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Using the LANDIS model to evaluate forest harvesting and planting strategies under possible warming climates in Northeastern China

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Abstract

The Small Khingan Mountains in northeastern China provide most of the timber and wood products in the country. Evaluating the long-term effects of harvesting and planting strategies is important especially as the climate changes. In this study, we evaluated the effects of the projected climate warming on potential changes in species' coverage (percent cover), area harvested (percentage of the study area) and species harvested, using the LANDIS model. Our evaluation was based on the harvest and planting plans specified in Natural Forest Protection Project (NFPP). Our simulated results show that the coverage of southern species such as Korean pine (*Pinus koraiensis*) and ribbed birch (*Betula costata*) increases, whereas the coverage of northern species like larch (*Larix gmelinii*), Kingan fir (*Abies nephrolepis*), spruces (*Picea koraiensis* and *P. jezoensis*) and Dahur birch (*Betula davurica*) decreases under the warming climate in the region. The species harvested primarily consist of the southern species, especially deciduous species under the warming climate. The warming climate leads to 11.2% increase in area harvested compared to that under the current climate, when planting is not simulated. When planting is simulated, tradeoffs between planting and area harvested are complex. The area harvested only increases in places where moderate planting is implemented, and decreases in places with both low ($\leq 5\%$ area planted) and high ($\geq 30\%$) planting percentage. This is because when the planting percentage is low, the rate of increase of harvestable species due to planting is lower than the rate of decrease of warming-declining species. When the planting percentage is high, the rate of increase of planted species is higher than the rate of colonization of warming-adapted deciduous species, and the planted species delay the establishment of the warming-adapted species that have short harvest rotations (due to lower harvestable ages). Our results suggest that the management strategy with planting area of 20% is the best among all the scenarios simulated. Under this warming climate, moderate planting area (e.g. 20%) increases the area harvested to about 43%, which is still less than that (58%) designated in the NFPP. These results have important implications for forest managers designing sustainable forest harvest and reforestation strategies for the landscape under the warming climate.

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1. Introduction

The Small Khingan Mountains in northeastern China is one of the three largest forested areas in the country. It provides more timber and wood products than most other forested regions in China. The Small Khingan Mountains are located in the transitional zone between the boreal and temperate forests of China. This area has the highest tree species diversity (Zhou, 1994; Xu, 2001). Prior to 1900, forests in this region were

regarded as a symbol of the 'origin' of the Manchurians who ruled in the Qing dynasties (1600–1900). This region was also believed to be protected from human emigration and timber harvesting. Only a very small population used the forest resource. Between 1900 and 1945, about 6 million ha of forest was harvested, totaling about 100 million m³ of timber. This decreased the forest volume by 60%. After World War II and the China's civil war (1948–1949), the need for timber increased immensely in China especially as the population increased. Harvested timber increased from 6 million m³ in 1949 to over 50 million m³ in 1984. Most forests were harvested with clear-cutting management (removes all species and all ages) during this period (Xin, 1987). Furthermore, 75% of the harvested timber was burned as firewood. The availability of

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