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BIOMEDICINOS MOKSLAI

Possibilities of Bioecological Methods for the Forecast of Tree Radial Growth

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Investigations evaluating link between the radial growth of trees and phenophases of peonies have been carried out. Collection-exposition of peonies in Kaunas Botanical Garden for this purpose was used. During phenological observations four cultivars were evaluated according re-sprouting, blossom and decorativeness. The radial growth of trees was investigated in dendrarium of Botanical Garden (European ash, English oak, Norway spruce and northern white-cedar) and forests of Kaunas region (English oak, Norway spruce, Scots pine and larch). The radial growth patterns of this species, its dependence on climate factors and links to phenopahases of peonies were evaluated. Research has demonstrated that phenophases of peonies depend on climate conditions of several months, especially on last winter conditions. It was established that the beginning of phenophases of peonies is related to the radial growth rates of trees. Links between the beginning of phenophases of peonies and tree radial growth enables to forecast the radial growth and peculiarities of the vegetation of peonies. Low winter temperatures and thin snow cover are one of the main factors influencing re-sprouting of peonies, similarly to the radial growth rates of many tree species.

Climate, dependence, disease, phenophases, radial growth.

Introduction

Methods of dendroindication, based on tree radial growth regularities and dependences on climate conditions, and approaches of phenology, dealing with seasonal development of plants, in practice were applied separately in Lithuania as well as over the world. The radial growth patterns of living trees, relationships to climate factors and data of the long-term chronologies were successfully applied for the reconstruction of past climate conditions and other environmental characteristics in many countries.

Reconstructions on summer temperatures in Fennoscandia from 500 AD (Briffa et al., 1992), variations of annual temperatures during the Holocene (Briffa, 2002) and river flow in Sweden (Jonsson, 2001) were successfully accomplished in the regions closest to Lithuania. Dendroindication on climate reconstruction and evaluation of vegetation changes are still rarely used in Lithuania.

The most important applications of dendroindication were presented in doctoral dissertation by R. Pukienė (1997) and in publication by J. Karpavičius (2005). The method applying data of the radial growth of growing trees was commonly used for the development of the forecast methods in Lithuania (Кайрюкштис и др., 1986; Kairiūkštis et al., 1987; Bitvinskas, 1990; Yadav et al., 1991).

The rates of development, duration of vegetation period, time of blooming and fruiting depend on climate conditions. All this is discussed in S. Nacevičius (1975) monograph. Phenological observations have been used in agriculture, horticulture, forestry, herb growing, and beekeeping estimating optimal terms for seasonal works and forecasting results in Lithuania and other countries. The long-term phenological observations are connected to climate variations and allow forecast the tendencies of climate change. Researches of this kind have been performed in Estonia (Ahas, 1999), Scandinavia, several other European countries (Defila et al., 2001; Emberlin et al., 2003; Wielgolaski, 2003) and Canada (Beaubien et al., 2000). There are no works on this topic in Lithuania until now. The relationships between radial growth, growth patterns of woody plants and the seasonal development of plants, explored by phenology, have been investigated neither in Lithuania nor in other countries.

The long-term phenological observations of growing at the same place for many years may help to reach these goals. The exposition of peonies at Kaunas Botanical Garden fits very well for the aims especially because investigated trees grow in the similar soil.

The coincidence of growing conditions allows evaluate reliably the relationships between the seasonal development of peonies and tree ring growth patterns. The detection of factors influencing the seasonal development of peonies and the radial growth of trees enables to forecast more reliably not only peculiarities of the peonies vegetation or tree radial growth but also future climate conditions in Lithuania.

The aims of the work are following: to evaluate the relationships between the tree radial growth of different tree species and phenophases of peony cultivars, to establish common factors determining the radial growth patterns and phenophases of peonies and evaluation of forecast possibilities.

Methods and materials

The collection-exposition of peonies in Kaunas Botanical Garden at Vytautas Magnus University was planted in 1982–1984 and covers area of 1842 m^2. Seedlings were planted in rows towards south direction. Peonies grow in sod carbonate gleyed soil. Light and medium hardness clayey soil predominated there. Soil of this kind is particularly favourable for peonies cultivation. Soil water is deeper than 1 m.

Phenological observations (according S. Nacevičius (1975) and biometrical measurements, according J. Vaidelys (1998) of *Paeonia lactiflora* Pall. breeds cultivated at Kaunas Botanical Garden of Vytautas Magnus University were performed during 1993–2005. The phytosanitarian state was evaluated applying visual method, isolating micromycetes to clean cultures using wet compartment and identifying using microscope according to descriptions of В.И.Билай et al. (1988).

For the detection of relationships between beginning of phenophases (re-sprouting –AT, blossom – ŽP) and tree radial growth four cultivars of peonies that differ in blossom time were selected.

Early hybrid – 'Maironis' (MA) and cultivars 'Virgilijus' (VI), medium earliness – 'Garbė Motinai' (GM) and late – 'Prof. K. Grybauskas' (PG). For the aim of research the radial growth of trees growing in Kaunas Botanical Garden and Šilėnai Forestry (S) of Dubrava experimental-educational forest enterprise (approximately 25 km from the Garden) for the same period was investigated.

Wood samples (cores) were taken from six different tree species. Experimental plots for European ash (*Fraxinus excelsior* L.), English oak (*Quercus robur* L.), Norway spruce (*Picea abies* (L.) Karsten) and Northern white-cedar (*Thuja occidentalis* L.) were located in Kaunas Botanical Garden and for Larch (*Larix sp.*), English oak, Norway spruce and Scots pine (*Pinus sylvestris* L.) in Šilėnai Forestry.

For the purpose of the research, 23 ash trees were selected in Botanical Garden. According to the growing place trees were divided into four groups. Five trees belonging to the first group (BSU1) grow near the former outhouse building (Ž. E. Žilibero 2), the second group (BSU2) grows at the beginning of Vilties and Ž. E. Žilibero streets, the third group (BSU3) grows to the north of the Ž. E. Žilibero 4 building and the fourth group (BSU4) is located to the west from the Ž. E. Žilibero 6 building.

Investigations on soil texture and soil water level have been performed in several research plots. A special ground borer or profile digging was used for this purpose. Soil research was performed between BSU1 and BSU2 and in BSU4 research plots. A thick humus surface horizon (20-40 cm) and rich clay soil with deeper transition to pure clay was found on both places. The soil water level between BSU1 and BSU2 was found at 110 cm depth and clay soil is characterized with thin insertions of moist sand. Soil by BSU4 is characterised by thinner humus layer, clay soil transits to gleyed layer at 160 cm depth indicating the surplus of water in the soil. The soil water level was deeper than 180 cm and soil was much more dry than at BSU1 and BSU2 research plots. Oaks (BSA), spruces (BSE) and white-cedar (BST) grow on the similar condition compared to ashes (BSU1and BSU2), because trees are located in the middle among above-mentioned buildings.

The plot S4 is situated on the top of ancient Nemunas river valley in Šilėnų Forestry with 70% *Pinus sylvestris* L. and 30% *Picea abies* (L.) Karst. The type was classified as *Pinetum oxalido-myrtillosum*. Clay layer at 2 m depth, which inhibited the downward water percolation, characterized the soil but water drained up along it towards the Kauno Marios. Elluvial grey horizon with brown spots was at 68-82 cm and illuvial grey with frequent brown spots – at 83-130 cm depth. For the purpose of research samples from pines (SP4) and spruces (SE4) in experimental plot were taken.

Fifty meters from the plot S4 experimental plot SP5 was selected. Trees of the plot grew in a small bog with peat layer up to 80 cm in thickness. The stand was pure (100% *Pinus sylvestris* L.) and forest type – *Pinetum sphagnosum*. Investigated oaks (SA8) grow alongside experimental plot (SP5) towards northeastern direction. Under thick layers of litter and humus, sand layer 0.3-0.5 m deeper, clay is found deeper in this stand. Cobles are present at 1.5 m depth. A surplus of water in lower places of the stand concentrates often in spring and after heavier rains.

For the purpose of the research radial growth data of one of the oldest pine forests growing in Panemunė Park was also used.

Using increment borer, samples from more than 10 trees in each researched plot were taken at the breast height. Due to a huge amount of ash trees with decay of pith and small amount of trees growing in each group at Kaunas Botanical Garden samples were taken from the less number of trees.

Tree ring widths, latewood and earlywood separately, were measured within 0.05 mm accuracy. For this purpose stereomicroscope MBS-9 was used. Tree ring width series obtained from individual tree were averaged into local chronologies.

For the assessment of relationships between number of days from 1st January of each year until the beginning of different phenophases and climate factors correlation coefficients and its criterion t were calculated. We used climate data from the nearest meteorological station located in Kaunas. The following data was used: air temperature and amount of precipitation during winter (t1;2, p1;2), spring (t3-5, p3-5) and summer (t6, p6). For the better comparison between number of days and the growth pattern of trees, data of the radial growth was multiplied by 100.

Results and discussion

Before discussing impact of climate conditions to the beginning of phenophase of peonies we will shortly review the most typical features of climate conditions during 1993–2005 (Table 1).

As it could be seen from the Table 1 much higher temperatures in both cold and warm seasons (except June) according to data of Kaunas meteorological station (1893 – 2005) dominated in 1993 – 2005. Especially warm weather conditions, compared to the long-term average, prevailed in February – May of 2000 – 2004. Earlier re-sprouting of peonies (already in the first decade of April) was registered in this period. Amount of precipitation in the cold period (January – March) greatly differs also from the long-term mean and exceeds the long term mean by 1.3 times. Meanwhile, precipitation in the warm period (April – June) was close to the average, except in April and May of 2000 – 2004.

These differences of temperatures and precipitation in separate periods are closely related to the re-sprouting and the beginning of blossom of peonies, therefore we will give short view on the influence of climate conditions of different months on the beginning of the mentioned phenophases (Table 2).

As it is seen in Table 2 air temperatures of all months show negative links with beginning of phenophase. Higher air temperatures affect the earlier beginning of the vegetation of peonies and vice versa. The re-sprouting and beginning of blossom of peonies depend not only on the climate conditions short before phenophases, but also on climate conditions in previous months and on conditions in winter. This is seen from the highest correlation coefficients (up to – 0.50; $t \geq 1.91$) with temperatures in January. Influence in February is weaker compared to January. This may be related to the deepness of soil freezing, which is mostly determined by temperatures and snow layer in January.

Table 1. Average monthly data of air temperature (in numerator) and precipitation (in denominator) in different climate periods
1 lentelė. Skirtingų klimatinių periodų vidutinės mėnesinės temperatūros (skaitiklyje) ir krituliai (vardiklyje)

Year, period *Metai, laikotarpis*	Month *Mėnuo* I	II	III	IV	V	VI
1996	-7.7 / 27	-7.7 / 25	-3.3 / 14	7.1 / 25	13.6 / 71	15.1 / 64
1993-2005	-2.8 / 46	-2.4 / 39	0.4 / 44	7.7 / 44	12.7 / 51	15.6 / 63
2000-2004	-3.5 / 43	-1.6 / 41	1.4 / 44	8.1 / 26	13.3 / 43	15.2 / 65
2004	-7.4 / 48	-2.0 / 42	1.6 / 59	7.3 / 15	11.0 / 37	14.1 / 63
2005	-0.3 / 48	-5.5 / 18	-3.4 / 48	7.5 / 37	12.1 / 77	15.0 / 78
1893-2005	-4.6 / 35	-4.1 / 29	-0.4 / 34	6.3 / 41	12.4 / 52	15.7 / 68

Table 2. Coefficients of correlation between monthly climate factors (temperatures – t and precipitation –p) and number of days until the beginning of different phenophases
2 lentelė. Koreliacijos koeficientai tarp mėnesinių klimatinių veiksnių (temperatūrų – t ir kritulių – p) ir dienų skaičiais nuo atskirų fenofazių pradžios

Climatic factor *Klimato veiksnys*	Cultivars and hybrid of peony and the beginning of phenophase *Bijūnų veislių ir hibridų fenofazių pradžia* VIAT*	VIŽP	GMAT	GMŽP	PGAT	PGŽP	MAAT	MAŽP
t1	-0.41	-0.47	-0.30	-0.52	-0.49	-0.38	-0.47	-0.46
t2	-0.29	-0.31	-0.34	-0.29	-0.11	-0.41	-0.23	-0.28
t3	-0.49	-0.38	-0.41	-0.16	-0.46	-0.18	-0.43	-0.37
t4	-	-0.51	-	-0.31	-	-0.43	-	-0.51
t5	-	-0.24	-	-0.43	-	-0.38	-	-0.23
p1	-0.43	-0.16	-0.11	0.02	-0.76	0.10	-0.40	-0.16
p2	-0.09	-0.36	-0.11	-0.20	-0.09	-0.33	-0.04	-0.36
p3	-0.40	-0.22	-0.09	0.04	-0.56	0.20	-0.42	-0.17
p4	-	-0.03	-	0.13	-	0.43	-	-0.01
p5	-	0.31	-	0.23	-	0.58	-	0.36

Notes: *t – average air temperature; p – amount of precipitation; VI – Virgilijus; GM – Garbė motinai; PG – Prof. K. Grybauskas; MA – Maironis; AT – re-sprouting; ŽP – blossom.
*Pastabos: *t – oro temperatūros vidurkis; p – kritulių kiekis; VI – Virgilijus; GM – Garbė motinai; PG – Prof. K. Grybauskas; MA – Maironis; AT – atželimas; ŽP – žydėjimas.*

As it is seen from Table 1 and Fig. 1 January in 1996 and 1997 were one of the coldest and the least snowy during 1993 – 2005. As the result soil could freeze deeper and therefore the re-sprouting of peonies have started very late (after 123 and 115 days) compared to all period.

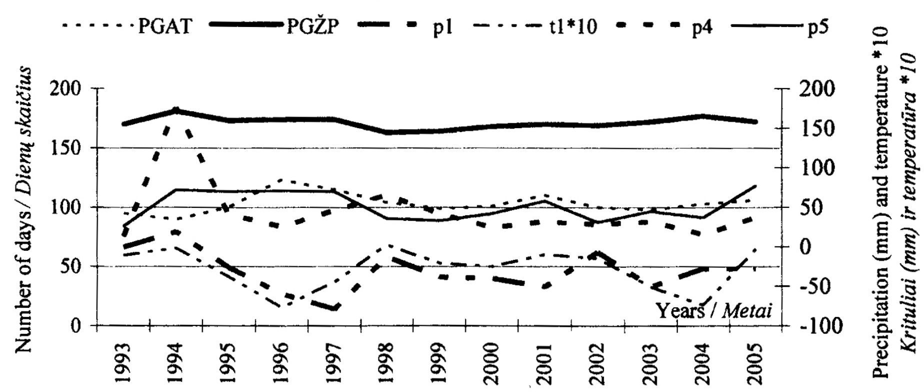

Fig. 1. The beginning of phenophases (PGAT and PGŽP) of peonies 'Prof. K. Grybauskas' and fluctuations of air temperature (t) and precipitation (p) in different months
1 pav. Bijūnų 'Prof. K. Grybauskas' fenofazių (PGAT ir PGŽT) pradžia ir mėnesių oro temperatūros (t) bei kritulių (p) kaita

Although January in 2004 was cold, but due to higher amount of precipitation, comparing to 1996 and 1997, impact of low temperatures for the re-sprouting of peonies was not observed. Sprouting of peonies started after 103 days. Higher than usual temperatures in February – March of 2004 also played positive role for peonies. This indicates that the beginning of phenophases of peonies depend not only on climate conditions of the certain month, but on the shift of climatic conditions during several preceding months.

The beginning of re-sprouting of 'Prof. K. Grybauskas' in 2005 proves well this affirmation. Though January of that year was quite warm (-0.3 °C), amount of precipitation was similar to 2004, but February and Mach of 2005 were considerably colder (-5.5 and -3.4 °C). February also was less snowy (18 mm), so soil could freeze strongly and re-sprouting of peony in 2005 started even three days later than in previous years. This shows that abundant precipitation during cold season protects soil from freezing and at the same time stimulates earlier re-sprouting of peonies. On the other hand abundant precipitation delays beginning of re-sprouting and blossom of peonies because after melting in spring soil is wet.

Phytosanitarian state of plants was also analyzed, but due to unreliable results it will be not discussed.

Because established relationships between the radial growth of different tree species and various factors (Karpavičius et al. 1996) coincide well with the data received estimating dependence of phenophases of peony cultivars on climate conditions, therefore we will review briefly correlation coefficients between separate phenophases of peonies and tree radial growth (Table 3).

Table 3. Correlation coefficients between separate phenophases of peonies and radial growth of trees (in numerator with earlywood; in dominator with latewood)

3 lentelė. Koreliacijos koeficientai tarp atskirų bijūnų fenofazių ir medžių radialiojo prieaugio (skaitiklyje – su ankstyvuoju; vardiklyje- su vėlyvuoju)

Experimental plots *Eksperimentinis plotas*	Phenophases of peonies *Bijūnų fenofazės*							
	MAAT	MAŽP	VIAT	VIŽP	GMAT	GMŽP	PGAT	PGŽP
SE4	0.14	-0.38	0.21	-0.32	-0.06	-0.35	0.27	-0.69
	0.09	-0.45	0.14	-0.40	-0.13	-0.46	0.40	-0.66
BSE	-0.04	-0.40	-0.01	-0.37	-0.17	-0.26	0.39	-0.19
	-0.28	0.20	-0.22	0.25	-0.37	0.20	-0.02	-0.11
BST	0.02	0.28	-0.04	0.30	0.00	0.47	0.07	0.41
	0.12	0.17	0.20	0.18	-0.09	0.17	0.50	-0.07
SP4	-0.30	-0.34	-0.25	-0.34	-0.25	-0.06	0.07	-0.32
	-0.13	-0.28	-0.05	-0.25	-0.09	-0.10	0.00	-0.32
SP5	-0.81	-0.52	-0.74	-0.53	-0.57	-0.26	-0.71	-0.09
	-0.70	-0.57	-0.66	-0.55	-0.67	-0.38	-0.35	-0.30
SA8	-0.13	-0.33	-0.13	-0.39	-0.04	-0.39	-0.23	-0.13
	0.05	-0.22	0.06	-0.39	-0.06	-0.46	0.06	-0.53
SM9	-0.02	-0.28	0.01	-0.38	0.13	-0.43	0.09	0.19
	0.12	0.06	0.11	-0.02	0.22	-0.24	0.05	0.16
SA9	-0.77	-0.72	-0.73	-0.78	-0.76	-0.63	-0.34	-0.32
	-0.51	-0.47	-0.44	-0.55	-0.38	-0.54	-0.33	-0.18
BSA	-0.58	-0.56	-0.59	-0.62	-0.46	-0.39	-0.46	-0.08
	-0.24	-0.43	-0.21	-0.52	-0.12	-057	-0.18	-0.15
BSU1	-0.49	-0.17	-0.46	-0.15	-0.45	0.06	-0.14	0.07
	-0.32	0.02	-0.26	0.04	-0.35	0.04	0.00	-0.04
BSU2	-0.38	-0.24	-0.36	-0.21	-0.38	-0.05	-0.04	0.02
	-0.48	-0.30	-0.50	-0.30	-0.55	-0.11	-0.04	0.06
BSU4	0.54	0.48	0.48	0.49	0.67	0.43	0.21	0.45
	0.27	0.29	0.23	0.24	0.50	0.16	-0.10	0.24

Notes: BS – Kaunas botanical garden; S – Šilėnai forestry; A – English oak; E – Norway spruce; M – Larch; P – Scots pine; U – European ash; T - Northern white-cedar.

Pastabos: BS – Kauno botanikos sodas; S – Šilėnų girininkija; A – paprastasis ąžuolas; E – paprastoji egl; M – maumedis; P – paprastoji pušis; U – paprastasis uosis; T – vakarinė tuja.

According to correlation coefficients which are often higher then ± 0.5 ($t \geq 1.91$) we can affirm that the beginning of separate phenophases of peonies and the radial growth of trees are under the influence of the same climate conditions. The relationships are well explained by applying plant physiology and influence of climate conditions manifests through other factors.

Negative coefficients of correlation show that the sooner separate phenophases starts the stronger probability that the radial growth of trees will increase (Fig. 2). This phenomenon may be explained by similar influence of climate conditions in spring to the radial growth of trees and phenophases of peonies. The higher temperature in spring, the quicker soils became dry after melting in spring. This triggers formation of favourable conditions for tree growth (Karpavičius et al., 1996) and beginning of vegetation of peonies. On the other hand the abundant precipitation in spring prevents warming of soil and retards vegetation of trees and peonies.

Relationships between the radial growth of trees, beginning of phenophases of peonies and soil hydrological conditions are indicated also by negative (r=-0.81; t=4.64) coefficients between the radial growth of earlywood of pines growing in bog and re-sprouting of peonies. It can be explained that the hydrological conditions of pines growing on humps of the bog are mostly different from growing conditions of peonies, therefore the sooner abatement of the level of melt waters, the more likely that the earlywood growth of pines will increase.

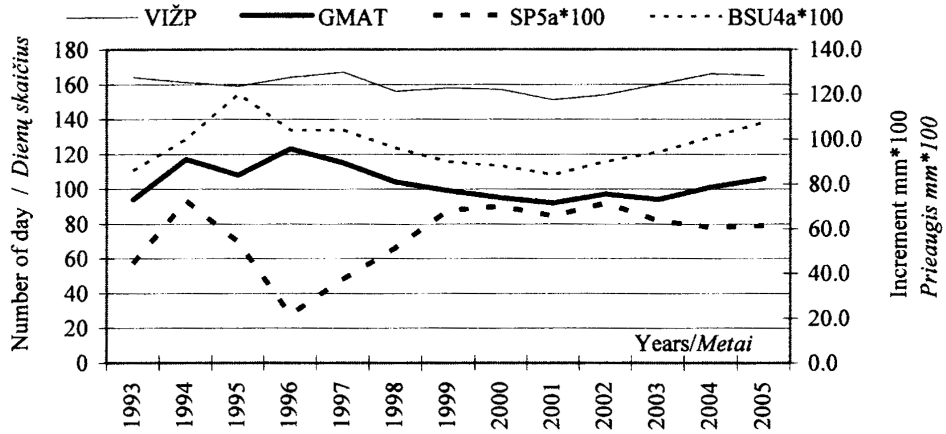

Fig. 2. Phenophases of peonies (VIŽP and GMAT) and earlywood (a) radial growth of trees dynamics (SP5 and BSU4) during 1993–2005
2 pav. *Bijūnų fenofazių (VIŽP ir GMAT) ir medžių ankstyvojo (a) radialiojo prieaugio dinamikos per 1993–2005 m.*

This shows that correlation coefficients between separate phenophases of peonies and the radial growth of trees are closely connected to hydrological conditions. Previous investigations have indicated that the response of radial growth of trees to temperatures and precipitation is connected to lithological composition of soil and depth of soil water (Kairaitis et al., 1996).

The dependence between phenophases of peonies and the radial growth of trees is confirmed by correlation coefficients with the radial growth of ash trees growing in Kaunas Botanical Garden. As it was already mentioned in methods, the soil water depth in the growing places of ash trees BSU1 and BSU2 are 1.1 m bellow surface and in research plot BSU4 – even deeper. Because ash trees are less resistant to water abundance then oaks (Ubysz, 2001), therefore high spring temperatures evaporating moisture have positive influence to the radial growth and negative, where water is found deeper (Karpavicius et al., 2006).

The correlation between the radial growth of trees and phenophases of peonies depend on biological peculiarities of different tree species. In spite of trees growing in Kaunas Botanical Garden – northern white-cedar (*Thuja occidentalis* L.) (BST) and Norway spruce (*Picea abies* (L.) Karsten) (BSE) and in Šilėnai Forestry – Larch (*Larix* spp.) (SM9) and English oak (*Quercus robur* L.) (SA9) are characterized by similar root systems – surface and deep (Navasaitis, 2004) and grow under the same growing conditions, but the coefficients between radial growth and phenophases of peonies differ.

Correlation coefficients with the radial growth of northern white-cedar are mostly positive, but with Norway spruce – negative. Also coefficients with growth of oaks are much higher than with larches growing at the same stand. These differences could be explained by needs of mentioned tree species to soil moisture during vegetation, and is confirmed by some dendrological investigations. E.g. northern white-cedar is not very demanding on soil, but sensitive to drought and mulch is recommended during the summer time (Navasaitis. 2004). For the more detailed relationships on biological peculiarities of trees further researches are needed.

Correlation coefficients might be even informative specifying influence of climate factors on the radial growth of trees. The majority of higher correlation coefficients (Table 3) indicate that the radial growth of trees is more connected to climate conditions until blossom of peonies. Therefore, for the radial growth of pines growing in bog (SP5) the more important are conditions until re-sprouting.

The correlation enable also to specify the beginning of the influence of climate conditions for the formation of earlywood and latewood. This is also confirmed by higher correlation coefficients between the latewood compared to earlywood of pines (SP5) and oaks growing in Šilėnai Forestry (SA8) and Kaunas Botanical Garden (BSA) with lately starting to blossom peony cultivars – 'Garbė Motinai' (on the average after 162 days) and 'Prof. K. Grybauskas' (on the average after 171 days). Previously discussed data confirms that using beginnings of phenophases of peonies it is possible to estimate reliably enough the radial growth of trees.

The trees accumulate in tree ring widths reliable information about the influence and trends of environment conditions. Respective cycles are peculiar for the dynamics of tree's radial growth. Recurrence of these cycles enables to forecast the growth reliably enough for some decades to the future. Using the methods proposed by Кайрюкштис and Дубинскайте (1986) forecast of the radial growth of the oldest growing pines in Panemunė Park was developed (Fig. 3).

For the evaluation of the forecast after nearly 20 years cores from trees of the same plot again were taken and growth was measured (dotted line in Fig. 3).

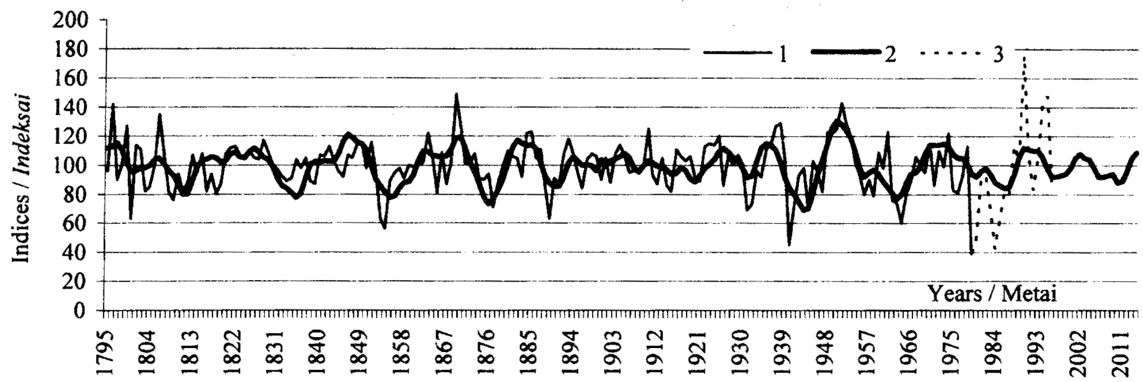

Fig. 3. Forecast of the radial growth of pines in Panemunė Park. 1 – radial growth used for forecast (1795-1978); 2 – approximated radial growth (1795-1978) and forecast for (1979-2014); 3 – actual radial growth data for 1979-1996

3 pav. Panemunės parko pušų radialiojo prieaugio prognozė. 1 – radialusis prieaugis naudotas prognozuojant (1795-1978); 2 – aproksimuotas radialusis prieaugis (1795-1978) ir jo prognozė 1979-2014 m; 3 – faktinis radialusis prieaugis 1979- 1996 m.

As could be seen from Fig. 3 the calculated forecast reflects the long-term (5 and more years) tendencies of the radial growth well enough (r = 0.62). Using correlations between the phenophases of peony cultivars and the radial growth of trees it is possible to forecast not only the radial growth in the future, but also the expected peculiarities of the vegetation of peonies. The usage of complex bio-ecological methods permits to specify the tendencies of environmental conditions.

Conclusions

1. The beginning of different phenophases of peonies depends not only on climate conditions in the nearest months, but also on conditions of previous seasons.

2. The important impact on the beginning of phenophases of peonies has climate conditions in previous winter. The less amount of snow is felt during January-March, the later re-sprouting of peonies begin. Abundant precipitation in April-May impedes beginning of re-sprouting and blossom of peonies also.

3. Negative impact to the beginning of phenophases of peonies has low temperatures during cold and warm seasons. A very similar influence of temperature and precipitation in winter and spring is also common to the radial growth of trees.

4. The earlies beginning of phenophases of peonies indicates higher radial growth of trees.

5. The correlation between the beginning of phenophases of peonies and the radial growth of trees are closely connected to the lithological composition of soil, soil water depth and biological peculiarities of trees (Karpavičius et al., 2004). Therefore forecasts of tree radial growth should be based on features above-mentioned.

6. The assessment of tree radial growth patterns by statistical means it is possible to forecast not only tendencies of tree radial growth, but also to foresee beginning of vegetation of various perennial plant.

7. The research carried out have proven the usage of complex bioecological methods for the investigation of environment and forecast, therefore it is recommended to perform analogical investigations in the future, applying data of development of different decorative and herby species, which are closely related to climate conditions in spring-summer.

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Bioekologinių metodų panaudojimo galimybės prognozuojant medžių radialųjį prieaugį

Santrauka

Atlikti tyrimai, įvertinantys ryšį tarp medžių rūšių radialiojo prieaugio ir bijūnų fenofazių. Tyrimuose naudota bijūnų kolekcija, auganti VDU Kauno botanikos sode. Vertinti keturių bijūnų veislių šie fenologiniai rodikliai: kero atželimas ir žydėjimo pradžia. Medžių radialiojo prieaugio tyrimai atlikti Kauno botanikos sodo dendroparke ir Kauno regiono miškuose. Analizuota paprastojo uosio, paprastojo ąžuolo, paprastosios eglės, vakarinės tujos ir maumedžio radialiojo prieaugio eiga, jos priklausomybė nuo klimato bei ryšys su bijūnų fenofazėmis. Rezultatai parodė, kad bijūnų fenofazės priklauso nuo keleto mėnesių klimato sąlygų, ypač praėjusios žiemos. Nustatyta, kad bijūnų fenofazių pradžia yra susijusi su medžių radialiojo prieaugio dydžiu. Ryšiai tarp bijūnų fenofazių pradžios ir medžių radialiojo prieaugio leidžia prognozuoti būsimą radialiojo prieaugio dydį ir bijūnų vegetacijos kaitą. Ypatingai neigiamą įtaką bijūnų atželimo pradžiai, kaip ir daugelio medžių rūšių radialiajam prieaugiui, turi žema žiemos temperatūra ir plona sniego danga.

Klimatas, priklausomybė, ligos, fenofazės, radialusis prieaugis.

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Возможности использования биоэкологических методов в прогнозировании радиального прироста деревьев

Резюме

Проведены исследования, оценивающие связь между радиальным приростом пород деревьев и фенофазами пионов. В исследованиях использовалась коллекция пионов, растущая в Каунасском ботаническом саду УВВ (Университет Витаутаса Великого). Для четырех сортов пионов оценивались следующие фенологические показатели: появление побегов и начало цветения. Исследования радиального прироста деревьев проведены в дендропарке Каунасского ботанического сада и в лесах Каунасского региона. Анализировался ход радиального прироста ясеня обыкновенного, дуба обыкновенного, ели обыкновенной, западной туи и лиственницы, его зависимость от климата и связь с фенофазами пионов. Результаты показали, что фенофазы пионов зависят от климатических условий нескольких месяцев, особенно от условий прошлой зимы. Установлено, что начало фенофаз пионов связано с величиной радиального прироста деревьев. Связи между началом фенофаз пионов и радиальным приростом деревьев дают возможность прогнозировать величину будущего радиального прироста и изменения вегетации пионов. На начало появления побегов пионов, как и на радиальный прирост большинства пород деревьев, особенно негативно влияет низкая зимняя температура и тонкий слой снега.

Климат, зависимость, болезни, фенофазы, радиальный прирост.

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