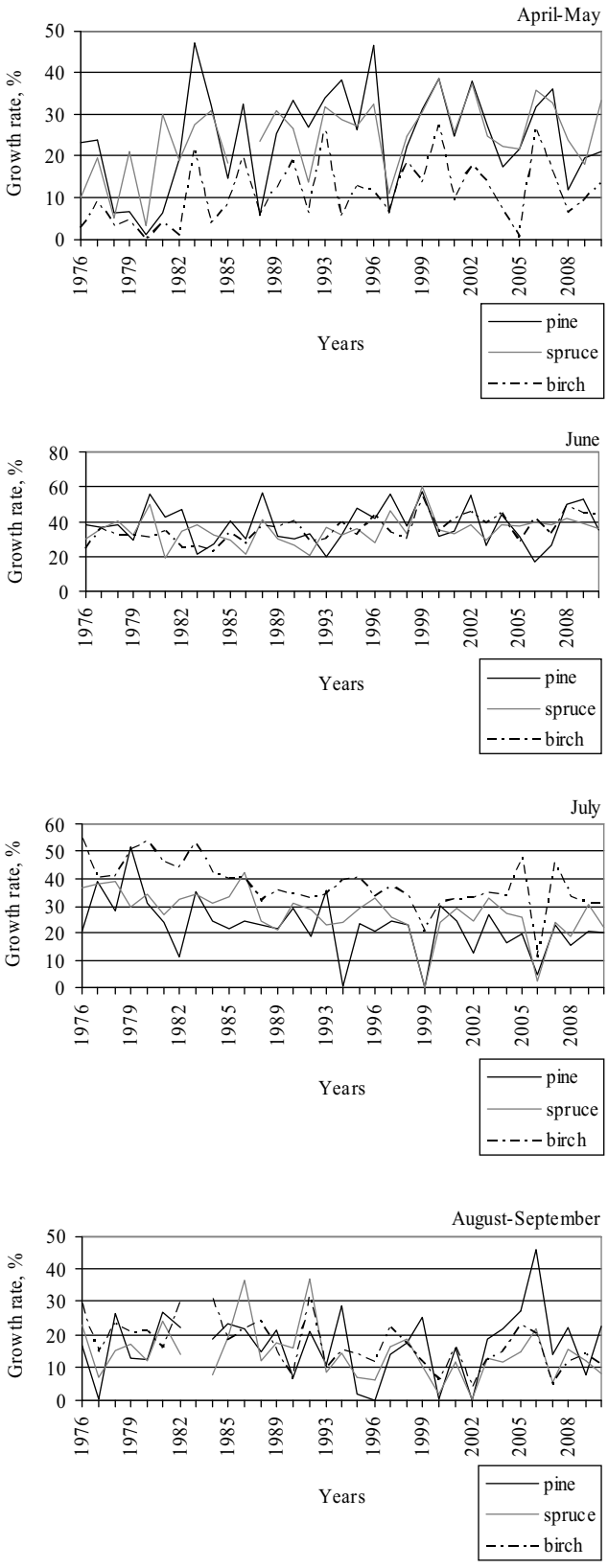


**Figure 6.** Average seasonal growth rate of pine, spruce, and birch (in % of the entire season) in April-May

The main differences among pine, spruce, and birch are as follows:

• The growth rate trend of pine is less pronounced in June, and in August-September it does not tend to decrease in comparison to spruce and birch.

• The most evident upward trend for spruce is noticed in April-May.

• The birch growth rate in June is increasing at most together with the most pronounced inverse trend in July-September.

## Discussion

Until now, an extensive number of studies on seasonal circumference growth were conducted. Due to a wide range of climatic conditions, the results contradict sometimes and cannot be directly compared to each other. For example, a great deal of studies was conducted in tropical forests (e.g., Biondi et al. 2005, Detienne and Barbier 1988, Downes et al. 1999, Dünisch et al. 2002). On the other hand, most investigations lasted usually only for a few years.

The growth onset and duration depend on the geographical latitude, i.e., climatic conditions. For example, the coniferous growth in Siberia (Putorana Mountains) begins in the third decade of June and lasts for 45-50 days until the middle of August (Канделаки and Демьянов 1982). The growth duration of spruce and pine in South Siberia and South Ural is longer and spans from the beginning of June to the second half of August (Горячев 1981, Забуга et al. 1983, Панарин and Солонько 1976, Терсков et al. 1981). Similar growth duration was found for trees in Karelia (Кищенко 1978). A recent investigation by Seo et al. (2011) in the northern boreal zone of Finland has revealed a growth duration of pine of 49-63 days. The growth of aspen in Estonia lasts for 95-100 days (Тамм and Туллус 1991) and growth of silver fir and European beech in the Czech Republic lasts for 133-140 days (Knott 2004). According to our investigations, the growth from 1976-2010 started in the first decade of May and ceased at the end of August (Fig. 4). Hence, the circumference growth of pine, spruce, and birch lasted on average for 111-117 days. The growth onset time is more variable among trees, while the cessation time is more uniform.

The average growth was highest for spruce, lower for birch and lowest for pine. We suspect that it is related to the spruce tolerance for shading under a closed canopy as well as genetic differences of the trees. The growth onset differences of spruce and birch are statistically significant ($p=0.03$); the growth of birch on average starts four days later than of spruce. The growth duration is longest for spruce (by 4-5 days) in comparison to birch and pine ($p=0.03$).

Previous investigations on the seasonal circumference growth dynamics in northern Lithuania (Biržai vicinity) were presented by Kairiūkštis (1963) and Кайрюкштис and Юодвалькис (1970). They found that the growth of spruce lasts on average 87±3 days and of birch 91±8 days from 1954-1966. The average onset of the growth was observed on 17$^{th}$ and 21$^{st}$ of May and cessation was noticed on 12$^{th}$ and 21$^{st}$ of August, respectively (Кайрюкштис and Юодвалькис 1970). This suggests that the growth duration of spruce and birch from 1954-1966 to 1976-1980 has increased by 21 and 9 days with an annual increase rate of 1.2 and 0.5 days per annum, respectively. According to our study, the duration of the growth of spruce and birch from 1976-1980 to 2006-2010 increased by 0.3 and 0.4 days per annum (Table 1).

The growth onset trend of the tree species from 1976-2010 is more pronounced in comparison to the cessation trend, and it determines an upward trend in growth duration during the study period (Table 1). The increase in growth duration perhaps is triggered by climate warming, which is especially obvious during the last decades. A similar increase in the duration of plant vegetation in Lithuania was also reported by Ozolinčius (2011).

The highest growth rate for pine and spruce was observed in June (38.2±1.9% and 35.5±1.4% of the annual growth, respectively). Studies carried out in Siberia described the highest growth rate for conifers from June-middle of July (Горячев 1981, Забуга et al. 1983). This is in agreement with the study in Finland by Seo et al. (2011), where nearly two thirds of the radial growth of pine was measured from mid June-mid July; growth culminated in the second half of June. On the contrary, Fiedler and Wenk (1973) in Germany found the highest growth rate for spruce in June-August and for pine in May-June. Their study was carried out at lower latitudes and consequently, tree growth was affected by warmer climatic conditions. The birch demonstrates slower growth in April-May and highest growth rate in July (11.0±1.3% and 37.7±1.6%, respectively). Perhaps, this is related to differences between deciduous and coniferous trees: evergreen conifers start vegetation more promptly than deciduous trees, in which the photosynthetic rate increases gradually together with leaf surface (MacDougal 1938). This is in agreement with our observations that the growth of birch on average starts four days later than spruce growth and corresponds to the results by Kairiūkštis (1963) and Кайрюкштис and Юодвалькис (1970), where the more rapid growth onset of spruce as compared to birch was established. Knott (2004) obtained similar results in the Czech Republic, where fir reached a maximum in

May and beech in June-July. On the other hand, this contrasts to the results of Tamm and Tullus (1991) in Estonia, where the highest growth rate for aspen was found in spring and beginning of summer.

There is a tendency among all species for an increase of growth in April-June and an inverse tendency in July-August (Table 1, Fig. 6). Hence, the growth is being shifted into spring and first half of summer. Probably, this is another evidence of climate warming (Ozolinčius 2011).

## Conclusions

From 1976-2010, circumference growth of pine, spruce, and birch was monitored in NE Lithuania using mechanical band dendrometers. The investigations have revealed the seasonal growth peculiarities of these tree species. The average onset of growth was observed on 6-10 of May and cessation on 29-30 of August. The growth duration was on average 111-117 days. However, the growth onset and cessation time are highly variable among individual trees. It is evident that the growth onset time is more variable in comparison to cessation time. The growth onset from 1976-2010 tends to start and cease earlier. Because the growth cessation trend is less pronounced in comparison to the onset trend, an increase in growth duration is noticeable.

Pine and spruce reach their maximum growth in June (Table 2), and birch in July (38.2±1.9%, 35.5±1.4%, and 37.7±1.6% from the annual growth, respectively). Birch shows much slower growth in April-May. Our research has revealed the common tendency for investigated tree species of a growth rate increase in April-June and an inverse trend in July-August. However, tree species-related specifics are notable. The growth rate of spruce tends to increase at most in April-May, and birch in June. Pine exhibits the slight growth increase in August-September in comparison to spruce and birch.

These results are still preliminary. For a more precise interpretation, it is necessary to assess the seasonal influence of climatic factors on various tree species and its changes during the vegetation season. At present, it is impossible to answer several questions related to differences among tree species, e.g., why the growth duration of spruce lasts longer than that of pine and birch, why the growth rate increase in spruce in April-May is more pronounced than in pine and birch and why the growth of birch tends to increase notably in June and decrease in July?

In spite of these limitations, our study extends the current knowledge on the growth of pine, spruce, and birch during the vegetation season by pointing out the shifts in growth onset, cessation, duration, and growth rate during separate months of the vegetation season.

## References

**Biondi, F., Hartsough, P. C. and Estrada, I. G.** 2005. Daily weather and tree growth at the tropical treeline of North America. *Arctic, Antarctic, and Alpine Research* 37(1): 16-24.

**Bukantis, A.** 1994. Lietuvos klimatas [Climate of Lithuania]. VU leidykla, Vilnius, 187 pp (in Lithuanian).

**Deslauriers, A., Rossi, S. and Anfodillo, T.** 2007. Dendrometer and intra-annual tree growth: What kind of information can be inferred? *Dendrochronologia* 25(2): 113-124.

**Detienne, P. and Barbier, C.** 1988. Rythmes de croissance de quelques essences de Guyane franēaise [Growth rates of some species of French Guyana]. *Bois et Forźts des Tropiques* 217: 63-76 (in French).

**Downes, G. M., Beadle, C., Gensler, W., Mummery, D. and Worledge, D.** 1999. Diurnal variation and radial growth of stems in young plantation Eucalypts. In: R. Wimmer and R.E. Vetter (Editors), Tree-ring analysis: biological methodological and environmental aspects. CABI publishing, Wallingford, p. 83-103.

**Dünisch, O., Bauch, J. and Gasparotto, L.** 2002. Formation of increment zones and intraanual growth dynamics in the xylem of *Swietenia macrophylla*, *Carapa guianensis*, and *Cedrela odorata* (*Meliaceae*). *IAWA Journal* 23(2): 101-119.

**Fiedler, F. and Wenk, G.** 1973. Der jahreszeitliche Ablauf des Dickenzuwachses von Fichten und Kiefern und seine Abhängigkeit von meteorologischen Faktoren [The seasonal circumference growth of spruces and pines and its dependence on meteorological factors]. *Wissenschaftliche Zeitschrift der Technische Universität Dresden* 22 (3): 531-535 (in German).

**Kahle, P.** 2005. Detecting anomalies in intra- and interannual radial growth of beech and spruce in the year 2003 by means of dendrometer data. ICP forests. Expert Panel Meeting on forest growth assessment on intensive monitoring plots, Igls, Austria, 2005: 27.

**Kairiūkštis, L.** 1963. Medžių augimas vegetacijos metu [Growth of trees during the vegetation time]. *Lietuvos miškų ūkio mokslinio tyrimo instituto darbai*, 7: 3-38 (in Lithuanian).

**Karpavičius, J. and Vitas, A. 2000.** Pastovūs medžių sezoninio radialinio prieaugio tyrimai Aukštaitijos nacionaliniame parke (Vaišnoriškėje) [Continuous research on seasonal tree radial increment in Aukštaitija National Park (Vaišnoriškė)]. *Ekologija* 1: 30-39 (in Lithuanian).

**Knott, R.** 2004. Seasonal dynamics of the diameter increment of fir (*Abies alba* Mill.) and beech (*Fagus sylvatica* L.) in a mixed stand. *Journal of Forest Science* 50(4): 149-160.

**MacDougal, D.** 1938. Tree growth. Leide, 240 pp.

**Mäkinen, H., Seo, J.-W., Nöjd, P., Schmitt, U. and Jalkanen, R.** 2008. Seasonal dynamics of wood formation: a comparison between pinning, microcoring and dendrometer measurements. *European Journal of Forest Research* 127: 235-245.

**Marion, L., Gričar, J. and Oven, P.** 2007. Wood formation in urban Norway maple trees studied by the micro-coring method. *Dendrochronologia* 25: 97-102.

**Ozolinčius, R.** 2011. Galimas klimato kaitos poveikis miško ekosistemų tvarumui: Lietuvoje atliktų tyrimų rezultatai

[Possible influence of climate change to the stability of forest ecosystems: results of research carried out in Lithuania]. Konferencijos "Agrariniai ir miškininkystės mokslai: naujausi tyrimų rezultatai ir inovatyvūs sprendimai" pranešimai. LAMMC, Girionys, p. 114-115 (in Lithuanian).

**Pook, E.W., Hall, T. and Newhouse, Il.** 1977. A recording band dendrometer of wide application. *Australian Forestry* 40(2): 132-143.

**Seo, J.-W., Eckstein, D. and Schmitt, U.** 2007. The pinning method - from pinning to data preparation. *Dendrochronologia* 25: 79-86.

**Seo, J.-W., Eckstein, D., Jalkanen, R. and Schmitt, U.** 2011. Climatic control of intra- and inter-annual cambium dynamics of Scots pine in northern Finland. *Environmental and Experimental Botany* 71:doi:10.1016/j.envexpbot.2011.01.003.

**Vitas, A**. 2002. Klimato veiksnių įtaka paprastosios eglės (*Picea abies* (L.) Karsten) radialiajam prieaugiui [Impact of climate factors on the radial increment of Norway spruce (*Picea abies* (L.) Karsten)]. Doctoral dissertation. Kaunas, VDU, p. 114 (in Lithuanian).

**Vitas, A.** 2006. Sensitivity of Scots pine trees to winter colds and summer droughts: dendroclimatological investigation. *Baltic Forestry* 12 (2): 220-226.

**Wolter, K. E.** 1968. A new method for marking xylem growth. *Forest Science* 14: 102-104.

**Zweifel, R. and Häsler, R.** 2001. Dynamics of water storage in mature subalpine *Picea abies*: temporal and spatial patterns of change in stem radius. *Tree Physiology* 21: 561-569.

**Битвинскас, Т**. 1984. Биоэкологические основы дендроклиматохронологических исследований [Bioecological background of dendroclimatochronological investigations]. Doctor habil. dissertation. Institute of Ecology for Plants and Animals, Sverdlovsk, 395 pp. (in Russian).

**Битвинскас, Т., Кайрайтис, И., Карпавичюс И., and Брукштус, В. 1981.** Комплексное исследование изменчивости условий среды (станция ботанических и дендроклиматических исследований в Национальном парке Литовской ССР - д. Вайшноришкес) [Complex research of the changes of environment conditions (station for botanical and dendroclimatological investigations in village Vaipnoripkl, National Park of Lithuanian SSR)]. Пространственные изменения климата и годичные кольца деревьев. Lithuanian Institute of Botany, Kaunas, p. 4-13 (in Russian).

**Горячев, В. М.** 1981. Сезонный рост лесообразующих пород в основных типах леса Висимского заповедника [Seasonal growth of tree species in the main forest types of Visimsky Reserve]. In: С.А. Мамаев, В.В. Иполитов and В.А. Кирсанов (Editors), 10 лет Висимскому государственному заповеднику [10 years of Visimsky State Reserve]. Sverdlovsk, p. 23-25 (in Russian).

**Забуга, В. Ф. and Забуга, Г. А.** 1991. О методах измерения радиального роста ствола сосны обыкновенной в экофизиологических исследованиях [On the methods for measurement of Scots pine stem radial growth in ecophysiological studies]. *Лесоведение* 3: 63-67 (in Russian).

**Забуга, В. Ф., Забуга, Г. А. and Солдатов, С. В.** 1983. Радиальный прирост сосны обыкновенной в лесостепных районах предбайкалья [Radial growth of *Pinus sylvestris* L. in forest-steppe districts of the Cisbaikal region]. *Лесоведение* 3: 83-86 (in Russian).

**Кайрюкштис, Л. А. and Юодвалькис, А. И.** 1970. Особености сезонного роста деревьев в свете дендрохронологических и дендроклиматических исследований [Peculiarities of seasonal growth of trees in dendrochronological and dendroclimatological aspects]. *Лесоведение* 3: 29-34 (in Russian).

**Канделаки, А. А. and Демьянов, В. А.** 1982. Динамика формирования годичных колец у древесных растений в горах Путорана [Dynamics of forming annual rings in woody plants in the Putoran Mountains]. *Лесоведение* 5: 46-49 (in Russian).

**Кищенко, И. Т.** 1978. Влияние погодных условий на сезонный рост сосны в условиях Карелии [Effects of weather conditions on seasonal growth of *Pinus sylvestris* L. in Karelia], *Лесоведение* 5: 36-51 (in Russian).

**Панарин, И. И. and Солонько, Г. Н.** 1976. Формирование годичного кольца древесины хвойных пород в условиях Прибайкалья и Хамар-Дабана [Formation of a wood ring in coniferous species in Hamar-Daban and Baikal Lake region]. *Лесоведение* 6: 50-58 (in Russian).

**Тамм, Ю. А. and Туллус, Х. Х.** 1991. Сезонная динамика радиального прироста стволов осины [Seasonal dynamics of aspen stem radial increment]. *Лесоведение* 1: 12-19 (in Russian).

**Терсков, И. А., Ваганов, Е. А. and Свидерская, И. В.** 1981. Трахеидограмма годичного кольца как характеристика скорости сезонного роста дерева [Tracheid curve of tree ring as a characteristic of seasonal growth rate]. Известия Сибирского отделения Академии наук СССР [News of the Academy of Sciences of SSSR (Siberian branch)]. Nauka, Novosibirsk, p. 22-30 (in Russian).

Received 28 April 2011
Accepted 16 November 2011

# СЕЗОННАЯ ВАРИАЦИЯ ПРИРОСТА СОСНЫ, ЕЛИ, И БЕРЕЗЫ В СЕВЕРО-ВОСТОЧНОЙ ЧАСТИ ЛИТВЫ, ЗАРЕГИСТРИРОВАННАЯ ПРИ ПОМОЩИ ЛЕНТОЧНЫХ ДЕНДРОМЕТРОВ

**А. Витас**

Резюме

Мы представляем результаты исследования проведенного в 1976-2010 на сезонном приросте деревьев в северо-восточной части Литвы. Изменения роста были регистрированы каждые три дня, используя ручные ленточные дендрометры на 29 деревьях: 23 сосны обыкновенной (*Pinus sylvestris* L.), 3 ели обыкновенной (*Picea abies* (L.) Karsten) и 3 повислой березы (*Betula pendula* Roth). Рост в течении периода исследования в среднем начинался с 6-10-го мая и прекращался 29-30-го августа; рост в среднем длился 111-117 дней. Мы обнаружили, что начало и время прекращения прироста очень менялись среди индивидуальных деревьев. Тенденция более раннего начала, прекращения, и удлинения продолжительности роста была установлена в период с 1976 до 2010 год. Сосна и ель достигают их максимального прироста в июне, в то время как береза – в июле. Береза демонстрирует медленный рост в апреле-мае по сравнению с сосной и елью. Наше исследование обнаружило тенденцию увеличения темпа роста в апреле-июне и обратную тенденцию в июле-августе.

**Ключевые слова**: дендрометр ленточный, ель обыкновенная, измерение периметра, повислая береза, сосна обыкновенная