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Informing Land & Resource Management

Simulating MPB Spread Management in Alberta and Beyond Using SpaDES

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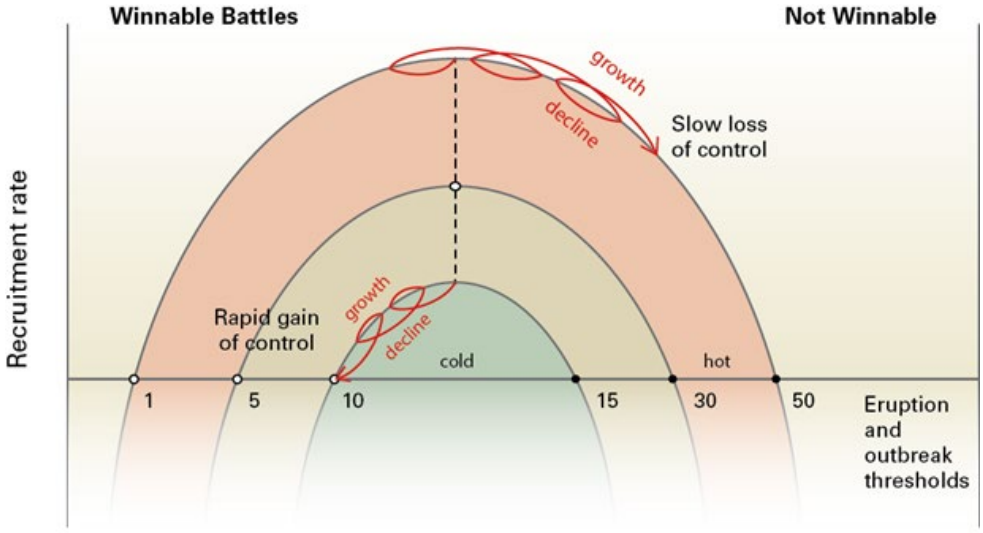
Alberta's forests continue to experience unprecedented changes driven by climate, pest outbreaks, and fire; all underlie different types of anthropogenic changes. Managing for these factors requires novel forecasting and decision support solutions, that tie directly and flexibly to policy needs as they arise; integrate the latest scientific information and data across multiple disciplines; deal with uncertainty; and are continuously updatable to keep up with developments in science, data, management, and policy.

On February 22, 2019, the Mountain Pine Beetle Ecology Program hosted a full-day workshop to showcase and discuss an innovative multi-year project led by Drs. Eliot McIntire and myself to simulate MPB spread in Alberta and Saskatchewan. Together with Drs. Barry Cooke and Dave Andison, we presented work on a new data-science platform called SpaDES and discussed challenges and successes of developing a scalable software framework and tools for tactical and strategic decision making. We presented a climate-sensitive forecasting model of forest vegetation, insect, and fire dynamics developed to exemplify the spread of mountain pine beetle (MPB) in the western Canadian boreal forest, and discussed extensions of the model and uses of the SpaDES simulation platform.

Dr. Cooke kicked off the morning session by providing a brief primer on MPB biology and a historical overview of the outbreaks in BC and AB, and how the eruptive dynamics of this insect have been modelled over the years. The major theme of this session was dealing with uncertainties in forest management, and how to reduce the risks of "monumental surprise".

Rapid, early, and sustained intervention, while beetle immigration is low, are the critical components needed for effective direct control of the beetle. One key challenge is the impact of warmer climate on beetle populations, which makes control of these outbreaks much more difficult.

The second session was led by Dr. McIntire, who extended the discussion on MPB and climate to discuss the cumulative impacts of various ecosystem dynamics and



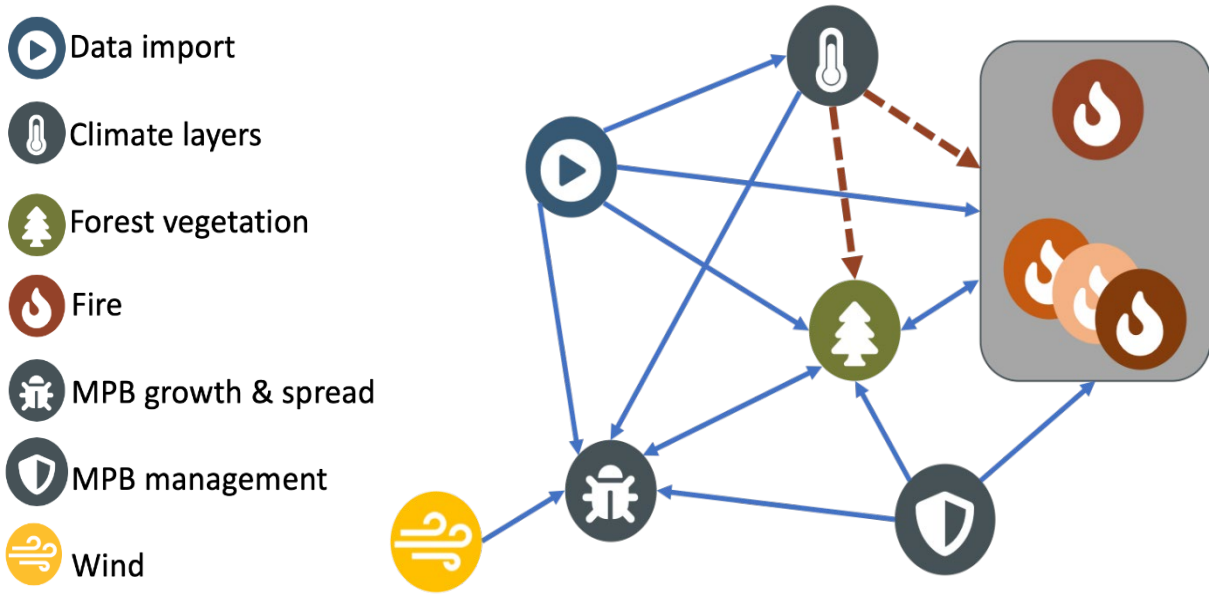
The ability to control MPB given three climate regimes, and a fixed suppression rate of 2/3 of a population, a realistic rate for low density MPB on the very leading edge of the invasion front as this rate is ~44% in western Alberta. From Hodge et al. 2017.[1]

[1] Hodge, J., B. J. Cooke, and R. L. McIntosh. 2017. "National Containment Strategy to Slow the Spread of Mountain Pine Beetle Across Canada." *Forest Pest Working Group of the Canadian Council of Forest Ministers*.

how we as scientists, policy makers, and forest practitioners can begin to integrate the best available information and data in our models and decisions. He introduced the SpaDES platform, an exciting new software tool for developing and running integrated data and simulation models. Dr. McIntire explained how this new tool can be used to bring together expertise from multiple disciplines to inform decisions using the best available, and frequently updated, scientific data and models, and highlighted the success of SpaDES in other projects led by the Canadian Forest Services. This MPB project is one of the early case studies with the platform and is being integrated with many other scientific models. Stay tuned for more applications.

Our afternoon sessions picked up where we left off, diving into the science of developing spatial simulation models of MPB eruptive dynamics and spread. I led the group through the various components of the model. The model captures the two major components of the outbreak: eruptive population growth and spread, based on previous aspatial modelling.[2] Our model simulates these two processes in a spatially explicit manner, across Alberta and parts of Saskatchewan, using several important data inputs: historic MPB attacks, climate suitability projections for MPB under various climate change scenarios, and large-scale vegetation maps. In addition to modelling MPB, we also explored the role fire plays on creating forest gaps that may impact beetle dispersal, and controlling beetle populations directly by burning infested stands. We evaluate the impacts of different MPB management scenarios on MPB spread rates.

Rounding out the workshop's discussions on these large-scale modelling efforts, Dr. Andison showcased another SpaDES-driven project from the Healthy Landscapes Program. He shared some of the challenges and successes of the LandWeb project, which simulates natural (historical) range of variation in the western Canadian boreal forests, and we discussed how we can deploy these tools for effective decision support. We wrapped up the workshop with several great discussions about MPB outbreak biology and how to get at answers to other integrated questions using SpaDES. We thank Dr. Keith McClain and Fran Hannigan for organizing this great event.



The integrated boreal MPB spread model. Key components are climate-sensitive MPB population growth and dispersal across the landscape, fire ignition and spread, and MPB management scenarios. The modular design allows for extensions, including realistic wind modeling for improved spread estimates, or using alternative vegetation and fire models that respond to changing climate (dashed lines).

[2] Cooke, B. J., and A. L. Carroll. 2017. Predicting the risk of mountain pine beetle spread to eastern pine forests: Considering uncertainty in uncertain times. Forest Ecology and Management 396:11–25.