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Projected impacts of 21st century climate change on the distribution of potential habitat for vegetation, forest types and major conifer species across 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 cover and forest types in Russia in the warming climate during the 21st century. We used large-scale bioclimatic models to predict zonal vegetation (RuBCliM), and forest cover (ForCliM) and forest types. A forest type was defined as a combination of a dominant tree conifer and a ground layer. Distributions of vegetation zones (zonobiomes), conifer species and forest types were simulated based on three bioclimatic indices (1) growing degree-days above 5oC ; (2) negative degree-days below 0oC; and (3) an annual moisture index (ratio of growing degree days to annual precipitation). Additionally, the presence/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.
We compared the modeled vegetation and the modeled tree species distributions in the contemporary climate to actual vegetation and forest maps using Kappa (K) statistics. RuBioCliM models of Russian zonal vegetation were fairly accurate (K= 0.40). Contemporary major conifer species (Pinus sibirica, Pinus sylvestris, Larix spp., Abies sibirica and Picea obovata) distributions also showed good match with the modeled ranges for the major conifer species from 41% to 78%. Those matches would be higher if only later seral stages were considered, because historically part of the primary conifer forests have been replaced by secondary birch and aspen forests after large disturbances (clearcuts and wildfire).
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 climate, most 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. Accumulated surface fuel loads due to increased tree mortality from drought, insects and other factors, especially at the southern forest border and in interior Siberia (Yakutia), together with an increase in severe fire weather would also lead to increases in large, high-severity fires, which are expected to facilitate vegetation progression towards equilibrium with the climate.