Growth Variability from Different Provenances of Pinus Sylvestris L. Planted in the Southern Taiga, Central Siberia

Yuliya SAVVA

Institute of Forest, Siberian Branch of the Russian Academy of Sciences, Akademgorodok, 660036, Krasnoyarsk, Russia

ABSTRACT. Eight tree-ring density and width parameters for 16 different Scots pine provenances, planted in the southern taiga, all over Russia, were measured with densitometric techniques. Age trends were excluded by standardization followed by calculation of mean chronological variability of each provenance. The individual variability of all parameters of radial growth within provenance areas was found to exceed the chronological variability, with variability caused mainly by climatic conditions. It was found that the sensitivity coefficient of latewood width, latewood and maximum densities and latewood percentage have tendency to decrease in relation to increasing the latitude of seed sources. Cluster analysis differentiated the provenances into three groups, However, the statistical distance between the groups was insignificant.

KEY WORDS: Pinus sylvestris, provenances, tree- ring sensitivity, individual variability, Siberia.

Introduction

Dendrochronological analysis permits the examination of natural population growth variability in relation to geographical distribution; it also permits determination of the influence of ecological factors (Zobel and van Buijtenen, 1989). There is much interest in estimating the effects of climate change on tree growth, because trees, with their long life spans, are least able to respond by migration or genetic selection in a short period of time (Davis, 1990).

The goals of the study are:

1) evaluation of individual variability of tree-ring parameters (interannual density and width) in Scots pine provenances growing in a plantation where site conditions are uniform.
2) evaluation the response of 16 Scots pine (*Pinus sylvestris* L.) provenances to climatic changes.

Methods and material studied

The 405 cores of 16 provenances were collected on the territory of Boguchani timber enterprise of Krasnoyarsk Region (58°23'N, 97°26'E). The natural sites of seed sources of provenances are distributed along four meridional transects: European, Urals, East-Siberian and Far Eastern. All cores were measured densitometrically (Schweingruber, 1988). Tree-ring width, earlywood width, latewood width, minimum and maximum densities, density of early- and latewood and percentage latewood were measured and crossdated. To exclude an age trend, the radial growth, minimum and earlywood density chronologies were standardized by the polynomial functions of the 3rd degree, the maximum and latewood density chronologies by linear functions, and the latewood percentage chronologies by polynomial functions of 2d degree. Then indices were calculated by dividing the measured parameter by the expected value obtained by the fitting curve (Cook et al., 1990) The chronological variability was evaluated by calculating the standard deviation of the indices for each provenance, and expresses the general climatic influences for the whole provenance. The variability from tree to tree in each provenance was evaluated by calculation the standard deviation for individual trees. The indices for each individual tree were calculated by dividing the raw values from each tree by the values of the computed average for the provenance curve.

To evaluate the radial growth fluctuations quantitatively the coefficient of sensitivity was calculated (Shiyatov, 1985). By determining the sensitivities it is possible to ascertain to what extent the growth of species is influenced by environmental factors.

The similarity between the provenances is expressed by cluster analysis (Aivazyan et al., 1987).

Results and discussion

The interannual variability of minimum density and earlywood density is insignificant (Table 1), for maximum density and latewood density is slightly higher. The variability of earlywood width, tree-ring width and portion of latewood triggered by weather is higher in comparison with the density parameters. The variability of latewood width is mainly affected by climate. The spread of the standard deviation of the tree-ring parameters within a provenance is significant. The interannual variability of minimum density changes from 0.030 for Yakutsk provenance up to 0.073 for the local Boguchani provenance (Table 1) and the maximum density varies from 0.042 at the Severo-Yeniseysk provenance up to 0.088 - at the Avzyan provenance. The maximum value of the standard deviation is twice as high as the minimum value of standard deviation within provenances.

Maximum density and latewood density have the lowest individual variability (0.062–0.099 and 0.064–0.105) (Table 1). Minimum density and earlywood density values are a little higher (0.099–0.172 and 0.057–0.104). The individual variability is higher for earlywood width (0.189–0.285), tree-ring width (0.181–0.272) and the ratio of latewood (0.224–0.304), with individual variability being highest for latewood width (0.284–0.386). The differences between individual variability within provenances sometimes reach about 1.5 times. The individual variability for all parameters is mostly higher than chronological variability (Table 1). The ratio of individual and chronological variability for the earlywood zone parameters exceeds those for the latewood zone ones.

The characteristics of tree-rings of different provenances were used to compute the similarities of the provenances (for similarities and distinctions). Cluster analysis identified two groups with maximum similarities within each group plus one provenance on its own. The first group, consists of provenances from the mean and southern taiga, the second group, consists of provenances from the forest-steppe, steppe zone and northern taiga. The Pechenga provenance provided an example of a unique provenance from the forest-tundra ecotone (69°40'N, 31°17'E). However, linkage distance between the first two groups is minor (v = 0.22). Only the Pechenega provenance is clearly separated from the other provenances (v = 0.35).

The sensitivity of density characteristics mainly of latewood zone decreases with increase in latitude of seed sources (Fig. 1). The correlation coefficient ($p < 0,05$) for the maximum density R = -0.74, latewood percentage R = -0.68, latewood density R = -0.65, earlywood density R = -0.42, latewood width R = -0.65.

The sensitivity of the latewood parameters has an obvious tendency to decrease with increase in the latitude of seed sources. It is connected with the fact, that trees in higher latitudes were adapted to maximally exploit the early part of the growing season (Vaganov et al., 1999), therefore the conditions of the second part do not so essentially affect the radial growth characteristics.

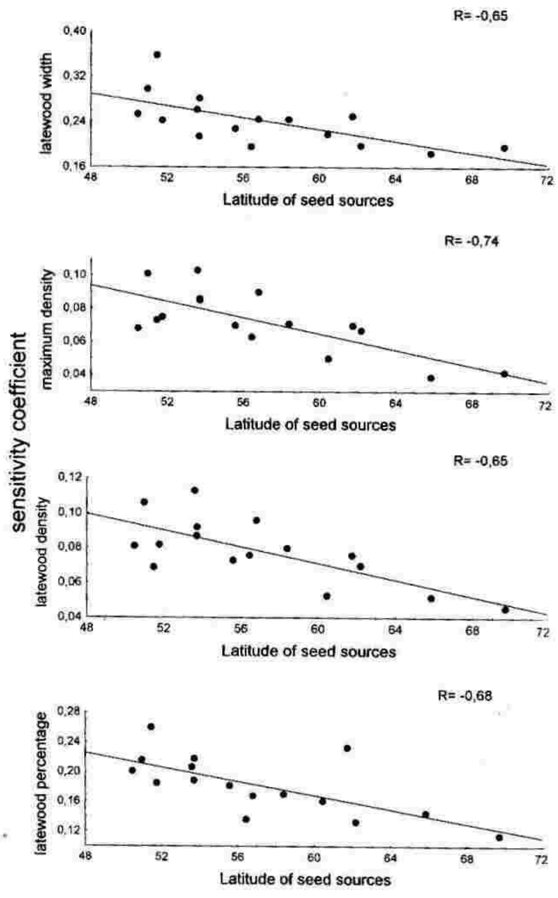

Fig. 1. The basic tendencies of change in the sensitivity coefficient of the tree-ring characteristics in relation to the geographical location of seed origin.

We found that the individual variability of all tree-ring parameters was one to four times greater than the chronological variability due to weather. According to Zobel and van Buijtenen (1989): "within each population some individual trees can have rather high values of density, and some - low, on a comparison with the average value for a stand, and this is a result of the strong genetic control among individual trees within a population". Genetic factors mainly control the wood formation of pines. However clustering revealed that the linkage distances between provenances were insignificant. Therefore there are general environmental factors, which mainly influence growth of the provenances and the interrelationships of the anatomical structure of tree rings. So, the individual variability is apparently mainly influenced not by genetic factors, but by local site factors such as position in a stand, light conditions, topography, rooting conditions and mechanical movement.

Conclusions

1. The individual variability within provenances exceeds the chronological variability for all parameters of radial growth and tree-ring structures.
2. Cluster analysis differentiated the 16 provenances into two groups plus one on its own. The distance between the groups is statistically insignificant. The forest-tundra provenance shows the greatest difference in comparison with the other two groups.
3. Latewood zone is more sensitive to environmental factors than the earlywood one in Scots pine provenancies planted in the southern taiga.

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