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Potential ecological and economic consequences of climate-driven agricultural and silvicultural transformations in central Siberia

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Increased warming predicted from general circulation models (GCMs) by the end of the century is expected to dramatically impact Siberian forests. Both natural climate-change-caused disturbance (weather, wildfire, infestation) and anthropogenic disturbance (legal/illegal logging) has increased, and their impact on Siberian boreal forest has been mounting over the last three decades. The Siberian BioClimatic Model (SiBCliM) was used to simulate Siberian forests, and the resultant maps show a severely decreased forest that has shifted northwards and a changed composition. Predicted dryer climates would enhance the risks of high fire danger and thawing permafrost, both of which challenge contemporary ecosystems. Our current goal is to evaluate the ecological and economic consequences of climate warming, to optimise economic loss/gain effects in forestry versus agriculture, to question the relative economic value of supporting forestry, agriculture or a mixed agro-forestry at the southern forest border in central Siberia predicted to undergo the most noticeable landcover and landuse changes.

We developed and used forest and agricultural bioclimatic models to predict forest shifts; novel tree species and their climatypes are introduced in a warmer climate and/or potential novel agriculture are introduced with a potential variety of crops by the end of the century. We applied two strategies to estimate climate change effects, motivated by forest disturbance. One is a genetic means of assisting trees and forests to be harmonized with a changing climate by developing management strategies for seed transfer to locations that are best ecologically suited to the genotypes in future climates. The second strategy is the establishment of agricultural lands in new forest-steppe and steppe habitats, because the forests would retreat northwards. Currently, food, forage, and biofuel crops primarily reside in the steppe and forest-steppe zones which are known to have favorable climatic and soil resources. During this century, traditional Siberian crops are predicted to gradually shift northwards and new crops, which are currently non-existent but potentially important in a warmer climate, could be introduced in the extreme south.

In a future warmer climate, the economic effect of climate change impacts on agriculture was estimated based on a production function approach and the Ricardian model. The production function estimated climate impacts of temperature, precipitation and carbon dioxide levels. The Ricardian model examined climate impacts on the net rent or value of farmland at various regions. The models produced the optimal distribution of agricultural lands between crop, livestock, and forestry sectors to compensate economic losses in forestry in potential landuse areas depending on climatic change.