AN ASSESSMENT OF SIREX NOCTILIO SPREAD AND POTENTIAL IMPACTS ON PINE WOOD SUPPLY AND HARVESTS IN EASTERN CANADA

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ABSTRACT

This study focuses on an emerging threat, *Sirex noctilio* Fabricius, a pine woodwasp recently detected in the United States and Canada and considered a high risk species to pine forests in North America. Our main objective is to estimate possible physical and economic impacts of a *S. noctilio* outbreak on standing pine biomass in eastern Canada. We develop a stochastic spread model to generate several invasion scenarios based on current expert knowledge about *S. noctilio* behavior in Canadian landscapes. The model links the spread patterns with the pine volume map and current regional harvest targets. Projections of killed pine volume range between 25.8 and 115 million m3 over 20 to 28 years depending on the spread model assumptions. Ontario shows the highest and most immediate losses (78% of total losses across eastern Canada over 20 years), and Quebec shares the rest (21.9% over 20 years). Short- and medium-term losses reach $86.3-254.1 million per year after 20 years and are split almost equally between Ontario and Quebec. The net present value of total harvest losses over 28 years is between $0.7 billion and $2.1 billion depending on model assumptions. Adaptation policies decrease short-term losses by 46 to 55 percent and potentially delay larger harvest failures by 9 to 11 years, perhaps buying time for knowledge gains and technical solutions.

Model

We use the Canadian Forest Service Forest Bioeconomic Model (CFS-FBM). The CFS-FBM biophysical component simulates the spread of invading organism, forest biomass growth, timber yields, and basic forest management activities (e.g., planting, thinnings, and harvest). The cost-benefit module uses the biophysical outputs and prices (such as silvicultural costs and forest product prices) to calculate the net revenues and timber supply costs from forestry activities. Data have been developed and the model applied to simulate *Sirex* spread scenarios across all of eastern Canada.

We use a modification of the traveling wave metapopulation model of Sharov and Liebhold (1998) to simulate the spread of *S .noctilio* as a discrete colonization process in a two-dimensional landscape. Based on expert judgments, the maximum annual rate of spread was assumed to be 50 km/year. Because *S. noctilio* does not have a history of observations in Canada, we provide the range of estimates about *S. noctilio* based on different infestation potential. To simulate the pine mortality, we use a ratio that denotes the per capita volume of pine mortality and limits the rate of pine mortality by the maximum limit. Based on observations from the outbreaks in Australian conditions, we assumed the range of maximum mortality rates for Canadian boreal landscapes to be between 4.4 and 16.7 m^3/ha/year or lower for 100-percent pine stands (or 0.8-3 m^3/ha/year when normalized for an average pine proportion in Canadian forests). The susceptibility of pine species was portrayed as a species- and age-dependent probability-density function. The maximum value of this function was based on the U.S. Forest Service FTHET pine susceptibility ratings.

Data and Scenarios

The map of standing pine volume was composed from Canada's National Forest Inventory (CanFI) and included Ontario, Quebec, New Brunswick, and Nova Scotia. The starting point for initial infestations was based on the detection survey conducted in Canada in 2005-2006 and assumes that positive findings would indicate the presence of the *S. noctilio* population in at least 25 percent of nearby pine forests.

We applied a heuristic harvest allocation model to project basic forest management activities in the study areas. Given the coarse scale of the study and the stochastic nature of the data used in the model, the preference has been given to the scoring techniques to calculate harvest allocations. Harvest has been allocated within the Annual Allowable Cut limits for the forest management regions identifying the major wood supply areas around big mills and wood processing facilities. The scoring used three criteria: (1) the present value of net fibre revenues, (2) the inverse distance to a nearest infestation front, and (3) a spatially uniform random error that represents other harvest considerations. To estimate pine AACs, we used existing softwood mills loads and capacities. We divided eastern Canada into the Areas of Primary Harvest (APH) centered on large wood processing facilities and groups of mills with total capacities of 105 m^3/year or more and used the annual mill volume consumption of softwoods to define AACs for each APH. APHs have been delineated based on the existing map of pine volume, assuming an annual growth rate for conifers of 1.8 m^3/ha/year and an average 100-year rotation. The AAC for pine wood was assumed to be proportional to the pine fraction of the total standing volume of coniferous species in the APH.

The present value of net fibre revenues included the costs of silviculture, harvest, transportation, and mandatory post-harvest treatments. Average transportation costs were calculated using a Forest Engineering Research Institute of Canada model. The average per unit per kilometer costs were set to \$0.12/m^3/km. Harvest costs were set to \$20/m^3, post-harvest mandatory treatment costs to \$400/ha, wood price at the mill gate to \$35/m^3, and the discount rate to 4 percent.

The study assesses economic impact of *S. noctilio* from the perspective of forest industry, as the changes in wood supply values delivered to the mill gate. The assessment of potential impacts includes two scenario runs–simulating harvests with and without *S. noctilio* invasion. The impacts are then calculated as a difference between the two scenarios. We explore three basic harvest strategies. The "No Adaptation" scenario applies the exact harvest configuration from the "no-invasion" scenario and hence simulates the economic impacts without any alterations of harvest patterns. The "Value Adaptation" scenario uses cost minimization strategies to adapt the harvest in response to the invasion. The "Value + Salvage" scenario is also driven by cost-minimization but reallocates the harvest closer to the infested area, hence representing a more proactive attempt at salvaging wood supply seemingly doomed to be killed by invasion.

Results

Sirex noctilio is a new species to North America with a short detection history, which dictated using a fairly simple spread model, a broad range of biophysical assumptions, and representing the results in a form of "what-if" scenarios. Overall, the projections show the total killed volume over 20 and 28 years as 25.8 to 43.7 and 79 to 115 million m3, respectively. Provincial totals follow the same tendency except the impacts are spread over time. The harvest allocation approach has relatively little impact on killed volume projections but drastically changes the economic impacts on harvest. For example, annual losses in the "Value Adaptation" scenarios were 1.7 to 2.5 times lower than in the "No Adaptation" scenarios, e.g., \$86.3-112.8 million per year vs. \$212-254 million per year at year 20. Total losses show a similar tendency. Depending on the harvest policy, the total net present value of the losses over 28 years is within \$1.5-2.1 billion in the "No Adaptation" scenario, \$0.7-1.1 billion in the "Value Adaptation" scenario, and \$1.2-1.9 billion in the "Value + Salvage" scenario. Total lump sum savings from using harvest adjustments in response to invasion reach \$0.84-1.0 billion over 28 years.

While harvest adaptation policies cannot slow the spread of invasion, they do help reduce short-term losses from the outbreak invasion by 46 to 55 percent. In general, harvest reallocations tend to avoid heavily infested sites with declining quality of standing wood. The results also suggest that given the long flying range of *S. noctilio*, the "Value + Salvage" scenario may not be an effective cost-saving option, especially when implemented within the existing Annual Allowable Cut limits.

We did not find a specific minimum loss of usable volume that causes large-scale wood supply shortages. "No Adaptation" scenarios show this threshold is between 43 and 111 M m^3 of killed biomass over 20 years. The "Value Adaptation" and "Value + Salvage" scenarios usually show higher levels starting from 230 M m3. Overall, without harvest adaptation, failures to maintain Annual Allowable Cut levels start to occur after 20 years when total area infested could exceed 15 million ha.

Conclusions

Incorporating harvest allocation models into the risk assessments of exotic pest invasions can better connect risk assessments to forest management. The results suggest that adaptation policies could decrease near-term losses by half and delay large harvest failures by 9 to 11 years. The results also suggest that for this species a preventive practice of moving the harvest closer to an infested area may not have an economic advantage or reduce physical losses of pine biomass from invasion. Existing AAC limits are simply too small to create a quarantine corridor comparable with the known flying range of *S. noctilio*.

Literature Cited

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