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Reconstruction of climate and the upper timberline dynamics since AD 745 by tree-ring data in the Polar Ural Mountains

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Introduction

On the eastern macroslope of Polar Ural Mountains there is a great number of dead trees and wood remnants of Siberian larch (*Larix sibirica* Ledeb.) located on the surface up to 60-80 m above the present upper timberline (Shiyatov 1993). Various direct and indirect evidences (altitudinal position, longevity and calendar life span of dead and living trees, shape of trunk, density and age structure of stand, variability of radial increment and ring-width indices) were used for detailed reconstruction of climate and the upper timberline changes for the last 1250 years. In the area of Rai-Iz Massif (66°50'N, 65°15'E) more than 400 cuts from wood remnants and 350 cores and cuts from living trees have been collected, mapped and absolutely dated by cross-dating procedure. Altitudinal position of the past and recent upper timberlines and individual age generations of larch trees was also mapped. To reconstruct climatic conditions of the past, the longer ring-width chronology was developed for this area (AD 745-1992) in comparison with previously published chronology (Shiyatov 1986, Graybill & Shiyatov 1992).

Results and discussion

Fig.1 shows location of 209 dated wood remnants *in situ* and 16 larch seedlings along the transect 430 m long and 20 m wide. This transect began at an elevation of 340 m a.s.l., where the highest remnants were found, and ended at the present timberline at an elevation of 280 m a.s.l.

During the last 1250 years a significant displacement of the upper timberline took place. The oldest wood remnants (AD 745-935) were only large roots located in the middle part of the transect. At this period the upper timberline was approximately 315 m a.s.l. or 35 m higher compared with its present position (280 m a.s.l.). It is difficult to conclude about stand density at this time as most remnants became rotted. From the middle of the 8th to the end of the 13th centuries there was intensive regeneration of larch, and the

timberline rised up to 340 m a.s.l. The 12th and 13th centuries were most favoralbe for larch trees growth. At this time the altitudinal position of the

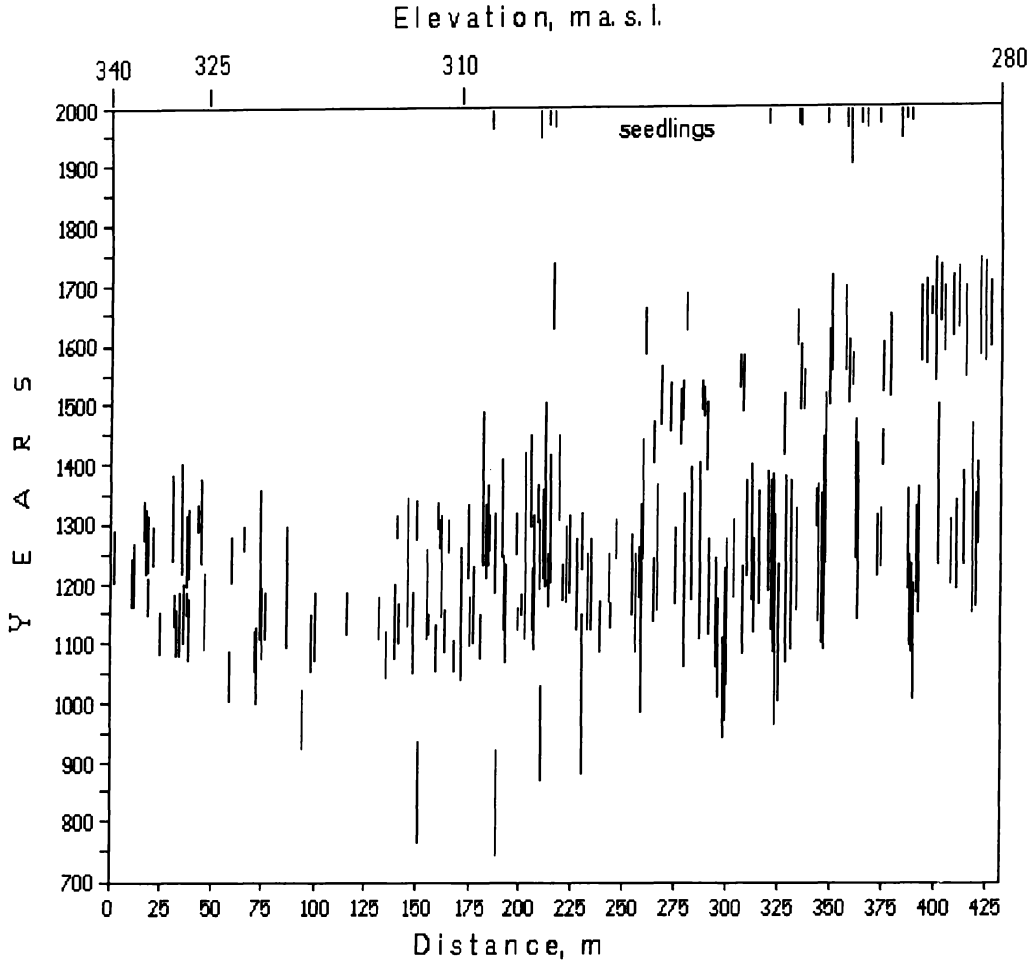

Fig. 1. Location of dated wood remnants and larch seedlings along the transect.

timberline was the highest, stand density the biggest, longevity of trees the longest, sizes of trees the largest, increment in diameter and height the most intensive as compared with other periods under review. At the close of the 13th century growing conditions deteriorated and larches, including young ones, began dying off. During the second half of the 14th century the retreat of timberline was very intensive and the upper timberline retreated up to 310 m a.s.l. Dying off of trees was observed along all parts of the transect. Adverse growing conditions were in the 15th century, and during this period the stand density was low. Only from the end of this century poor larch regeneration started in the lower part of the transect. This process continued during the 16th century and no retreat of the timberline took place. The first half of the

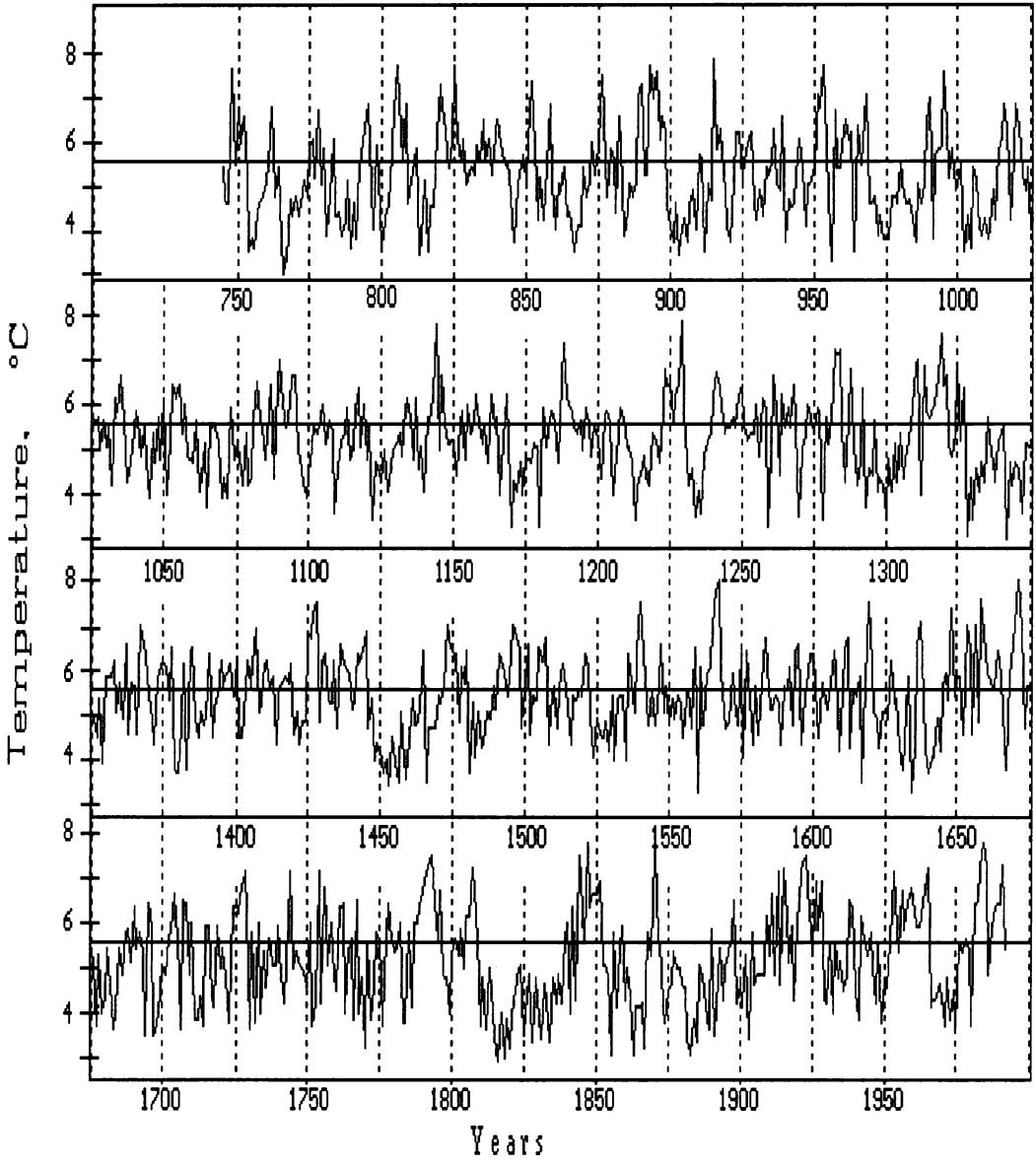

Fig. 2. Reconstructed average June-July temperature for Rai-Iz meteorological station from RAIARS ring-width chronology.

17th century was unfavorable for larch growth and the timberline retreated to 290 m a.s.l. During the second part of this century the decline of larch stand ceased and rather dense larch stand existed in the lowest part of the transect. The 18th century was favorable for trees growth. Most adverse period for the last 1250 years was in the 19th century. At this time there was not a single

living tree over the whole transect, and the upper timberline retreated up to 280 m a.s.l. During the 20th century there was a rather intensive regeneration of larch, and now 16 trees of 30-90 years old grow in the lower half of the transect.

Thus, during the last 1250 years the upper timberline and structure of larch stands altered significantly. The range of displacement of the upper timberline on the transect was 60 m in altitude and 430 m along the slope. In some parts of the Rai-Iz Massif this displacement was bigger (up to 80 m in altitude and 800 m along the slope). In the area of the upper timberline there was no evidence of fires or other catastrophic phenomena, the most probable reason of these displacements is climatic changes.

To reconstruct climatic conditions the mean ring-width chronology AD 745-1992 have been used. This chronology contains strong climatic signal, mainly June-July temperatures of current growth year. Reconstruction of this climatic parameter is shown in Fig.2. During the period investigated there were considerable annual, decadal and secular oscillations of summer temperatures. Changes in stand structure and altitudinal position of the upper timberline are caused by long-term oscillations of climatic conditions. Intensive dying off of trees in the area of the upper timberline coincides with cold periods no less than 20-30 years long. Most favorable climatic period for tree growth was during the 12-13th centuries when periods of long-term cooling were absent. The coldest period was during the 19th century when June-July temperature was 2-3°C below the average for two long periods. The long-term climatic fluctuations which have the biggest influence on forest ecosystem dynamics are rather poorly presented in this chronology due to detrending individual ring-width chronologies.

Acknowledgments

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References

Graybill, D.A. & Shiyatov, S.G. 1992. Dendroclimatic evidence from the northern Soviet Union. Climate Since A.D. 1500. Raymond S. Bradley & Philip D. Jones, eds. London & New York: Routledge, pp.393-414.

Shiyatov, S.G. 1986. Dendrochronology of the upper timberline in the Urals. Moscow: Nauka, 136 pp. (in Russian).

Shiyatov, S. G. 1993. The upper timberline dynamics during the last 1100 years in the Polar Ural Mountains. Oscillations of the Alpine and Polar Tree Limits in the Holocene. Burkhard Frenzel, ed. Stuttgart, Jena & New York: Gustav Fischer Verlag, pp.195-203.