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Projected impacts of the 21st century climate change on the forests and major conifer species in Russia

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Global simulations have demonstrated the potential for profound effects of GCM-projected climate change on the distribution of terrestrial ecosystems and individual species at all hierarchical levels. We modeled progressions of potential vegetation cover, forest-forming tree species and forest types in Russia in the warming climate during the 21st century. Large-scale bioclimatic models were developed to predict Russian zonal vegetation (RuBCliM), forests, forest-forming tree species and forest types (ForCliM). A forest type was defined as a combination of a dominant tree conifer and a ground layer (2-3 dominant species). Distributions of vegetation zones (zonobiomes), conifer species and forest types were simulated based on three bioclimatic indices (1) growing degree-days above 5 degrees Celcius; (2) negative degree-days below 0 degrees Celcius; and (3) an annual moisture index (ratio of growing degree days to annual precipitation). Additionally, the presence or absence of continuous permafrost, identified by active layer depth of 2 m, was explicitly included in the models as limiting the forests and tree species distribution in Siberia. All simulations to predict vegetation change across Russia were run by coupling our bioclimatic models with bioclimatic indices and the permafrost distribution for the baseline period 1971-2000 and for the future decades of 2011-2020, 2041-2050 and 2091-2100. To provide a range of warming we used three global climate models (CGCM3.1, HadCM3 and IPSLCM4) and three climate change scenarios (A1B, A2 and B1). The CGCM model and the B1 scenario projected the smallest temperature increases, and the IPSL model and the A2 scenario projected the greatest temperature increases.

With these projected climates, the zonobiomes would need to shift far to the north in order to reach equilibrium with the change in climate. Under the warmer and drier projected future climate, at least half of Russia would be suitable for the forest-steppe ecotone and grasslands rather than for forests. Water stress tolerant light-needled taiga (Pinus sylvestris and Larix spp.) would have an increased advantage over water-loving dark-needled taiga (Pinus sibica, Abies sibirica, Picea obovata) in a new climate. The permafrost-tolerant L. dahurica taiga would remain the dominant forest type in the many current permafrost areas because permafrost would not retreat fast. An increase in severe fire weather would lead to increases in large, high-severity fires, especially at the southern forest border and in interior Siberia (Yakutia), which are expected to facilitate vegetation progression towards equilibrium with the climate.

Adaptation to climate change may be facilitated by: (1) assisting migration of forests and tree species by seed transfer from locations where current climate is most similar to that projected in the future in order to establish genotypes that may be more ecologically suited as climate changes; and (2) introduction of suitable agricultural crops that currently may not be present in the region but may be potentially used in a warmer climate in steppe and forest-steppe areas that are expected to replace the retreating forests.

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