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Informing Land & Resource Management

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Alternative approaches for integrated area-wide management of the mountain pine beetle epidemic in Alberta

Current efforts at controlling the mountain pine beetle (MPB) in Alberta focus on direct suppression via removal of infested trees. This can be effective in the early stages of infestation, when MPB populations are low, though not in years when weather and forest conditions facilitate high rates of beetle survival. The likelihood of successful area-wide suppression of MPB in Alberta is further compromised by the fact that a sizeable proportion of the Alberta landbase is ill-suited for removal/destruction of infested trees because infestations are inaccessible (as much as 78% of a given forest management area, for example), or in forests where tree removal is restricted/prohibited such as parks, riparian areas, special conservation or wildlife areas, and military reserves. The effect of this "net-down" of areas eligible for the control of MPB on the spread of the beetle is unknown; in the worst case, it could completely undermine the impact of controls elsewhere.

In a previous fRI Research–funded project, we developed a model (MPBSpread[1]) to predict the rate and extent of MPB attack and used it to successfully project the spread of populations across a landscape in central Alberta. This project builds on that work by utilizing MPBSpread to assess the efficacy and impact of current control methods on a much broader (province-wide) scale versus an alternative approach based around manipulating host availability.

Adding Economics to MPBSpread

A principal objective of the previous modelling work was to evaluate the relative efficacy of control efforts to date in slowing the spread and associated impacts of MPB within north-central Alberta. Two scenarios were simulated. The first represented a "do-nothing" approach to project how the infestation might have developed in the absence of any control efforts. The second scenario included Level-1 (single tree removal) and Level-2 (stand-level harvesting) treatments on infested areas designed to represent the ongoing "slow the spread" management program implemented by the Government of Alberta.

[1] MPBSpread is a raster-based cell model utilizing an algorithm that defines the annual transition of uninfested cells to an infested status. The model takes account of stochasticity, demographics, climate, prevailing wind direction, and anthropogenic factors (control measures, for example) to predict the spread of MPB. See Carroll et al. 2017. "Assessing the effectiveness of Alberta's forest management program against the mountain pine beetle." fRI Research project 246.18 Final Report. 54pp. https://friresearch.ca/sites/default/files/MPBEP_2017_07_%20Control%20Efficacy%20report_0.pdf).

Slow the spread treatments were constrained using an area-based approach, whereby maximum annual limits were set on the total areas that could be treated by Level-1 and -2 controls, respectively. The simplicity of this approach had considerable utility because the focus of the research was largely a *post-hoc* evaluation of previous control efforts and spread dynamics. Now, however, the emphasis is on the predictive capabilities of MPBSpread in conjunction with explicit consideration of how time and effort might best be allocated to achieve beetle control objectives. Model developments are now focused on the application of algorithms that assign specific economic costs to the full suite of control activities, including red attack surveys, green attack (ground) surveys, cut-and-burn activities, and quality assurance/ control assessments; and how the management zones (inactive and leading-edge) and their boundaries (Figure 1) can be defined going forward for those areas that are not yet infested with MPB.

MPBSpread uses a spatially explicit cellular automata approach to simulate beetle spread. This involves the application of a series of rules describing MPB behavior in relation to host and landscape characteristics. These rules are used to calculate from one year to the next, the probability of colonization from an occupied cell to suitable but unoccupied recipient cells. Actual colonization events are then triggered as binary events (colonized or not) by a randomization process. Following colonization, trees are then killed within the model (red attack) while others are colonized (green attack) both within the immediate area and after dispersal elsewhere. These features of the model are now being incorporated into algorithms that predict the red and green boundaries (the geographic limit of beetle-killed trees and of current-year attack, respectively), the beetle boundary (the geographic limit of positive finds in baited trees), and the leading edge and inactive zones (Figure 1).

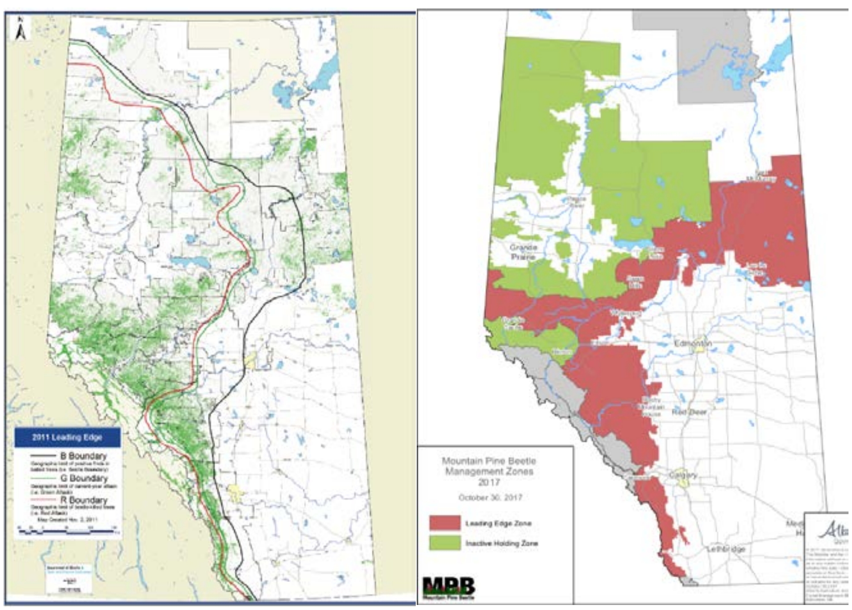

Figure 1. Left panel: Approximate boundaries of leading edges of red-attack trees (R Boundary), green-attack trees (G Boundary) and Beetle attacks (B Boundary) in 2011. Source: Nealis and Cooke, 2014 "CCFM Forest Pest Working Group Report". Right panel: mountain pine beetle management zones, as defined in 2017 by Alberta Agriculture and Forestry.

Once these modifications are complete, MPBSpread will be calibrated using beetle distribution data for the 2008–2018 period. MPBSpread will then be used to project beetle movement over the subsequent 10-year period based on the current MPB slow-the-spread control strategy (the status quo). This timeframe is critical to limiting beetle spread and should be sufficient to establish firm conclusions regarding control efficacy. The model will generate a broad range of outputs (Table 1) to facilitate a thorough evaluation of management impacts. In addition, the proportion of 16-ha cells colonized by MPB along the northern and eastern borders of Alberta will be determined for each replicate, as an index of extra-provincial spread. The following represent the additional scenarios to be evaluated with MPBSpread.

Table 1. Impact metrics generated from MPBSpread

MPB	Ecological	Economic
Rate of spread	Forest area	Timber value lost
Perimeter to area ratio	Volume (living pine)	Value of merchantable timber inventory
Direction of spread	Volume (dead pine)	Change in harvest volume (level, size and species, proportion of salvage volumes)
Total area colonized	Pine area killed	Economic activity (in relation to harvest levels)
	Pine area living	Regeneration/rehabilitation costs
	Habitat connectivity	Delivered wood cost
	Habitat fragmentation	Detection and control costs

Scenario 1: Modifying the Status Quo

Detection and eradication efforts are costly to undertake. They will be modified (increased) to evaluate their relative impact on the rate and extent of MPB spread.

Scenario 2: Evaluating the Net-Down Problem

As outlined above, a sizeable proportion of the landbase does not receive any significant beetle control. The relative impact of this net down will be evaluated by conducting simulations when these areas are subject to no control (as occurs now) versus with control. The latter will be applied using Level-1 activities that vary from full control (no areas are excluded) to partial control (certain sites are selected or Level-1 controls are applied at variable rates).

Scenario 3: Do Nothing

A final consideration is that the MPB control program generates only a marginal improvement in outcomes with respect to limiting the impact on pine mortality; the model will simulate the spread of MPB when no efforts at control are implemented anywhere on the landscape.

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