

**Monitoring and Decision Support for Forest Management in a
Mountain Pine Beetle Environment**

**Terms of Reference
for
Development of a Preliminary Decision Support Tool**

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1. Introduction

Development of the original Project design was based on a needs assessment undertaken in 2006 and 2007. The results of the assessment were incorporated in the FRIAA Proposal document¹ and The Forestry Corp (TFC) proposal for technical support services,² both of which were accepted for funding during the first phase of the Project. Needs for a preliminary decision support system were clarified and elaborated at a workshop held in Hinton June 26, 2009.³

Consistent with the original proposals, the development of a decision support tool will involve initial projection of baseline stand conditions under a range of mortality, secondary structure and regeneration scenarios. This will be followed by a synthesis of the projections and other expert knowledge to produce a decision support tool suitable for planners scheduling harvests and silvicultural operations in forests under MPB attack. The work will be undertaken by a qualified consultant (“the Contractor”), with inputs provided from other identified experts and sources.

2. Objectives

2.1. Original Project Proposal - October 2007

The pre-proposal assessment identified the need for answers to the following questions:

1. Killed wood

- What is the shelf life and fall-down rate of killed wood?
- What factors affect shelf life, and how? E.g. how does shelf life vary by ecological and inventory type?
- What are the risks of fire and other events that might preclude salvage and cover retention?
- How long can stands be retained for salvage without compromising the feasibility of adequate regeneration?

2. Secondary structure

- What will be the composition of residual stands left after MPB attack?
- How much and what type of secondary structure (seedlings, saplings, sub-canopy and canopy trees that will survive a beetle attack) already exists in pure and mixed pine stands?
- How does it vary by ecological and inventory types?
- How will it perform (in terms of survival, release and growth after pine is killed) and what factors will affect or jeopardize its performance?
- What stand types need to be exempted from salvage to conserve secondary structure?

3. New regeneration

- What will be the future composition and growth of residual stands?
- To what extent will the response of vegetative competition and other factors to canopy mortality influence or compromise tree regeneration?
- How and what management interventions can be used to alter the future development pathways in regeneration of affected stands?

¹ FRIAA-07-08 Provincial Projects Initiative. *Monitoring and Decision Support for Forest Management in a Mountain Pine Beetle Environment*. Proposal prepared by the: Foothills Growth and Yield Association. October 9, 2007.

² The Forestry Corp. *Proposal to Support Implementation of FRIAA MPB Project - Forest Management in a Mountain Pine Beetle Environment*. February 6, 2008.

³ Foothills Research Institute - Foothills Growth and Yield Association. *Report of MPB-Silviculture Decision Tools Workshop*, held June 26, 2009, Hinton Training Centre, Hinton, Alberta.

The intent is to incorporate answers to the above questions into a decision support tool that will assist managers to make quick and rationale decisions in a complex and fast-changing situation. The proposal envisages the tool integrating:

- Analysis of the baseline and monitoring data assembled by the Project;
- Projections by simulation models such as TASS, GYPSY and / or MGM;
- Expert knowledge of collaborating researchers, managers and decision-makers;
- Graphic displays, tabular reporting, visualization techniques etc.;

to forecast the stand development, growth and yield following various levels of MPB attack over a range of site and treatment conditions including:

- The 8 ecological strata recognized in the Project design;
- Prevalent ranges of primary and secondary stand structures observed in these strata;
- Salvage and retention of primary structure;
- Alternative site preparation, planting, species selection, and tending prescriptions.

The proposal states that the decision support tool will consist of an information report summarizing projections and guidelines for a selected range of stand conditions and treatment alternatives, and a user-friendly computer program providing projections and guidelines in response to an interactive search. It was intended that the tool should include:

- Quantitative stand-level projections for predominant post-attack conditions and management intervention alternatives, that planners can incorporate quickly into landscape-level and timber supply forecasts;
- Silvicultural guidelines for mitigating negative impacts on mid and long-term timber and cover supply.
- Feed-back from ongoing monitoring to continually improve initial projections and guidelines.

The scope of the Project is limited to providing the information required to support rational silvicultural strategies aimed at mitigating the impacts of MPB outbreaks. It is intended to provide a stand-level projection capability, which will provide inputs to, and will not obviate the need for, forest-level analyses and decision-support systems. It does not include detection, susceptibility reduction, spread control and suppression requirements already addressed by the Alberta provincial MPB Management Strategy and related industrial detection and control initiatives. It will, however, provide useful information for prioritizing the timing and locations of salvage operations and silvicultural interventions made during and after such operations.

2.2. Clarification and Elaboration of Objectives - June 2009 Workshop

During the workshop it became clear that the objectives of Alberta government and industry were very closely aligned. The main decisions that have to be supported are: salvage or no salvage, whether other silvicultural interventions are needed, and whether there is potential for interventions to stimulate succession. The fundamental information required for these decisions are forecasts of what will happen to attacked stands with or without salvage and / or other silvicultural treatments, and of what will be the effects on timber production and wildlife habitat (particularly for caribou). These information requirements will be met by the application of available models and knowledge to (the extent currently possible) quantify, validate and expand the forecasts of post-MPB stand dynamics made by the Government's 2007 Expert Panel on Lodgepole Pine Stand Dynamics.

Subsidiary and related questions are:

- How should harvests be sequenced to best meet management objectives for both MPB and caribou?
- Which stands should be salvaged immediately, versus salvaged on a lower priority or left?

- What would be appropriate interventions to get attacked stands which cannot be salvaged back into production?
- How will trees and respond in stands where there's no salvage?
- What is the importance of other species in the timber supply?
- What understorey structures and compositions are worth saving?
- Where should salvaging pine be avoided because of the understorey?
- How will non-pine understorey species change after attack – will they release or not?
- What are the risks from other pests, particularly in view of climate change?
- What else can companies be doing today to prepare for management after beetle attack, and what silviculture practices can be changed to better “beetle proof” the forest in future?

Outputs from the decision support tool should be linkable to mapping systems, but the tool itself will not need to be spatial. FGYA members require a forecasting tool that can support their own analyses and planning / decision systems; they do not require or wish the tool to prescribe decisions or (at least initially) guidelines.

2.3. Summary of Objectives

The objective of the Preliminary Decision Support Tool assignment will be to project stand conditions under a range of mortality, secondary structure and regeneration scenarios for each stratum (see Table 1) characterized from the baseline PSP data, using MGM, GYPSY (and if possible TIPSY or TASS). The results will be interpreted and synthesized into a tool which FMA holders can apply to projecting scenarios at landscape levels.

Table 1. Site Stratification

Ecosite (and Edatopic) Type	Ecosites ⁴	NSR ⁵	Stratum #
1. Bearberry / lichen / hairy wild rye (submesic / subxeric, medium – low)	b, c (b)	any	1
2. Labrador tea – mesic (mesic – poor)	d (c)	UF	2
		LF	3
3. Billberry / cranberry / sarsaparilla / rhododendron (mesic / medium)	e (d)	SA/UF	4
		LF	5
4. Honeysuckle / fern (subhygric – rich)	f (e)	UF	6
		LF	7
5. Labrador tea – hygric (hygric – poor)	h (f)	any	8

3. Projections

Projections of stand development will be made under a range of mortality, secondary structure and regeneration assumptions for each stratum characterized from the baseline PSP data. The simulations will be run from time of MPB attack to predicted maturity of post-attack regeneration. The components of stand development to be represented in the simulations are described below.

⁴ Ecosites as classified by *Field guide to ecosites of west-central Alberta*, J.D. Beckinham, I.G.W. Corns and J.H. Archibald, Can. For. Serv. Special Report 9, 1996. Equivalent classifications for southwestern Alberta are shown in brackets (*Field guide to ecosites of southwestern Alberta*, J.D. Beckingham, G.D. Klappstein, and I.G.W. Corns, Can. For. Serv.)

⁵ Natural sub-regions (NSR): UF = Upper Foothills, LF = Lower Foothills, SA = Sub-alpine

3.1. Existing Stand Structure

The latest mensurational data from 149 PSP's, together with supplementary baseline data collected in 2008, will be used to characterize average and ranges of pre-attack stand conditions for the 8 strata. Summarization and representation of the data will be as required for providing input to GYPSY, MGM and TASS, and for expert assessment of non-tree vegetation. Simulations may be made on individual plots, and the results aggregated, or the simulations may be performed on aggregated input data. The minimum representation for simulation will be average site and stand conditions for each stratum, with and without understorey presence.

3.2. MPB-induced Mortality

No forecasting of tree mortality from susceptibility, climate, site and other risk factors will be attempted at this time. Instead, projections will be made for each stratum at 3 levels of pine kill (mild, moderate, severe) to be set in consultation with the Project Technical Committee.

3.3. Operational Intervention

Scenarios will be developed to represent the following interventions:

1. No salvage or other treatment (for all strata / residual structure combinations);
2. Salvage followed by limited interventions to encourage natural regeneration and / or retention of secondary structure (for selected strata / understorey combinations);
3. Salvage followed by site preparation, planting and vegetation control (for selected strata).

Strata / stand structure combinations to be simulated will be selected in consultation with the Project Technical Committee. The bases for assumptions to be used in the various scenarios are outlined below.

3.4. Shelf-life and Fall-down of Killed Timber

No analysis of Project or other Alberta data will be required at this time. However, preliminary projections will be made for changes in wood quality and fall rates to at least 10 years after attack, based on interpretation or direct application of published results from B.C. The projected variables will include:

- Fall-down rate;
- Moisture content;
- Specific gravity;
- Blue-stain fungi;
- Checking, saprot and woodborer damage.

Reference to the latest CFS working papers of Lewis, Magnussen *et al* is recommended for this purpose⁶, though identification and inclusion of information from other sources are also encouraged.

3.5. Seed Supply, Germination and Survival of Post-attack Regeneration

Regeneration following attack will be predicted from different information sources depending on intervention scenario. Estimates of regeneration ingress and survival following salvage, site preparation, planting and vegetation control (i.e. intervention scenarios #2 and #3 in Section 3.3 above) will be based on FGYA research into conventional post-harvest treatments, and will be provided for each of the 8 strata by the FGYA Research and Development Associate.

Timing and extent of natural regeneration under intervention scenario #1 (no salvage or treatment) will be estimated based on the opinions of the Contractor, Project Technical Committee and other experts, drawing in particular on the following information sources which will be provided to the Contractor:

⁶ Kathy Lewis and Doug Thompson. *Change in wood quality and fall rate of trees up to ten years after death from mountain pine beetle*. CFS Pacific Forestry Centre MPB Working Paper 2008-30.

Steen Magnussen and Dave Harrison. *Assessing the shelf life attributes of mountain pine beetle-killed trees*. CFS Pacific Forestry Centre MPB Working Paper 2008-27.

- Vic Leiffers *et al* (University of Alberta): seed release after MPB outbreak (results presented at June 26, 2009 Project workshop);
- Dave Coates *et al* (B.C. Forest Service): studies of recruitment following MPB attack in B.C.⁷;
- Rene Alfaro *et al* (Canadian Forest Service): stand reconstructions of overstorey establishment.⁸

3.6. Growth Response of the Residual Stand and Post-attack Regeneration

The growth and mortality of residual overstorey and understorey trees, including saplings and seedlings, and the growth of new regeneration, will be predicted with the latest available versions of GYPSY, MGM and TASS for up to 100 years after attack. MPB attacks subsequent to the first need not be explicitly simulated at this time (but expert opinions and data on the risks and probability of subsequent attack will be sought for inclusion in the decision-support system).

In the absence of specific and validated routines within the models for simulating post-attack scenarios:

- Even-aged stand development following full salvage will be projected using the same approach currently applied to post-harvest regeneration;
- Overstorey development under the non-salvage scenarios will be projected with the pine kill by MPB simulated as a thinning;
- Understorey development and growth of post-attack regeneration will be projected taking into account the expected timing and extent of overstorey foliage loss, and assumptions for regeneration developed as per the previous section.

The results will be compared between models by the Contractor and reviewed by the Project Management Committee. Where differences occur, expert opinion will be used to select the “most likely” trajectory. Results will also be compared with disturbance histories re-constructed with dendro-chronological data from a sub-set of the stands sampled by the Project.⁸ (These re-constructions include overstorey release following disturbance, and establishment of advance regeneration.)

3.7. Non-tree Vegetation Responses

The Contractor will consult with Dr. Ellen MacDonald on projection of non-tree vegetation that has been identified in the supplementary baseline measurements.

4. Synthesis

The synthesis will be limited at this time to consolidation of the matrix of projection results into an interactive stand-level predictive tool. The tool must:

- Provide quantitative stand-level projections for predominant post-attack conditions, with and without salvage;
- Display the projections with tables and graphs of the stand development components identified in Section 3 above;
- Link to conventional inventory and ecological map data as required for aggregate timber and habitat supply forecasting at the landscape level;
- Provide direct answers, or allow users to explore answers, to most or all of the questions identified in Section 2 above, recognizing that such answers usually will be preliminary, non-validated, and limited by the extent of available data and knowledge;

⁷ Astrup, R., D. Coates and E. Hall. 2008. *Recruitment limitations in forests: lessons from an unprecedented mountain pine beetle epidemic*. Forest Ecology and Management 256: 1743-1750.

D. Coates. 2009. Evaluation of stand dynamics after a 25-30 year old MPB attack in the Flathead Region of south eastern British Columbia. FIA-FSP Project Number: M085196. Final Technical Report

⁸ R.Alfaro, J. Axelson and B .Hawkes. 2009. *The dendroecology and stand dynamics of a selection of permanent sample plots, Alberta*. Preliminary project report.

- Facilitate sensitivity analyses and identification of critical weaknesses in the prediction system and inputs;
- Incorporate provision for validation, adjustment and continual improvement of predictions from ongoing monitoring of actual results.

The synthesis as developed by the Contractor will not include management interpretations e.g. interim silvicultural guidelines for mitigating negative impacts on mid and long-term supply. Such guidelines will be developed later by FGYA members and other users of the tool, and may be incorporated into subsequent versions. The Contractor will provide the tool in the form of a user-friendly computer program (preferably Excel / Visual Basic) compatible with all FGYA members' operating systems, plus an information report describing its development and providing instructions for its use. Source code will become the property of the FRI and FGYA.