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Spatio-temporal dynamics of the upper tree line in the polar Urals: centuries-old downward and upward shift

Mikhailovich, Anna P.¹; Fomin, Valery V.²; Shiyatov, Stepan G.³

¹Department of Physical Methods and Devices for Quality Control, Ural Federal University, Yekaterinburg, the Russian Federation

²GIS-technologies Research Laboratory in Ecology and Forest Sciences, Ural State Forest Engineering University, Yekaterinburg, the Russian Federation

³Laboratory of Dendrochronology, Institute of Plant and Animal Ecology, the Russian Federation
Correspondence: fomval@gmail.com

Keywords: upper tree line ecotone, distribution of trees, spatio-temporal dynamics, Polar Urals, *Larix sibirica* Ledeb

A ground-based mapping of the location of trees (*Larix sibirica* Ledeb) growing in the upper tree line ecotone and died during the Little Ice Age on the southeastern macroslope of the Rai-Iz mountain massif (Polar Urals, Russia) was implemented. According to the pattern recognition of aerial and satellite images of high spatial resolution taken in the 1960s, 1980s, 2000s and 2010s the location of trees with the height more than 4–6 meters in the study area was defined. Over the past 50 years, the number of trees in the study area has doubled. Repeated landscape photographs taken from the same photographic points in the 1960s and 2010s also indicate the expansion of woody vegetation into the tundra. At the same time, it has been established that modern trees, as a whole, have not reached the parts of the region yet where they grew in the past. Using the original method of determining the boundaries between the main types of phytocenohoras (closed, open and light forests as well as the tundra with single trees), the maps that characterize the distribution of phytocenochoras in the study area in the second half of the 20th and early 21st centuries were created. We found a 15 percent increase in the areas of closed, open and light forests due to reducing the areas of tundra with single trees.

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