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Climate driven height growth change of multistem trees of Siberian larch in the Polar Ural mountains

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Introduction

Siberian larch growing at the edge of its proliferation possesses various adaptive properties that allow it to exist successfully in the extreme natural and climatic conditions (Gorchakovskiy and Shiyatov, 1985). Quite successive existence of larch at the Polar Urals is possible because of several biological and morphological adaptations. Biological adaptations include the short period of auxiblasts growth (14-28 days), dominant development and substantial life duration of brachiblasts (up to 100 years), and the high content of protective metabolites (Iroshnikov, 1984). Morphological features of coniferous species growing in boreal areas (including Siberian larch) are the ability to exist in a number of life forms (stem, bush, creeping) and to change the growth form under the change of environmental conditions (Gorochkevich and Kustova, 2002).

There is large number of trees that changed several growth forms in the course of their lifetime in the ecotone of the upper forest bound at Polar Urals. Most often, these are the multistem trees that are generated by forming several vertical stems from the creeping form. Such trees can serve as climate change indicators.

The purpose of this paper is to study the effect climate has on form genesis and growth characteristics of the multistem Siberian larch trees.

Major research goals:

- reveal the dates of forming stems and changing growth form;
- examine, whether the growth form change causes a change of tree growth characteristics (axial and radial growth).

Materials and methods

The research is performed in the forest-tundra area (100-300 meters above sea level) at the eastern macroslope of Polar Urals.

The selection of model trees was performed based on a route method. Individual trees of a group of several stems which originate from a single base, which first grew plagiotropically and then orthotropically were selected as model trees.

The cross-sections of 35 Siberian larch (*Larix sibirica* Ledeb.) stems, belonging to six multistem trees are used for analysis. For each stem the morphological parameters are described, including growth form, vitality, stem height and diameter, crown shape and size. Average stem height was 3 meters, diameter at base was 15 cm.

Cuts were made at three main levels (Fig.1) – at the base of a horizontal stem (O), in the point of transfer to vertical growth (A), and at the height of a vertical stem equal to OA.

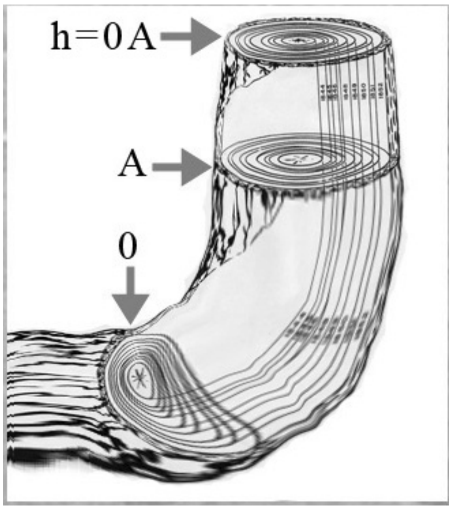

Figure 1: Illustration of levels at which cross-sections have been taken for growth analysis

Specimen dating and growth analysis were performed using dendrochronological methods.

Results and discussion

Figure 2 illustrates the dates of appearance and of life form change of the larch model trees over time. For convenience of analysis growth start dates are smoothed by decades. The smoothed curve demonstrating dynamics of summer months' thermal mode for the analyzed period is also drawn.

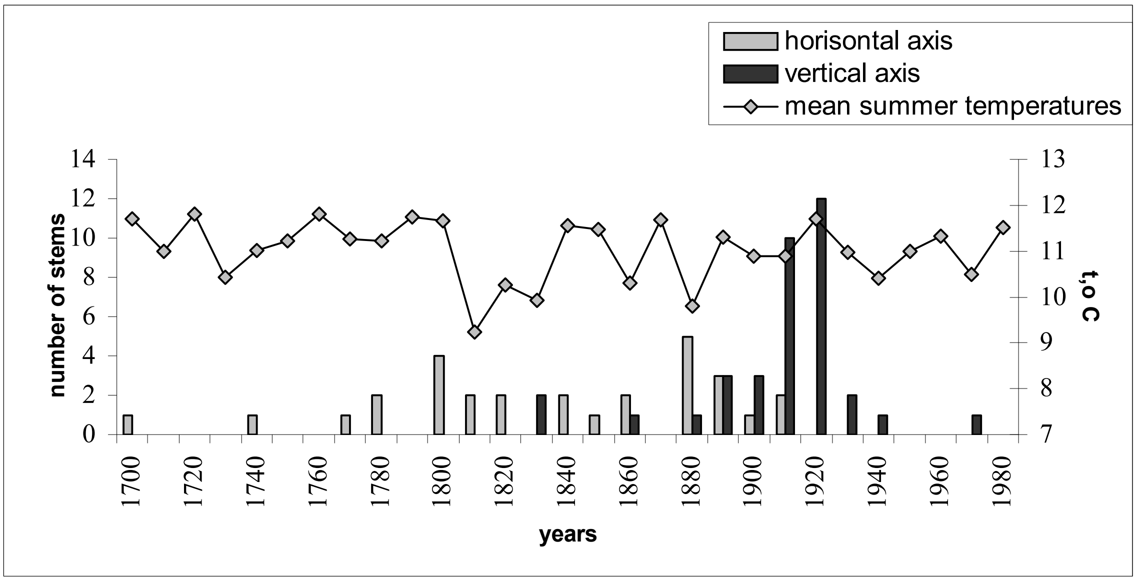

Figure 2: Dates of appearance of the life form change for the Siberian larch model trees and changes of summer months' thermal mode

The growth of horizontal stems started in 18th and 19th centuries. Before the beginning of the 20th century most trees were creeping. In the 1920s the growth form for the majority of studied trees became multistem.

To reveal dendroclimatic relations the analysis of summer months' thermal mode effect on the frequency of tree growth start and life form change dates is undertaken. Analysis does not demonstrate a relation between the frequencies of horizontal stem growth start dates and average summer temperatures of vegetation season. It is possible that the appearance of such trees was affected by other climatic factors, such as the amount of precipitation or the snow accumulation conditions. Regretfully, there is no reconstruction of these factors for the examined period. Nevertheless, a direct statistical relation exists between the dynamics of average summer temperature, and the frequency of years with growth form change for the trees (r=0.68).

According to literature data the 18^{th} and 19^{th} centuries at the Urals are characterized by adverse thermal conditions (Graybill and Shiyatov, 1992) and humidity (Mazepa, 1999). In the early 20^{th} century a substantial thermal mode improvement occurred.

The obtained results demonstrate that the change of larch growth form occurred because of the improvement of the environmental conditions and is probably related to climate warming in the beginning of the 20^{th} century. The transition to orthotropic growth form caused a change in stem characteristics, including axial and radial growth. Average axial growth of orthotropic stem parts substantially increased compared to plagiotropic parts (see figure 3) – from 1 to 4 centimeters per year. Obtained differences are statistically significant (T=5,2; p=0,000003%).

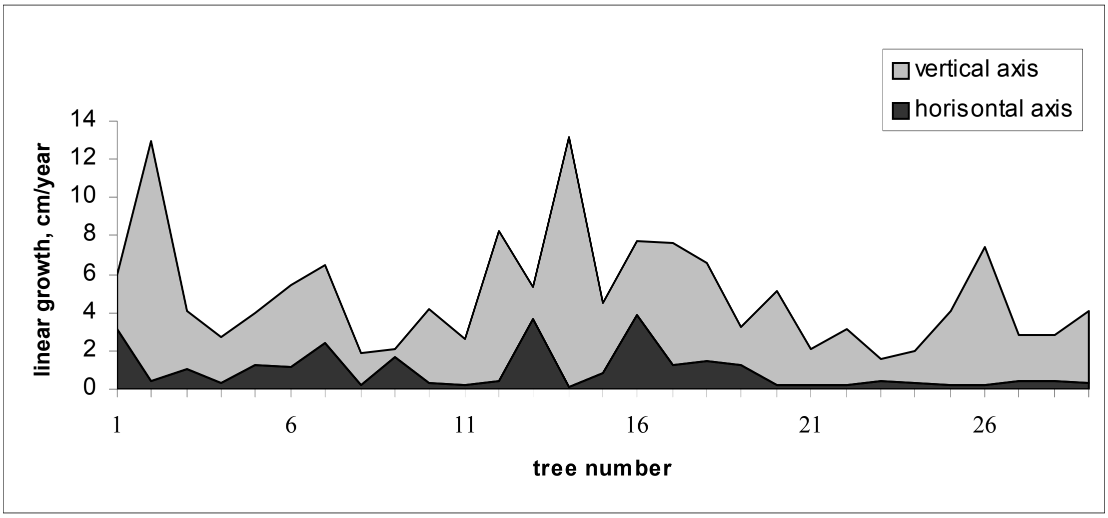

Figure 3: Average axial growth of horizontal (plagiotropic) and vertical (orthotropic) stem

Analysis of radial growth for cross-sections taken at different basic heights (Fig. 4) demonstrate the increase in radial growth. Average tree-ring width increased by 0,08 mm, while going from O to OA. Obtained differences are statistically significant (T=2,5; p=0,013%).

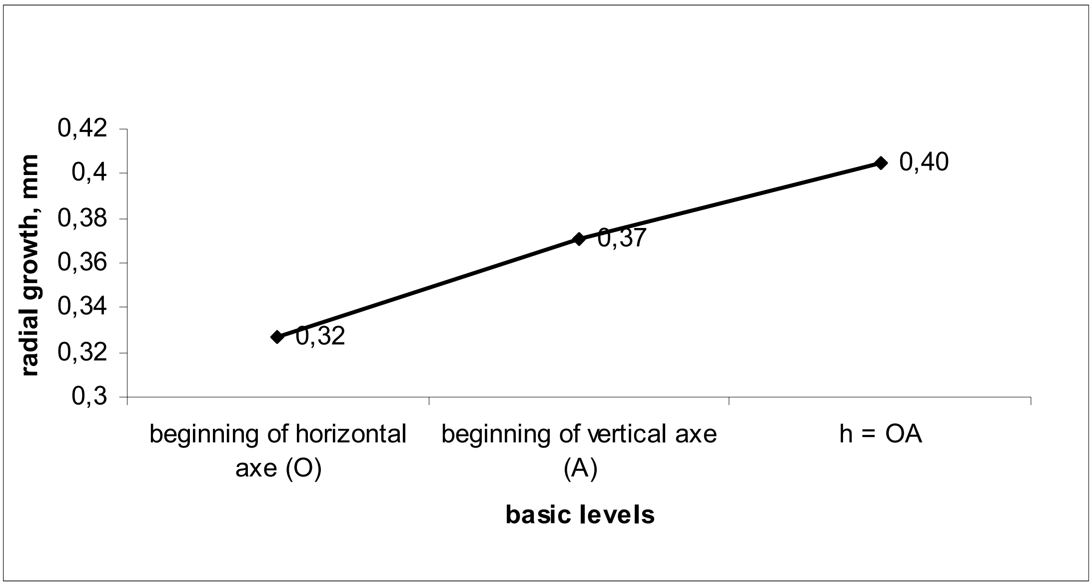

Figure 4: Average radial growth at different stem heights

Conclusion

Improvement of the thermal mode at the beginning of the 20th century caused the growth form change from plagiotropic to orthotropic for the studied samples of Siberian larch in the ecotone of the upper forest boundary at Polar Urals. Axial growth rate and radial growth for orthotropic stem parts are substantially higher than the corresponding characteristics of plagiotropic parts.

Acknowledgements

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Literature

Goroshkevich, S.N., Kustova, E.A. (2002): Morphogenesis of the creeping life form of Siberian cedar at the upper limit of proliferation in West Sayan Mountains. *Ecology 4*: 243-249.

Gorchakovskiy, P.L., Shiyatov, S.G. (1985): Phytoindication of the environmental conditions and natural processes in the alpine terrain. M. Nauka. 208 pp.

Iroshnikov, A.I. (1984): Siberian larch at the northern boundary of proliferation: Materials proceedings of the session on the results of research activities at Archangelsk Institute of Forest and Dendrochemistry for 1983. Archangelsk. 93 p.

Mazepa, V.S. (1999): Effects of precipitation on the radial growth dynamics for the coniferous is sub-Arctic regions of Eurasia. *Lesovedenie 6*: 15-22.

Graybill, D.A., Shiyatov, S.G. (1992): Dendroclimatic evidence from the northern Soviet Union. In: Bradley, S., Jones, P.D., Climate since A.D. 1500. Routledge, London and New York: 393-414.