

Assessing uncertainty of growth predictions for a single tree-based stand growth simulator

Mathieu Fortin, ing. f., Ph. D., Josianne DeBlois, Stat. ASSQ, M. Sc. and Steve Bédard, ing. f., M. Sc.

Direction de la recherche forestière, Ministère des Ressources naturelles et de la Faune du Québec

Introduction

SaMARE is a single tree-based growth simulator that has been calibrated for uneven-aged northern hardwood stands in southern Québec. Like most growth simulators, SaMARE first aims at providing forest managers with unbiased growth predictions. However, decision-making does not require growth predictions only, but also an assessment of the uncertainty of these predictions. In this study, we focused on this assessment.

Methods

The simulator is based on 5-year steps. It encompasses eight modules as shown in Figure 1. In order to provide long-term predictions, SaMARE uses a complete iterative stochastic approach, usually referred to as a Monte Carlo simulation. Random numbers are generated to simulate i) the errors of the parameter estimates, ii) the residual errors, and iii) the different random components. For a particular stand attribute, the mean and the distribution of the Monte Carlo iterations, respectively, provide a mean predicted value and its uncertainty.

To test the reliability of these Monte Carlo-simulated predicted values and errors, we used 90 0.5-ha permanent sample plots that were measured on a 5-year schedule for up to 15 years following selection cutting in hardwood stands. The mean bias was calculated on the differences between the observed and the mean predicted values. The reliability and coverage were tested using a nonparametric analysis based on ranks. The tests were performed on several stand attributes and run with a 1000-iteration Monte Carlo simulation for each plot. Under the assumptions of unbiasedness, biases and error coverages are expected to be close to 0 and 100%, respectively, whereas the ranks of the observed value, compared with the predicted ones, should be uniformly distributed from 1 to 1000.

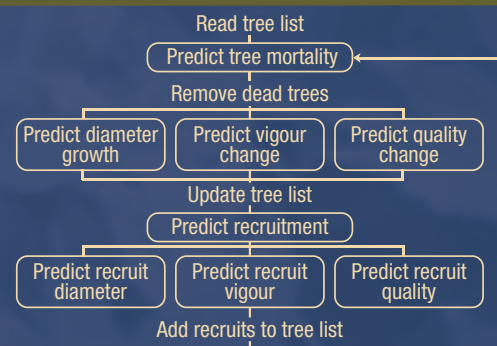


Figure 1. Flowchart of SaMARE for a 5-year step (the boxes indicate the simulator's eight modules).

Results

The results were similar for the different stand attributes. Consequently, only the results for merchantable stand basal area ($\text{dbh} \geq 9.1 \text{ cm}$) are presented here. The biases for the 5-year, 10-year, and 15-year projections are shown in Figure 2. Basically, these biases were small, ranging from -0.1 to 0.2 m^2/ha . The largest bias was observed for the 15-year measurement.

Most of the observed values were encompassed by the Monte Carlo-simulated predicted values, because the coverages were close or equal to 100% for the three measurements (Figure 3). Moreover, there was no major departure from the assumption of uniform distribution among the ranks.

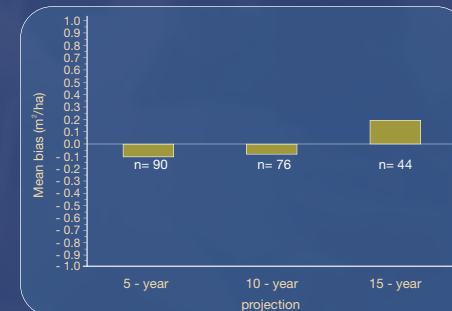


Figure 2. Biases associated with basal area predictions for the three projections.

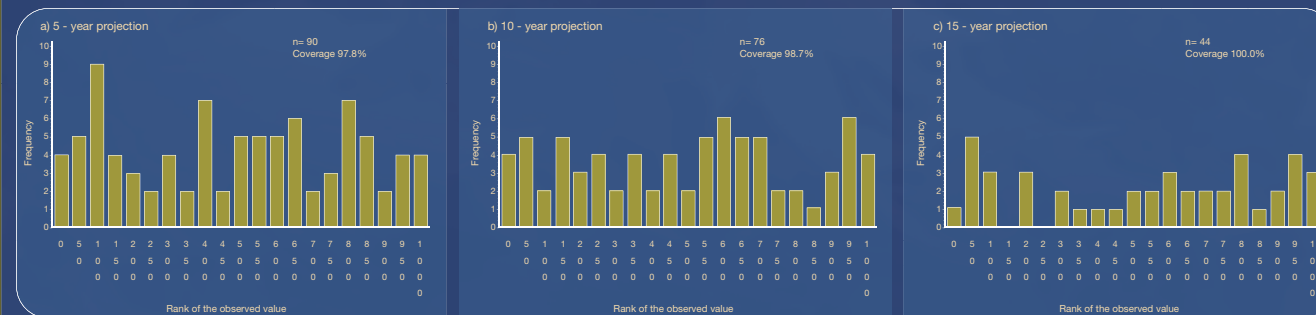


Figure 3. Coverage and rank analysis for the basal area predictions.

Conclusions

Although the Monte Carlo approach is known to underestimate the true variability of growth projections in some contexts (cf., Kangas 1999), our results indicate that this technique, when coupled with the SaMARE growth simulator provides unbiased estimates for the mean predicted stand attributes and its uncertainty. The special attention given to error assessment when calibrating the eight modules of SaMARE may explain why the Monte Carlo approach is reliable in our case study.

Reference

KANGAS, A.S. 1999. Methods for assessing uncertainty of growth and yield predictions. *Can. J. For. Res.* 29: 1357-1364.

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