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Scots pine pointer-years in northwestern Latvia and their relationship with climatic factors

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Abstract

At six sampling sites in northwestern Latvia Scots pines (*Pinus sylvestris* L.) were cored to obtain tree-ring width data and determine site pointer-year values (years with markedly wider or narrower tree-ring width compared to neighboring tree-rings). Correlation analysis was performed between pointer-year values and climatic factors (mean temperatures and precipitation sum) to determine significant relationships. There were only three years (negative 1940 and 1969, positive 1957), when all sampling sites had common pointer-years. The main climatic factors influencing development of pointer-years were February mean temperatures and June precipitation sum. Pointer-year development is mainly determined by local factors.

Key words: dendroclimatology, *Pinus sylvestris*, pointer-years, tree-rings.

Introduction

It is well known that tree-rings contain extensive information about environment changes during the time when the tree has lived (Schweingruber 1996) and one of the features to assess those changes is pointer-years (years with markedly wider or narrower tree-ring width compared to neighboring tree-rings) that indicate regional and local influence of environmental changes (Schweingruber 1990). The suitability of pointer-years to determine extreme growth reactions has been shown already in other studies (Neuwirth et al. 2004; Lebourgeois et al. 2005; Neuwirth et al. 2007).

Scots pine (*Pinus sylvestris* L.) growth depends on growing conditions [pines growing on dunes have narrower tree-rings compared to those growing on firm parental soil (Rigling et al. 2001)], stand structure [density (Tegelmark 1999)] and climatic factors [climatic factors explain up to 50 % of pine tree-ring width variation in Finland (Lindholm et al. 2000)], indicating that it is suitable for pointer-year analysis. As Scots pine is the oldest present-day tree species in Latvia and its area covers the whole Latvia territory (Prieditis 1999) it should be well adapted to local conditions and should show major changes in those conditions.

The aim of this work was to identify pointer-years in tree-ring series of Scots pine at three locations and to determine their relationship with climatic factors. It was hypothesized that there would be common pointer-years between sites.

Materials and methods

Study sites

Sampling sites were located in the northwestern part of Latvia in dry forests. The Kolka 1, Kolka 2, Kolka 3 and Kolka 4 sampling sites were located near the Baltic seashore in Slitere National Park (Fig. 1), the Engure sampling site was located near Engure lake and Spare near Gulbju lake. Sampling site Kolka 1 was located on an inland dune ridge beside a bog, about 6 km from the Baltic Sea; Kolka 2 and Kolka 3 sampling sites about 300 m from the sea on a bluff, some trees partly buried by sand; and the Kolka 4 sampling site on a parallel dune ridges (Brumelis et al. 2005). The Spare sampling site was located on a slope near a lakeshore and the Engure sampling site on low land between Engure Lake and the Riga Gulf.

Climatological data

Climatological data were obtained from the Latvian Environment, Geology and Meteorology Agency for the Kolka, Mersrags and Stende Meteorological Stations. For the Kolka Meteorological Station data were available beginning from 1925 (temperatures) and 1891 (precipitation), for Mersrags from 1896 (temperatures and precipitation), and for Stende from 1924 (temperatures and precipitation). Data from the Kolka Meteorological Station was used for the Kolka 1, Kolka 2, Kolka 3, Kolka 4 sampling sites, Mersrags Meteorological Station data for the Engure sampling site, and Stende Meteorological Station data for the Spare sampling site.

Mean January temperature in northwestern Latvia (Kolka Station) is –2.5 °C and in July 16.7 °C, yearly mean precipitation sum is about 584 mm. At the Spare sampling site

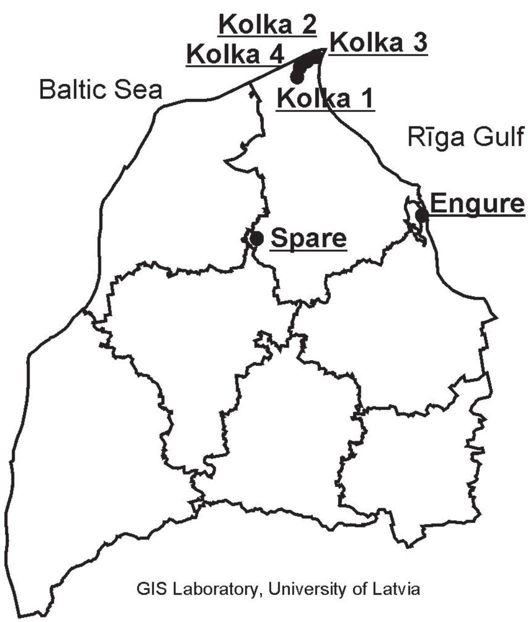

Fig. 1. Location of sampling sites in Latvia.

(Stende Station) winter temperatures are lower (mean January temperature –4.1 °C) and precipitation sum higher (668 mm).

In total 34 climatic factors were used – mean monthly temperatures and precipitation sum (from prior year October till September); autumn (prior year September - November), winter (prior year December - February), spring (March - May), summer (June - August) and growing season (prior year October - September) mean temperatures and precipitation sum.

Sample collection and measurement

Sample collection took place in 2001 (Kolka 1, Kolka 2, Kolka 3, Kolka 4) and 2006 (Engure, Spare). Tree-ring width samples (wood cores) were taken from the oldest trees. One (Kolka 1, Kolka 2, Kolka 3, Kolka 4) or two (Engure, Spare) tree-ring samples per tree were taken with an increment borer at breast height (1.3 m); overall 20 trees at Engure, 20 trees at Spare, 20 trees at Kolka 1, 14 trees at Kolka 2, 29 trees at Kolka 3 and 26 trees at Kolka 4 were sampled. For the tree-ring width measurement a LINTAB "measuring table" connected with TSAP software (Rinn 1996) was used. Cross-dating and quality control of tree-ring measurement were performed using the program COFECHA (Holmes 1983). After tree-ring width measurement and quality control for Engure and Spare sampling sites average tree-ting width was calculated for each tree that had two cores.

Statistical analysis

Analysis was performed for the time period from 1890 till 2006. Pointer-year intensity values were calculated using a modified Skeleton-plot method (Neuwirth et al. 2004). Tree-ring width of each tree was compared to the previous 5 year mean tree-ring width and the difference was expressed as intensity classes (5th intensity class was reached for a difference greater than 80 %; 1st intensity class for a difference less than 20 %). Site pointer-year intensity (I) was calculated using formula:

$$I = \frac{100}{k \times n} \sum_{j=1}^{k} h_j \times i_j ,$$

where k – number of intensity classes; n – total number of trees; h_j – number of trees in intensity class; i_j – value of intensity class.

Correlation analysis was performed using SPSS software (Morgan et al. 2004) between sampling site pointer-year intensity values and climatic factors (mean temperature and precipitation sum) in two ways: (a) all pointer-year intensity values for each sampling site were used; (b) only significant pointer-year intensity values (intensity values greater than 25 % or less than –25 %) were used. Climatic factors were expressed as standard deviation units – from each climatic factor value the mean value for the analyzed time period was subtracted and the result was divided by the standard deviation for that time period.

Results

After quality checking and cross-dating, 10 trees at Kolka 1, 12 trees at Kolka 2, 18 trees each at Engure, Kolka 3, and Spare and 20 trees at the Kolka 4 sampling sites were used for further analysis. In the time period from 1890 till 2006, Kolka 2 site had the largest number of significant pointer-years per 10 years (4.0; Table 1), Kolka 3 site had 3.9 but

Table 1. Number of positive, negative, total and 10-year average significant pointer-years (pointer-year intensity value above 25 % or below –25 %) at sampling-sites

Sampling site	Engure	Kolka 1	Kolka 2	Kolka 3	Kolka 4	Spare
Positive	13	19	22	21	14	19
Negative	18	19	25	25	19	22
Total	31	38	47	46	33	41
Average in 10 years	**2.6**	**3.2**	**4.0**	**3.9**	**2.8**	**3.5**

Table 2. Cases of statistically significant Pearson correlation (at α = 0.05) between all pointer-year intensity values, only significant pointer-year intensity values (intensity values greater than 25 % or less than –25 %) at sampling-sites and mean temperatures at corresponding meteorological stations

Sampling site	October	January	February	March	April	September	Winter	Spring	Season
All pointer-years included									
Engure			0.200			0.215	0.211		0.260
Kolka 1			0.362	0.311				0.264	0.261
Kolka 2		0.328	0.447	0.376	0.236		0.379	0.334	0.374
Kolka 3		0.257	0.418	0.289			0.300	0.252	0.298
Kolka 4			0.293						
Spare	0.238		0.321	0.273			0.291	0.221	0.302
Only significant pointer-years included									
Engure		0.476	0.409				0.464		0.470
Kolka 1			0.440	0.430				0.379	
Kolka 2		0.428	0.537	0.435			0.440	0.428	0.451
Kolka 3		0.356	0.505						
Kolka 4									
Spare	0.343		0.484	0.451	0.422		0.462	0.431	0.515

Engure site only 2.6 significant pointer-years. In years 1940 and 1969 trees at all sampling sites had significant negative pointer-years and in 1957 represented a significant positive pointer-year (Fig. 2). As pointer-year values and standard deviation units of climatic factors corresponded to normal distribution, the Pearson correlation coefficient was used.

When all pointer-year intensity values were included in analysis, all of the sampling sites pointer-year values had statistically significant correlation with mean February temperature (Table 2) and all except Kolka 4 with growing season mean temperature. There was no statistically significant correlation between pointer-years and six-month, autumn and summer mean temperatures. Excepting the Spare sampling site, pointer-year values had statistically significant correlation with June precipitation sum (Table 3). There was no statistically significant correlation between pointer-years and nine-month, autumn, winter, season precipitation sum. Kolka 4 sampling site pointer-year values had statistically significant correlation only with February mean temperature and June precipitation sum.

Using only significant pointer-year intensity values (intensity values greater than 25 % or less than –25 %) in the analysis, excepting the Kolka 4 sampling site, pointer-year values

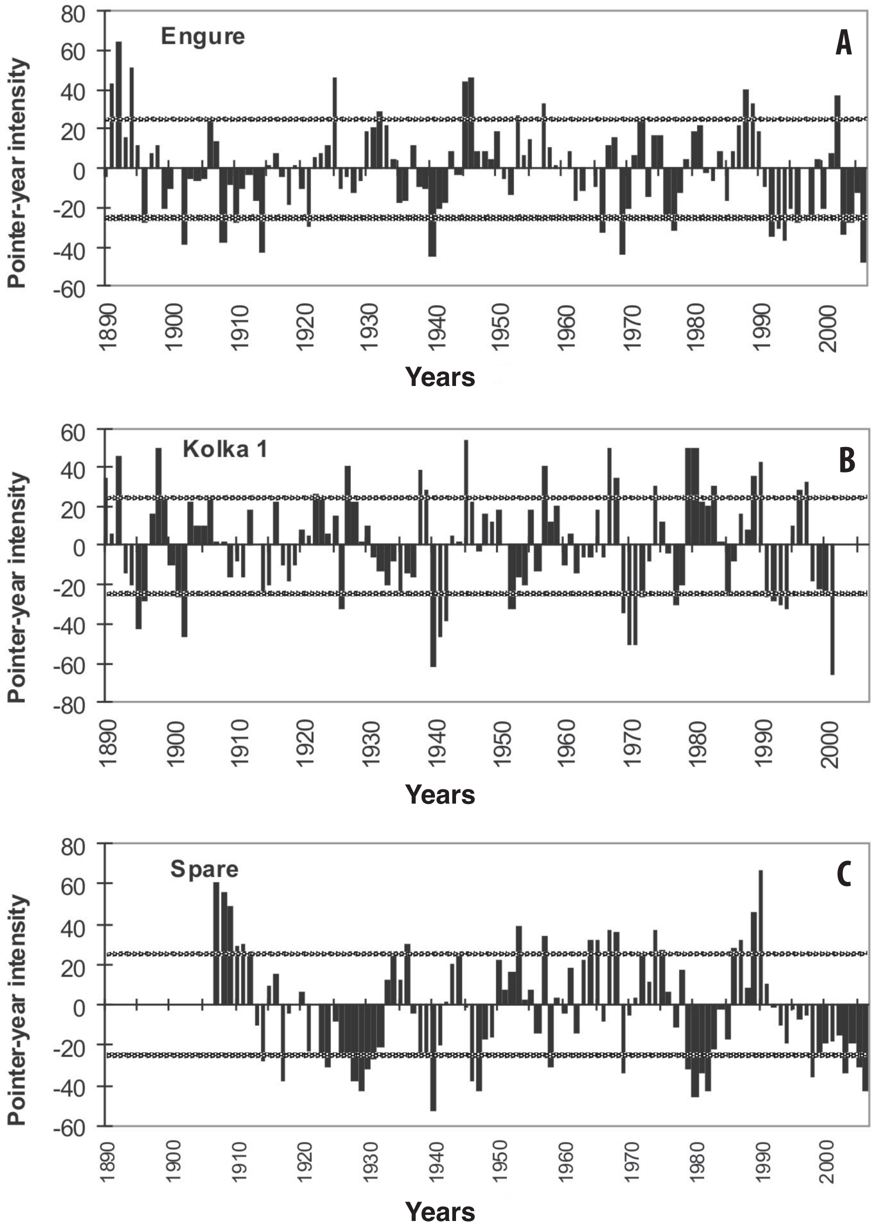

Fig. 2. Pointer-year intensity values at Engure (A), Kolka 1 (B) and Spare (C) sampling sites. Dashed lines show upper (25 %) and lower (–25 %) limits for significant pointer-years.

Table 3. Cases of statistically significant Pearson correlation (at α = 0.05) between all pointer-year intensity values, only significant pointer-year intensity values (intensity values greater than 25 % or less than −25 %) at sampling-sites and precipitation sum at corresponding meteorological stations

Sampling site	December	May	June	September	Spring	Summer
All pointer-years included						
Engure			0.195			0.203
Kolka 1			0.189			
Kolka 2		0.211	0.279		0.221	
Kolka 3			0.229			
Kolka 4			0.348			
Spare				0.233		
Only significant pointer-years included						
Engure			0.534			
Kolka 1						
Kolka 2		0.279	0.410		0.320	
Kolka 3			0.423			
Kolka 4	0.345		0.595			
Spare				0.359		

had statistically significant correlation with February mean temperature. Kolka 4 sampling site pointer-year values had no statistically significant correlation with mean temperatures and Kolka 1 with precipitation sum. There was no statistically significant correlation between sampling site pointer-year values and seven-month, autumn mean temperatures, eight months, autumn, winter, season precipitation sum.

Discussion

Although there were only three cases when all sampling sites had common pointer-years, there were common features between sampling sites. One common feature was correlation with February mean temperature, which has been observed in other studies on Scots pine tree-ring chronologies, not only in Latvia (Elferts 2007) but also in Poland (Cedro 2001) and Estonia (Pärn 2003). Abrupt changes in February mean temperatures – decline or increase compared to long-term mean temperatures – causes formation of respectively narrower or wider tree-rings. Significant positive correlation coefficients between most of sampling site pointer-year values with March, winter and spring mean temperatures show that the growth of Scots pine is determined by temperatures during the winter and beginning of spring. One explanation could be that if winter temperatures are higher then the frozen soil layer is shallow and trees can start the growing season earlier.

On the dry soil sites higher June precipitation sum had a positive effect on the Scots pine growth not only in the studied areas but also in Southern Finland (Lindholm et al. 2000) and Poland (Cedro 2001). Higher temperatures in June might lead to increase of evapotranspiration and decline of moisture in soil. Precipitation in other months did not show any common trend between sampling sites, indicating that in this region precipitation has minimal impact on Scots pine growth and that there exists optimal moisture availability in the soil (Linderholm 2001; Elferts 2007). Lack of a significant correlation between Spare sampling site pointer-year values and June precipitation sum could be explained by location near lake shore, which influences the moisture level in soil.

The low number (three) of cases with common pointer-years at all sampling sites suggests that development of pointer-years was mainly determined by local factors, for example, local climatic conditions, stand factors, or possibly insect outbreaks. Neuwirth et al. (2007) found that also in a much larger scale (Central Europe) common pointer-years occurred in years of extreme climatic conditions. All Kolka sampling sites had eight common pointer-years (five negative, three positive) showing that closer sampling sites had more common pointer-years. The years when all sampling sites showed significant pointer-years were determined by climatic factors. In 1940 at all sampling sites there was a very significant negative pointer-year (very narrow tree-ring), in the same year February the mean temperature at Kolka station was −12.5 °C, which is 9 °C lower than the long-term mean temperature. Also a lower temperature was observed in March and growing season, and also precipitation sum in June was lower. Previously it was shown that these factors are the most important in relation to tree growth. The year 1969 also was characterized by lower February and March temperatures and low precipitation sum in June (at Kolka station only 2 mm). In 1957, when all sampling sites showed a positive pointer-year, winter was very mild, and mean temperatures at Kolka station in December, January and February were above 0 °C, which positively influenced tree growth.

In conclusion, this study showed that pointer-year development mainly is determined by local factors, except years when abrupt changes in climatic conditions are observed. Also February temperature is the main climatic factor associated with Scots pine growth in Latvia.

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Parastās priedes zīmīgie gadi Latvijas ziemeļrietumos un to saistība ar klimatiskajiem faktoriem

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Kopsavilkums

Sešos parauglaukumos Latvijas ziemeļrietumos ņēma parastās priedes (*Pinus sylvestris* L.) urbumus, lai iegūtu gadskārtu platumu datus un varētu noteikt zīmīgo gadu vērtības (gads, kurā gadskārta ir izteikti šaurāka vai platāka, salīdzinot ar citām tuvākajām gadskārtām). Starp zīmīgo gadu vērtībām un klimatiskajiem faktoriem (vidējā temperatūra un nokrišņu daudzums) veica korelācijas analīzi, lai noteiktu būtiskās saistības. Konstatēja tikai trīs gadus (negatīvi – 1940. un 1969., pozitīvs – 1969.), kuri visos parauglaukumos bija zīmīgie gadi. Galvenie klimatiskie faktori, kas ietekmē zīmīgo gadu rašanos, ir februāra vidējā temperatūr un jūnija nokrišņu daudzums. Zīmīgo gadu rašanās galvenokārt ir saistīta ar lokālajiem faktoriem.