Individual-based simulation of tree line dynamics in the Siberian North

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Keywords: community structure and dynamics, individual-based models, movement ecology.

Abstract: Throughout the last decades, climate change led to a dramatic increase of temperatures in the Arctic. As a consequence, vast tundra areas might be transformed to taiga by immigration of tree species which were released from temperature limitation. The geographical position of the tree line is predicted to shift further north, and, alongside the tundra-taiga transitions the areas' albedo decreases, which additionally increase local temperatures and might positively feedback to global warming. However, major uncertainties prevail in predicting the speed and magnitude of the tree line advance due to complex interactions of intraspecific processes determining tree stand dynamics. For this reason, an individual-based and spatially explicit model was developed and calibrated for the dominant larch tree species forming the tree line in the Siberian North. In order to achieve a most realistic model, the model handles explicitly each life history stage of the larch individuals and the models' processes were adapted to observed patterns of surveyed tree stands. The credibility of simulated results is supported by results of a thorough sensitivity and uncertainty analysis, namely small resulting sensitivity values. Forcing the model with a reconstructed millennial long weather time series for the region realistic tree stands emerged. Furthermore, the model reliably predicted the current tree line position. Additionally, large area simulations were used to compare model results to findings of palaeoecological approaches. After profound calibrations the presented model can be used as a suitable tool for investigations of the tree line position through space and time, including yet uncertain future changes.