FIA-FSP project number: M075025
Title: A Strategic Analysis Framework for Managing Forests under the Mountain Pine Beetle Outbreak.

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Project Length: 2 years
Project End Date: March 30, 2008

Project Purpose and Management Implications

Objectives of landscape-level planning are to promote sustainability and stewardship of multiple resource values with an emphasis on consistent fibre flow, but events such as mountain pine beetle (Dendroctonus ponderosae Hopkins, MPB) outbreaks create uncertainty that hampers meeting those objectives (Sutherland et al. 2004). Events as large as the current MPB outbreak can cause forests to lose some resilience to absorb further perturbation and reduce their capacity to provide key ecosystem services, such as wildlife habitat, mid- to long-term timber supply, and jobs (MOFR 2005).

Innovative and forward-looking approaches that address uncertainty are needed to manage landscapes for both timber and non-timber values. In the mid-1970's, the East Kootenays experienced a MPB outbreak that can be used to provide a solid foundation for examining the potential consequences of the current epidemic. The purpose of our project is to exploit this information to guide MPB-related decisions through a strategic analysis that compares the consequences of historic responses to alternative management approaches. To develop our methodology we use the Cranbrook Timber Supply Area, in south-eastern British Columbia, as our study area. The project has three main objectives; 1) provide an analysis framework to evaluate resource values and trade-offs with explicit accounting for the uncertainty surrounding disturbance events, such as MPB outbreaks, 2) provide guidance to managers for addressing current MPB-impacted landscapes based on an evaluation of historic data on a previous MPB infestation and forward looking projections, and 3) project potential future increases in, and impacts of, development activities such as recreation, grazing and harvest of non-timber forest products that may result from increased road development associated with salvage harvesting of MPB-killed stands:

Methodology Overview

Objective 1

Development of Analysis Framework

The purpose of the analysis framework is to provide a structured approach to addressing the question of the future supply and associated uncertainties of ecosystem services, primarily timber and wildlife habitat, to events such as the current MPB outbreak. To accomplish this goal we have extended a collaborative framework implemented by Fall et al. (2001). This collaborative framework was designed specifically to include stakeholders and experts in relevant disciplines. It allows us to exploit the collective knowledge available to explore and contrast historic, current, and hypothetical management responses to MPB outbreaks at a variety of scales for the Cranbrook study area. Such frameworks ensure that mutually relevant questions and solutions are addressed, that a multi-disciplinary approach is used to resolve the problem and that stakeholders are involved in the process. This collaborative process encourages acceptance and shared ownership of the resulting models and their outcomes. We propose further extending the collaborative framework of Fall et al. (2001) by incorporating the techniques of scenario planning (Peterson et al. 2003, MA 2005, Carpenter et al. 2006), which provides a methodology to project the future supply of ecosystem services and investigate relevant uncertainties. Through the analysis framework plausible scenarios of future landscape condition can be constructed. This enables the development of management policies that can potentially provide a socially acceptable supply of ecosystem services across a range of future conditions. This strategy provides a reasonable approach to manage the uncertainty of future events (Carpenter et al. 2006).

General Landscape Model Building

We use landscape models to explore historic and future landscape condition. Landscape models are used to spatially capture ecological and management condition across a variety of scales. They typically include sub-models of forest growth, timber harvesting, succession, natural disturbance, and habitat supply (Fall et al. 2001). To ensure cost effectiveness and timeliness, we are leveraging landscape modelling efforts from a range of other projects by linking to them and adapting their models. For example, for MPB projections we downscaled results from the provincial MPB projection model (BCMPB, Eng et al. 2005). This downscaling allows us to build on the extensive efforts of the provincial-scale project, and keeps results consistent with other MPB analyses. For this project a general landscape model will be created that will enable a retrospective, and a dynamic landscape-projection analysis. It will include processes of forest management, including elements such as cut block size and spatial distribution, access constraints, targeted harvest based on stand characteristics and alternative fibre flow. As well, the landscape modelling will include stand aging and succession, MPB dynamics (downscaled from BCMPB), road development, and wild fire. Habitat supply models for selected wildlife species and other ecological and socio-economic indicators will be linked to the landscape dynamics, providing comprehensive output. Disturbance and succession models are tied to the Biogeoclimatic Ecosystem Classification (BEC) layer. Climate change scenarios will be modelled by modifying the BEC layer according to provincial projections (Hamann and Wang 2005) and altering disturbance regimes. As the main dynamic model will be stochastic, each one will require multiple runs. The landscape models will be implemented using the SELES (Spatially Explicit Landscape Event Simulator) modelling system (Fall and Fall 2001). This software is a flexible tool for building and processing grid-based, spatio-temporal models that has been used for a wide range of related projects, including the BCMPB.

Objective 2

Historic MPB Outbreak Re-construction

Past information on spatial and temporal characteristics of MPB outbreaks provides an opportunity to explore patterns and interactions with management (Nelson 2005). By examining historic data on MPB outbreak trends, fire and harvest activities, insights can be gained into the current outbreak leading to a better understanding of ecological and forestry response to natural disturbances and management interventions. Road access is a key driver for many forest resource values, especially values sensitive to human intervention or values for which access is important to derive benefit (Forman and Alexander 1998). Historical information can provide a blueprint for how road access has evolved in conjunction with management in MPB-impacted landscapes. As well, information on existing and proposed roads, along with knowledge of access policies, can help frame potential future management options.

The previous East Kootenay MPB outbreak that occurred in the late 1970's was characterized by creating electronic map layers of the pre-outbreak forest and road network conditions. Forest inventory information that describes forest stand initiation and disturbance history was used to generate annual maps of the severity of bark beetle infestations, fire and historic timber harvesting, reflecting historic management response. A "roll back" model, built using SELES, was used to re-create the forest condition of 1973, prior to the 1970's MPB outbreak. To generate a map of roads for 1973 the current road network was split into a set of segments. In the forest inventories harvesting activities are recorded back to the 1940s in the Cranbrook study area. The highway system was used as a starting point and the segments of the road network required to access blocks harvested between 1949 and 1972 were activated resulting in a base road network condition for 1973.

Starting in 1973, we projected landscape conditions forward to 2004 with an aim of exploring the range of possible outcomes. These represent a range of "real options" available for managers during that period. The following six scenarios were constructed:

1. Historic logging: This scenario simply replays historic logging, fire and MPB to provide a simple baseline comparison and to verify that the model ends up with conditions close to 2004 conditions.

2. No management: This scenario simply replays natural disturbance over this time period, to provide a baseline of how the forest conditions may have evolved in the absence of logging.
3. Default management: This scenario applies the "status quo" management regime assumed in TSR 3 over this time frame, with an additional priority for salvage of disturbed stands.
4. No salvage: This scenario is the same as above, except no salvage was applied.
5. Susceptibility focus: This scenario applied a priority to focus harvest as much as possible in stands susceptible to MPB, based on an approximation of the Shore and Safranyik MPB susceptibility rating. This scenario aims to quantify the degree to which susceptibility may have been reduced over this time frame.
6. Minimize roads: This scenario harvests the same volume, but with a focus on minimizing the amount of road constructed to access stands. The aim was to quantify the minimum amount of road that could have been built to harvest wood.

Objective 3

MPB Outbreak and Landscape Change Scenario Planning

Scenario planning and assessment is a systematic way of gaining insights into complex and uncertain futures (Peterson et al. 2003). In contrast to what is required to manage the current MPB outbreak, traditional planning does not incorporate the inherent uncertainty of incomplete ecological knowledge and unknown ecological response to management interventions. The analysis framework and historical MPB reconstruction enable the implementation of scenario planning in the Cranbrook study area. The scenario planning objective is the primary activity for the 2007/2008 project year.

Through the analysis framework, a set of scenarios are being designed to incorporate management objectives that operate under a range of potential futures differentiated by varying landscape components such as 1) MPB outbreak ends or continues unabated; 2) management applies no salvage, moderate salvage or aggressive salvage; 3) post-MPB, return to traditional forest management or proceed with an alterative form of management; 4) species recover as under historical climate, or climate change is mild or severe, leading to species conversion with change in ecological niches; and 5) develop road access and potential associated developments to entire productive forest or delineate road-free areas and intensive management areas. A scenario is made up of a number of these types of components. Overall, each scenario captures a trend, such as change in climate, a shift from commercial forestry to recreation, increase in conservation oriented goals or a continuation of current ecological and economic dynamics. The scenarios will lead to a series of "what if" management responses that allows us to explore potential futures, and the development of management policies that will maintain ecosystem services that are robust to range of conditions. Risks will be quantified as probabilities of persistence or change to alternative states through a decision analysis based on expert knowledge (Peterman and Peters 1998) and our historical MPB outbreak reconstruction. Management interventions will be described to reduce the risks and mitigate potential unavoidable impacts caused by the MPB outbreak.

Project Scope and Regional Applicability

The chief benefit of the project's products will be to inform our audience of the consequences of current policy and articulate alternative management strategies based on principles of sustainable forest management. This project will generate two major products: 1) an analysis framework to support decision makers and project participants ability to assess timber and non-timber values, trade-offs, and interactions, with explicit accounting for uncertainty; and 2) a report that evaluates current policy, provides alternative options, and delivers guidance to inform MPB-related decisions.

This project's results and methodologies are relevant to any landscape where there is high uncertainty in the supply of ecosystem services, particularly areas impacted by MPB. The Cranbrook Timber Supply Area in south-eastern British Columbia is the study area for the project and comprises the southern half of the province's Rocky Mountain Forest District. The project's target audience is managers and decision-makers responsible for developing strategies concerning the MPB outbreak in the interior of British Columbia.

Because the MPB outbreak could have wide-ranging impacts and our project addresses both timber and non-timber values there are several beneficiaries of this project's results. Project participants include Forest industry, British Columbia provincial forest planning and environment offices, conservation groups and First Nations.

Interim Conclusions

Objective 1

Development of Analysis Framework

In the first year, we implemented an analysis framework and we will use it in the 2007/2008 project year to continue our development of stochastic, landscape-based models designed to aid understanding and communication of ecological and decision uncertainty in resource management specific to the MPB outbreak.

Our analysis framework, integrating the methods of Fall et al. (2001), Peterson et al. (2003) and Cumming et al. (2005), has four basic steps titled Context, Current State, Alternate States and Scenarios:

1. Context: includes:
    a. identification of focal issues,
    b. identification of ecosystem services
    c. specification of scale, including physical extent of study area and time horizon under consideration. As well, the spatial resolution, or granularity, and the finest temporal time step used in the analysis, and
    d. establishment of a stakeholder, decision maker and scientist collaboration.
2. Current State: description of the essential system attributes of the current system:
    a. structural components,
    b. functional relationships,
    c. sources of system innovation, and
    d. sources of system continuity.
3. Alternate States: description of the drivers, or forces, that may contribute to plausible futures and includes:
    a. scenario themes: identified by project participants,
    b. forces: social-ecological internal and external forces that may shape the study area, including an assessment of those that are partially controllable and those that are not, and
    c. likelihood: an assessment of the likelihood of ecological and management forces occurring.
4. Scenarios: definition of a set of scenarios of future social-ecological conditions and includes:
    a. Scenario definition: based on the current system and the forces that act on it, including management policies.
    b. Scenario testing: an evaluation of the plausibility and social-ecological consequences of a scenario.
    c. Management options and interventions: management interventions that may alter the trajectory of a scenario to a preferred future condition.

General Landscape Model Building

A general landscape model was built to support a retrospective and a dynamic landscape-projection analysis. The landscape model includes the ability to model forest management, including evaluation of a variety of cut block size and spatial distributions, a range of access constraints, targeted harvests based on stand characteristics and alternative fibre flows. We have included stand aging and succession, MPB dynamics downscaled from BCMPB, road development, and fire sub-models. Using some of the same sub-models as the dynamic projection model, the retrospective analysis model allows us to replay historic disturbance and to evaluate the implications of different management strategies had they been implemented in 1973 – please see Historic MPB Outbreak Re-construction below.

Objective 2

Historic MPB Outbreak Re-construction

We integrated historic inventories from the Provincial government, Canadian Forest Service and Tembec to create annual historical maps of forest condition, area burned by wild fire, bark beetle outbreaks and timber harvesting. As well, we generated the 1973 landscape and modelled a set five scenarios and their implications on area harvested, mean volume harvested/year, mean age harvested, kilometres of roads build and an indicator of the susceptibility of the wood harvested (Table 1).

Table 1. Base metrics for retrospective scenarios.

Scenario	Area harvested (ha/yr)	Mean volume/ha harvested (m^3/ha)	Mean age harvested (years)	Mainline roads built (km)	Mean susceptibility harvested (0-100)
Historic logging	2,360	219	122	5,390	20
Default management	1,950	263	160	3,410	20
No salvage	1,990	258	159	2,430	20
Susceptibility focus	2,260	226	112	4,560	47
Minimize roads	2,040	251	145	2,230	24

The area of forest with susceptibility of at least 40% would have been reduced by about 30,000 ha if harvest had focused on reduction of such stands from 1973 to 2003 (Table 2). Other management scenarios reduced susceptible stands by about 20,000 ha over the no harvest scenario. The main susceptibility harvested is about 20% to 24% for all scenarios, except Susceptibility focus, where it is 47% (Table 1).

The amount of road built varies considerably between scenarios, with a low of just over 2,400 km built over period (minimize roads scenario) to a high of over twice that level (Table 1). The scenario the aims to reduce susceptibility leads to relatively high levels of roading. The historic logging scenario does not re-create all currently mapped roads (there are over 18,000 km in the inventory file, but the historic logging scenario ends with about 9,300 km). This is due in part to roads created historically for reasons other than harvest access, but may suggest that the CLM produces a less compact road network than historically.

Table 2. Area with susceptibility rating of at least 40% from different retrospective scenarios starting in 1973 and running to 2003. Note that the historic logging scenario does not define a THLB (since it simply replays past harvesting).

Scenario	Susceptibility ≥ 40% total (ha)	Susceptibility ≥ 40% THLB (ha)
No management	143,400 ha	104,200 ha
Historic logging	124,400 ha	N/A
Default management	126,400 ha	89,000 ha
No salvage	127,800 ha	89,800 ha
Susceptibility focus	92,100 ha	58,300 ha
Minimize roads	123,000 ha	85,600 ha

Objective 3

MPB Outbreak and Landscape Change Scenario Planning

This activity is planned for 2007/2008

Contact Information

Project Leader: Don Morgan

Proponent Organization: Research Branch, Ministry of Forests

Mailing Address:PO Box 9519 Stn Prov Govt, Victoria, BC V8W 9C2,
E-Mail Address: Don.Morgan@gov.bc.ca
Telephone: 250-877-1242
Fax: 250-847-6353

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