Forest Landscape Response to Different Harvest Scenarios under Climate Warming _ A Spatial Simulation Study

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Abstract

This study examined forest landscape responses to climate warming in a large (~0.5 million ha) boreal and northern hardwood forest region in northern Wisconsin, U.S.A. We examined whether it contributed to the decline of currently predominant tree species and whether harvests can be used as effective means to prolong the transformation of current forest landscapes to those under warmer conditions. We used a modeling approach by linking a spatially explicit landscape model (LANDIS) with a gap model (LINKAGES). Individual tree species responses at stand scales were simulated with LINKAGES, which integrated soil, climate and species data. Such responses were quantified as inputs for LANDIS, which was then used to integrate large spatial processes such as disturbance and harvesting with ecosystem processes. This protocol allowed us to examine regional forest landscape response to climate warming at the species level with greater realism than by using gap models or landscape transition models alone.

Our simulation results suggest that forest landscapes in two ecoregions of northern Wisconsin would experience a significant change under a climate-warming scenario that a 5°C temperature increase occurs over next 100 years. In the lakeshore ecoregion, with more favorable water and nutrient conditions, currently dominant boreal and northern hardwood forests would transform into southern hardwood forests. This result is consistent with the general trends simulated by other models for this region, but shows that landscape transition takes much longer time. By incorporating realistic initial seed source and simulating spatially explicit seed dispersal, our results suggest that the landscape transition is gradual and becomes apparent during 2150-2300 in contemporary time assuming warming occurs from the beginning of this century.

Forest harvesting plays an important role in delaying the decline of boreal forests and northern hardwoods. The greatest differences in resulting landscapes under different harvest scenarios (clear cutting group selection, and selection cutting) occurred starting around year 2150. However, harvest does not alter the long-term impacts of climate warming, as the proportions of various cover types simulated under different harvest scenarios at year 300 are very similar.

At year 2300 in the lakeshore ecoregion, formerly dominant paper birch, yellow birch, sugar maple, balsam fir, and quaking aspen forests were replaced largely by southern oak species (bur oak, white oak, and black oak), white ash, and hickory. Boreal forests in this ecoregion completely disappeared, while northern hardwoods became a minor cover type compared to southern hardwood forests. A more dramatic transformation occurred in the barrens ecoregion. More than 98% of jack pine and red pine forests disappeared. Because southern hardwood species may be unable to reproduce and establish under warming conditions, the barrens ecoregion could transform into an area with only grass and shrub species.