QuickNotes
Science summaries from fRI Research

Toward pre-emptive management of future outbreaks: predicting the distribution of post-epidemic mountain pine beetle populations in the western boreal forest

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Recent efforts to control MPB spread across Alberta through a 'slow-the-spread' program have been largely effective (Carroll et al. 2017, 2020). This program targets epidemic populations that have a high propensity for spreading as long as there is enough suitable mature pine for beetles to attack and kill. However, beetle populations can decline when there is not enough suitable pine on the landscape, if there are extreme cold weather events, or if immigration from source populations declines. In British Columbia, MPB populations have largely collapsed throughout the province and Carroll et al. (2020) have projected that epidemic populations will collapse across most of Alberta within the next decade.

After epidemics collapse, MPB populations persist in the endemic state (Safranyik and Carroll 2006). During this phase, local beetle populations are not large enough to engage in collective mass-attacks, and instead are restricted to stressed and suppressed trees. Recently, we have demonstrated that lodgepole pine stands within the expanded range of MPB may support higher densities of endemic beetles than lodgepole within the historical range, while jack pine stands are largely unsuitable for endemic beetles due to differences in the abundance and diversity of predators and competitors and microbial interactions among habitat types (Burke and Carroll 2020; Carroll and Pokorny 2020). Further, differences in stand structure, connectivity, and landscape context among habitat types also affect endemic

Federal-Provincial MPB Research Partnership

Mountain Pine Beetle remains a severe threat to Alberta's pine forests despite the province making positive progress in controlling its spread within the province and reducing the risk to the rest of Canada.

Natural Resources Canada and Alberta Agriculture and Forestry have provided funding to a suite of projects with the goals of limiting the spread of Mountain Pine Beetle and mitigating damages where it has already invaded.

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suitability, and hence, the likelihood of endemic beetle establishment, persistence, and potential for future outbreaks (Safranyik et al. 2010; Burke and Carroll 2020; Carroll and Pokorny 2020). However, this work has primarily focused on lodgepole and jack pine stands near the leading edge of MPB's expanded outbreak range and it is unknown how generalizable these stand and landscape differences are to the greater boreal and thus landscape models are required. Previous efforts to model differences in endemic suitability have suggested that a modified version of the stand susceptibility index (Shore and Safranyik 1992) that places a greater reliance on stand density index (SDI; an estimate of the degree of inter-tree competition within a stand), may be useful as this metric is correlated with the abundance of suppressed, low-vigor trees susceptible to endemic MPB colonization (Carroll and Pokorny 2020).

Future locally generated eruptions of MPB require both established endemic populations and external forces that can facilitate population transitions via the accumulation of suitable low-vigor host trees, such as increasing temperatures, drought, wind-throw events, and defoliator or pathogen outbreaks (Safranyik and Carroll 2006). Climate and land-use change are projected to increase the frequency and severity of such events. Thus, if endemic populations go unmanaged then there remains a very high likelihood of recurrent outbreaks over large areas of Alberta triggered by relatively minor changes in forest conditions (Cooke and Carroll 2017). Synchronous future eruptions could have devasting impacts on Alberta forests and could lead to further spread eastward across the boreal, potentially leading to eastward shifts in eruption epicenters and spread into eastern pine species. Thus, it is imperative to identify suitable endemic habitat in Alberta and across the boreal for long-term monitoring and proactive landscape management.

The proposed work contributes both to Theme 3 (Detection of MPB) and Theme 1 (MPB Biology) as our model will facilitate programs to monitor for MPB during the population phase when it is undetectable by aerial survey programs (Cooke and Carroll 2017). Further, we have little understanding of how beetles transition between population states, especially how populations collapse from the epidemic to endemic phase. Developing a model of endemic suitability for jack and lodgepole pine in Alberta, and sampling highly suitable stands for endemic persistence, will enhance our understanding of the future of MPB in the montane-boreal transition zone and will contribute to all of the key outcomes identified by Anon (2020): Limit the spread of MPB (i) into the eastern boreal forest, and (ii) along the eastern slopes of Alberta; (iii) mitigate damage to Alberta's pine resources in locations where MPB is already established; and (iv) generate knowledge and innovative management techniques to support MPB management. Furthermore, a model of endemic suitability will help inform projections of beetle dynamics in other novel habitats, such as high-elevation whitebark pine forests in British Columbia where the dynamics of population collapse and endemic establishment are of great interest (Howe et al. *in prep*). Finally, by integrating forest inventory data (AVI) and remotely sensed data in Alberta, we can bridge the gap between the detailed forest inventory data resources available in British Columbia and Alberta, and the remaining prairie provinces of Saskatchewan and Manitoba where forest inventory resources are sparse. Successful funding of this project will help fill critical gaps in monitoring programs and aid in the development of robust and publicly available decision support tools for better management practices.

Objectives

Our long-term goal is to improve both monitoring and management programs in Alberta and across the boreal. Our overall objectives are:

1. To generate a model that incorporates SDI as a means of identifying stands that exhibit stand structural traits associated with endemic suitability within Alberta;
2. To test our model predictions in lodgepole and jack pine via ground-truthing of actual stand structure, endemic suitability, and presence/absence of endemic populations; and

3. To predict where suitable endemic habitat exists outside Alberta using continental-scale remote sensing data.

These objectives will allow us to test the following hypotheses: 1) stands with high stand density index (SDI) values are the most suitable for endemic populations; 2) differences in stand density index will be a better predictor of endemic establishment than models designed for epidemic populations; and 3) the amount of suitable endemic habitat varies significantly across Alberta and the boreal. Addressing these objectives will allow for the establishment of long-term monitoring methods for endemic populations, increased ability to predict future outbreaks, and identification of stands for proactive management interventions.

Expected outcomes

Aim 1: Identify stands putatively capable of supporting endemic populations. Recently, Carroll and Pokorny (2020) demonstrated that endemic MPB habitat suitability is related to key stand mensurational characteristics included in the Alberta vegetation inventory (AVI) data. We will use AVI data to calculate SDI values for pine habitats in Alberta, under the assumption that stands with high values represent suitable endemic habitat. (Note: all AVI data will be acquired from Alberta Agriculture, Forestry and Rural Economic Development (updated ministry name, 2021), and relevant FMA holders following establishment of appropriate data sharing agreements).

Aim 2: Test the model predictions of endemic habitat. Based on data detailing the distribution of epidemic MPB derived from MPBSpread (Carroll et al. 2017, 2020) and our model from A1, we will identify stands predicted to be currently or imminently occupied by endemic MPB. We will sample sites that fall along a gradient of predicted suitability and rigorously sample for SDI, endemic susceptible trees, and endemic beetles following the procedure of Carroll and Pokorny (2020). In addition, equivalent surveys will be conducted at additional sites that fall outside the current distribution of epidemic MPB to ground-truth the generality of our model.

Aim 3: Predict suitable endemic habitat in Alberta and across the boreal. Model predictions from A1 and subsequent model refinement based on A2 will be integrated with LANDSAT-derived predictions of stand mensurational characteristics at a 30m resolution across all of Canada (https://opendata.nfis.org/) (Matasci et al. 2018). LANDSAT derived data will be 'ground-truthed' based on the National Forest Inventory permanent plot system (see https://nfi.nfis.org/en/). The model will be developed based on SDI and refined based on A1 and A2. Finally, we will create projections of future endemic habitat by integrating our model predictions, historical disturbance regimes (https://opendata.nfis.org/) (Hermosilla et al. 2015), and MPB climatic suitability (BioSim; Regniere 1996). All products from A3 will be made publicly available in an interactive form (e.g., as an R Shiny app) available on the UBC FIDEL website (https://fidel.forestry.ubc.ca/).

Implications for Land Management

Successful completion of our objectives will greatly contribute to operational decisions, risk assessment, and policy development. First, after testing and improving our model, we believe that it could be used to identify candidate stands for monitoring endemic MPB populations. Since MPB eruptions are often synchronous across landscapes (Aukema et al. 2006), intensive monitoring at critical sites could be employed to forecast and provide a warning of future outbreaks. Second, this model could be used effectively for risk mitigation by facilitating targeted management of highly suitable endemic habitat. For example, harvesting and thinning programs could be designed to decrease the number and connectivity of mature pine stands above a certain SDI threshold. Finally, we will make all model results publicly available, which may help bridge the current gap of data accessibility and compatibility among provinces.

Expected date of completion of the project

March 31, 2024

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