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

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1. Project Overview

1.1. Initiative and Title

This proposal "Monitoring and Decision Support for Forest Management in a Mountain Pine Beetle Environment"[1] is submitted for funding support under the FRIAA-07-08 Provincial Projects Initiative.

1.2. Applicant

The Applicant is the Foothills Growth and Yield Association (FGYA), a research partnership of 9 FRIAA members managed on their behalf by the Foothills Model Forest. The Director of the FGYA is R. W. Udell, and the Research and Development Associate and Scientific Authority for this Proposal is Dr. W. R. Dempster.

The Applicant will be represented with respect to this proposal by:

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1.3. Background Information on the Applicant and Partners

The **Foothills Growth and Yield Association** represents a unique and innovative approach to project implementation and to promoting the enhanced management of the forest resources of Alberta. Its mission and mandate are to continually improve the assessment of lodgepole pine growth and yield in managed stands by:

- Forecasting and monitoring responses to silvicultural treatments;
- Facilitating the scientific development and validation of yield forecasts used by members in managing their tenures;
- Promoting knowledge, shared responsibility and cost-effective cooperation.

Nine companies holding Forest Management Agreements throughout the natural range of lodgepole pine in Alberta (see Figure 1) cooperate in the Association as voting members and sponsors (see Table 1). The Forest Management Branch of Alberta Sustainable Resource Development (SRD) and the Foothills Model Forest (FMF) participate as non-voting members, with the FMF acting as the coordinating agency. The Association and its projects are governed by a Memorandum of Agreement (MOA) among the members, and a Steering Committee consisting of the contact persons listed in Table 1. Member agencies provide qualified technical representatives to assist in the development, implementation and application of projects.

The FGYA, like the Foothills Model Forest, is focused on the development of information and tools that assist member companies, and others, in improving their knowledge of growth and

[1] Letters of support may refer to "regeneration" versus "forest" management. Such letters refer to the same proposal. The final project name was adopted late in proposal development. It does not reflect a change in scope, but was considered to better reflect the relevance of the proposed work.

yield and the factors that influence them. This in turn supports improved silvicultural practice, timber supply forecasting and management planning. The Association has an established track record in the development of monitoring networks for providing decision support to the management of lodgepole pine. These include:

- *Lodgepole pine regeneration* - major network of 408 regeneration monitoring plots established on a controlled experimental design over a range of ecosites and vegetation management treatments; establishment report and initial yield projections published; results to 5 years currently being used to develop regeneration models;
- *Comparison of pre-harvest and post-harvest stand development* - results from paired-plot study published, reported in major international conference, and applied in yield projections;
- *Historic research trials* - ongoing collaborative project with SRD and the Canadian Forest Service (CFS); results to date published; acquired data being used in testing growth and yield models;
- *Enhanced management of lodgepole pine* - network of 48 research sites established to monitor responses to density management and fertilization.

Table 1. Members of the Foothills Growth and Yield Association

Agency	Contact (Steering Committee)		Technical Representative	
Alberta Newsprint Company	G. Branton	(780) 778 7012	J. Kennedy	(780) 778 7920
Blue Ridge Lumber	M. Summers	(780) 648 6325	C. Scott	(780) 648 6200
Canfor	D. Weeks	(780) 538 7745	J. Ashley	(780) 538 7793
Foothills Model Forest	M. Summers	(780) 648 6325	D. Mucha	(780) 865 8290
Government of Alberta	D. Sklar	(780) 422 4590	D. Price	(780) 422 0329
Hinton Wood Products	R. Briand	(780) 865 8181	G. Buckmaster	(780) 490 2307
Millar Western Forest Products	T. McCready	(780) 778 2221	T. McCready	(780) 778 2221
Spray Lake Sawmills	E. Kulcsar	(403) 932 2234	E. Kulcsar	(403) 932 2234
Sundance Forest Industries	J. Huey	(780) 723 3977	P. Golec	(780) 723 3977
Sundre Forest Products	R. Held	(403) 638 4482	R. Held	(403) 638 4482
Weyerhaeuser Canada	G. Behuniak	(780) 539 8207	G. Behuniak	(780) 539 8207

The **Foothills Model Forest** (FMF) will provide funding and administrative support for the Project under its Mountain Pine Beetle Fire Ecology Program (MPBFEB). The FMF is a non-profit corporation that has been conducting applied research in sustainable forest management since 1992. The organization is dedicated to the development of science, tools and information that will improve the knowledge and practice of forest management within Alberta and beyond. The model forest has over 100 partners and has a demonstrated ability to develop and support information and practical tools that provide high value in advancing sustainable forest management in Alberta and elsewhere.

Alberta Sustainable Resource Development (SRD) is responsible for managing and protecting Alberta's forest resources. SRD is the crown land manager and sets forest management policy for planning and operations. SRD is partnering with the FGYA in this project as it addresses key forest management issues identified by the department. SRD resources relevant to this project include:

- Crown Permanent Sample Plot (PSP) network which will contribute to the monitoring network described in this proposal.
- Draft report produced by department staff, "*Dynamics of Alberta's Pine Dominated Ecosites Following Mountain Pine Beetle"* which identified the need for this project and which will aid in project design.

- Mountain pine beetle susceptibility mapping and the "*Mountain Pine Beetle Priority Decision Support System*".
- Scientific policy expertise in ecology (John Stadt) and silviculture (Ken Greenway).
- The provincial growth and yield projection system (GYPSY).

The **Pacific Forestry Centre of the Canadian Forest Service** (CFS), Victoria, BC, will participate in the project under a collaborative research agreement. The Centre will provide specialist expertise in stand dynamics and dendrochronology which will greatly strengthen the baseline assessment of MPB attacked stands and the forecasting of future stand development. The team will draw on a wealth of research and modeling capability acquired in B.C. and elsewhere.

Dr. Ellen Macdonald is a professor of forest ecology at the University of Alberta, with interests in forest regeneration, stand dynamics, and responses of understorey plant communities to disturbance. She has agreed to participate in the project in an advisory and analytical capacity. Her work on understorey plant communities and their influence on forest regeneration will be invaluable in the development of forecasting and decision support tools for managing stands attacked by MPB.

1.4. Site Selection

Lodgepole pine extends throughout much of western Alberta, and is most predominant in the Foothills and Sub-alpine natural sub-regions of the province. The Project is designed to cover the majority of the natural range of Lodgepole pine in Alberta (see Figure 1).

1.5. Potential Application of Results

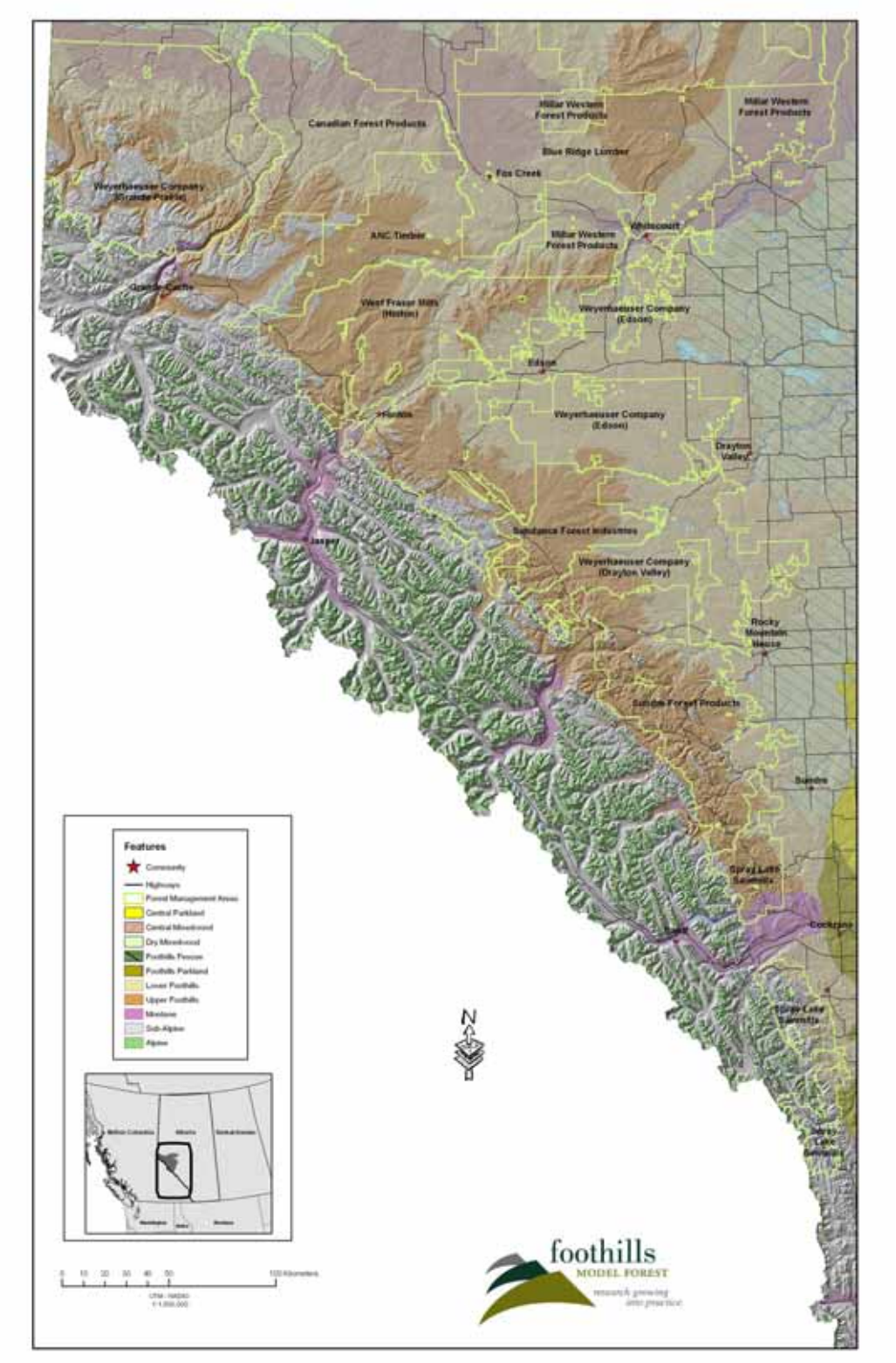
This project includes a number of activities that will culminate in a computerized and documentary decision support tool to assist forest managers assess treatment options and their implications for stand development, growth and yield of pure and mixed-species lodgepole pine stands attacked by mountain pine beetle. Such a tool is urgently needed by Alberta forest managers confronted with the challenge of mitigating the impacts of MPB outbreaks on future timber supply and on other resources affected by loss of forest cover (e.g. wildlife habitat and water). The potential applications are further described in Section 2.

1.6. Relevant References and Reference Information

The FGYA and SRD have assembled a strong justification for the project and its design.

In 2006 and 2007 the FGYA steering committee and technical representatives identified and elaborated the need for a new initiative to examine the MPB problem in relation to regeneration silviculture, and develop information and management tools to assist members, as well as others in ameliorating the impacts of MPB on allowable cuts and maintenance of operations. (FGYA 2007, *Business and Work Plan*). Funds were provided for the initial field visits and scoping of the project. Industry members of the Association, along with guests from SRD and other agencies toured MPB-infested sites in the Prince George Area in July 2008. Hosts from the BC Ministry of Forests were generous in helping with tour arrangements and sharing their insights and recommendations. Following the tour, the Association developed a report and recommendations for appropriate follow-up and research into the issue: *Tour of Mountain Pine Beetle Affected Areas in the Prince George Forest District July 11 and 12, 2007Draft Report and Recommendations* (www.fmf.ca/pa_FGYA.html). The report provided the initial context for development of this proposal.

Figure 1. Map of Project Area



During the same period SRD convened a panel of leading ecologists from BC and Alberta to outline expectations of what successional trajectories will be followed by each pine dominated ecosite following beetle disturbance in Alberta. A key recommendation of their report was that the hypotheses made by the panel should be validated by a specially created network of PSPs in which a broad range of ecosystem attributes are measured (SRD draft report, 2007, *Dynamics of Alberta's Pine Dominated Ecosites Following Mountain Pine Beetle*, ed. J. Stadt). The proposed project addresses this recommendation and will utilize the report in prioritizing sampling effort.

The project team and partners collectively have also assembled a strong basis for the design, methodology, and implementation of the project.

The FGYA membership, together with provincial and federal governments, has well-established systems for monitoring the growth and yield of lodgepole pine timber in Alberta[2]. SRD has developed detailed protocols for the measurement of PSP's, including assessment of juvenile stand dynamics[3].

SRD utilized these PSP data to develop a provincial growth and yield projection system[4]. The initial system had a strong emphasis on lodgepole pine, and has recently been expanded to all species and species mixtures. These and other models developed in Alberta (MGM) and B.C. (TADAM, TIPSY, TASS and / or SORTIE) will provide the basis for initial projections of stand development following MPB attack.

The FGYA has undertaken studies of the post-harvest development of lodgepole pine regeneration[5], and is in the process of compiling a regeneration establishment model using data from the first 5 years results of its large regenerated lodgepole pine trial.[6]

The conditions created by MPB attack require that conventional growth and yield tools be supplemented with a strong knowledge of understorey vegetation community dynamics and their impacts on forest regeneration and secondary structure. The work of Dr. Ellen Macdonald at the University of Alberta will be invaluable in this regard.[7]

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[2] Bott, Murphy and Udell, 2003, *Learning from the forest.* Fifth House Publishers. 91-95

[3] Forest Management Branch, SRD, 2005, *Stand Dynamics System Field Re-measurement Manual*

[4] Huang, S., Morgan, D.J., Klappstein, G., Heidt, J., Yang, Y., and Greidanus, G. 2001. *A growth and yield projection system (GYPSY) for natural and regenerated lodgepole pine stands in Alberta*. Alberta Sustainable Resource Development Tech. Rep. Pub. No. T/485, Edmonton, Alberta.

[5] Dempster, W.R. and S. Huang, 2004, *Enhanced Fibre Production and Management of Lodgepole Pine*, paper presented at the Joint CIF/SAF AGM and convention, October 2-6, 2004, Edmonton;

[6] Dempster, W.R. and R. McPherson *Lodgepole Pine Regeneration Project Establishment Report*, April 2003 (www.fmf.ca/pa_FGYA.html)

[7] Macdonald, S.E. and T.E. Fenniak. 2007. *Understory plant communities of boreal mixedwood forests in western Canada: natural patterns and response to variable-retention harvesting.* Forest Ecology and Management 242: 34-48.

Macdonald S. E. 2007. *Effects of partial post-fire salvage harvesting on vegetation communities in the boreal mixedwood forest region of northeastern Alberta*, Canada. Forest Ecology and Management 239: 21-31.

Peters, V.S., S.E. Macdonald, and M.R.T. Dale. 2006. *The importance of initial versus delayed regeneration of white spruce in boreal mixedwood succession.* Canadian Journal of Forest Research 36: 1597-1609.

A large amount of information and knowledge on the dynamics of MPB in relation to forest stand development has been acquired in B.C. and elsewhere. In 2006, project collaborator Dr Rene Alfaro was awarded the 2006 Canadian Forest Service Merit Award in recognition of his contribution to a synthesis of this work.[8] Dr. Alfero and his team bring a wealth of knowledge and expertise to the project, including dendrochronological approaches that will be used to assist in characterizing and predicting stand dynamics in an MPB environment.[9]

2. Proposal Objectives

This section describes what forest resources and what aspects of forest resource management the proposed project will help to improve and how the proposed project will do so.

Lodgepole pine forests are a major contributor to Alberta's forest industry, provide important habitat to a diverse range of species including caribou and grizzly bear, and play a key role in the hydrological functioning of vital watersheds along the eastern slopes of the Rocky Mountains. Although the mountain pine beetle (MPB) has long been a factor in the dynamics of western Canadian forests, the extent of the current outbreak in British Columbia is unprecedented, and has exceeded all expectations in terms of the range of age classes destroyed (see Figure 2). Most or all of the factors that led to the B.C. outbreak are increasingly prevalent in Alberta, and major incursions have occurred in the last 2 years. The area covered by the Foothills Model Forest, the forest tenures of the FGYA members (see Figure 1), and the SRD managed Forest Management Units includes the main concentrations of lodgepole pine, and the majority of its natural range, in Alberta. The entire lodgepole pine resource within this area is now considered at risk of MPB infestation and provides significant challenges for Alberta's forest managers. These challenges include:

- *Regenerating stands in the unique environments created following beetle disturbance.* A wide diversity of understorey vegetation responses following beetle disturbance will require managers to utilize a variety of regeneration strategies.
- *Designing salvage harvest operations that consider regeneration and mid-term timber supply factors.* The BC experience has shown that both factors can be compromised by inappropriately designed salvage strategies.
- *Forest management planning to create a desired future forest in the absence of an understanding of the successional trajectories followed by post-beetle disturbed stands.* This lack of understanding compromises the ability to plan for a wide range of forest values and risks, including timber supply, wildlife habitat, hydrological functioning, and fire risk.

The objective of the proposed project is to provide a decision-support tool to assist forest managers in mitigating the impact of mountain pine beetle disturbance on forest resources such as timber, wildlife habitat, and water. Managers urgently require such a tool in order to assess treatment options and their implications for stand development and growth and yield of pure and mixed-species lodgepole pine stands attacked by mountain pine beetle. The tool will integrate the

[8] Safranik, L. and B. Wilson (eds.), 2006, *The mountain pine beetle. A synthesis of biology, management and impacts on lodgepole pine.* Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Canada. 304.

[9] Campbell, Elizabeth M, René I. Alfaro and Brad Hawkes. *Spatial distribution of mountain pine beetle outbreaks in relation to climate and stand characteristics: a dendroecological analysis*. Journal of Integrative Plant Biology 49(2):168-178.

collection and management of baseline and monitoring data with simulation models, graphic displays, tabular reporting capabilities and expert knowledge to assist managers in selecting rational options that are likely to best meet their objectives. It is an essential prerequisite to operational interventions aimed at mitigating the forest management problem posed by MPB.

Figure 2. Red attack in 24 year old B.C. lodgepole pine stand

The forest management problem in pure and mixed pine forests attacked by MPB will boil down to orchestrating the supply of forest cover and wood from three sources:

1. In the *short term* industry must be maintained by killed wood harvested from the old forest.
2. The part of the forest that is currently classed as secondary structure (seedlings, saplings, sub-canopy and canopy trees that will survive a beetle attack) must be conserved and developed to the maximum extent possible to maintain a source of forest cover and timber supply during the *mid term*.
3. The third *long term* source of cover and timber will be the new forest created by natural regeneration and silvicultural effort following attack or harvest of the old forest.

Managing the timing of availability of supplies from these three sources will be crucial to the state of the forest and survival of the forest industry in Alberta. Managers will need to be able to assess:

1. For how long will killed wood provide cover or be salvageable, how does this vary by ecotype and how can this information be used to prioritize salvage scheduling, thereby maximizing total volume recovery?
2. When and how much wood and forest cover will be supplied from surviving trees, existing natural regeneration and non-pine species?
3. When will wood and cover from the new regeneration be available?

Answers to the above questions will depend on answers to the following more complex series of subsidiary 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?

The project will provide initial answers to the above questions and consolidate them into a decision support tool that will assist managers to make quick and rationale decisions in a complex and fast-changing situation. The tool will 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 this project is limited to providing the information required to support rational silvicultural strategies aimed at mitigating the impacts of MPB outbreaks. It will not address organizational and policy issues. 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 guidance for prioritizing the timing and locations of salvage operations, as well as special measures to be taken during and after such operations.

The objectives and associated tasks identified for funding under this proposal are of vital importance to the FGYA and all Albertans, but are not the responsibilities of the member companies of the FGYA under legislation, regulation, forest tenure, policy, specific agreement, or generally accepted practice.

3. Project Information

3.1. Project Objectives in Relation to FRIP Program Objectives

This section expands on the proposed project's objectives in relation to FRIP program objectives.

The project will support all 4 of the FRIP programs key objectives:

1. Enhancing the forest resources of Alberta.
A decision support tool that minimizes the impact of MPB on stand development and succession is critically needed and, at present, lacking in Alberta. Mitigating the medium and long-term effects of pending outbreaks in Alberta on the state of the forest and timber supplies is of paramount importance to all Albertans.

2. Promoting the enhanced management of the forest resources of Alberta.
Appropriate and prioritized management of MPB-infested or susceptible stands is likely to be the highest priority for enhanced forest management for many years to come. By providing a much-needed basis for selecting mitigation measures, applicable to all forest users, the project will promote enhanced forest management. Perversely, this "enhancement" in the case of MPB means minimizing the negative AAC downfall arising from the infestation through measures that prolong the salvage of existing stands while maximizing the growth potential of secondary structure and other species.

3. Improving the sustained yield of the forest resources of Alberta.
Appropriate management of the lodgepole pine as well as secondary structure and other species associated with Lodgepole pine stands will be critical in minimizing the impacts of MPB. For example, salvage that targets dead stands with long shelf life while bypassing those with shorter shelf life and salvage that destroys secondary structure and takes other species that could survive and provide mid-term timber supply are two examples of inappropriate management strategies that could be avoided given the information and tools envisaged in this Proposal.

4. Promoting integrated resource management.
As demonstrated in B.C. the effects of MPB outbreaks are ecologically, economically and visually traumatic. Uninformed and inappropriate treatment of these outbreaks can exacerbate and prolong these negative impacts, and this Project suggests the development of tools to minimize these impacts while promoting integrated resource management. Further, information gathered in the course of this project, particularly information on vegetation responses to MPB-caused pine mortality, will be of high value in evaluating and mitigating the impact of MPB on habitat, including that of species at risk.

The project meets all proposal criteria and additional criteria as set out in the Call for Project Proposals. In addition, it will be noted that the proposed project:

- Provides benefits of broadly based relevance to Albertans;
- Will greatly benefit the management of forest resources in Alberta;
- Is operationally orientated and will provide an urgently required basis for selecting the most beneficial field practices;
- Involves multi-disciplinary partnerships involving a variety of skills;
- Leverages FRIAA funding with other sources of funding and in-kind contributions;
- Is actively supported by 9 FRIAA members, the Forest Management Branch of the government of Alberta, and the Foothills Model Forest MPB Fire Ecology Program.

3.2. Methods

This section describes the technical methods to be applied. Further details on the scheduling of activities are given in Section 3.7.

The following is an aggressive four-pronged and multi- agency approach to achieving the project objectives (and answering the associated questions identified in Section 2):

1. *Baseline assessment* of susceptible stand types;
2. *Projection* of growth performance of secondary structure and post-attack regeneration, as well as degrade rates in damaged standing timber;
3. *Monitoring* of stand development over a range of sites subjected to MPB attack;
4. *Synthesis* of answers into a decision support tool.

The choice of what data to collect, project, monitor and synthesize into a decision support tool must necessarily be highly prioritized. We have used the following question as the essential basis for guiding this choice: is the information likely to be necessary to support prudent selection of a mitigating forest management intervention following MPB attack? Where the answer is negative, no project resources have been scheduled for collecting the information, however scientifically interesting it might be.

3.2.1. *Baseline Assessment*

The FGYA industry membership and SRD collectively own over 4,000 permanent sample plots in pine-leading, predominantly fire-origin stands. Most of these plots have repeat measurements, some going back more than 40 years. (The availability of retrospective information on stand development greatly assists the projection of future development using growth models.) It is proposed that a sub-sample of these plots within susceptible and at-risk pure and mixed pine stands, representing the most important combinations of primary (pine) and secondary structures across a geographic range of prevalent ecosites, be selected as a basis for baseline assessment and ongoing monitoring. Selection will be assisted by SRD's MPB risk ranking system based on available biological, climate and connectivity data. Installation of some new plots may be necessary to obtain the most effective sampling design for both baseline assessment and subsequent monitoring.

Mensurational data from these plots, will be used to characterize and quantify pre-attack levels of both primary and secondary structure. The assessments will be based on existing data collected and contributed by FGYA members supplemented by additional measurements, and will include ecological site classification, soil conditions, fuels, and ground vegetation in addition to detailed stand and tree information. The latter would include measures of tree health, wood quality, small advanced regeneration, and cone opening / seed viability as well as conventional species, bole, age and crown information. Repeat measurement series will be supported by dendrochronological examinations of a further sub-sample (5-10%) of the selected 240 plots in order to better reconstruct the origin and development histories of stands, especially those with secondary or complex structures. Destructive sampling in buffers or replicated plots will be necessary for this purpose.

The following strategy will be applied to selecting and scheduling plots for baseline assessment:

1. An "ideal" target sample of 240 PSPs will be identified within 8 ecological strata, distributed among FMA's proportional to pine-leading areas, throughout the entire FGYA area. The plots will also be proportionally selected to represent the range of species composition and secondary structure within each stratum, as indicated by pre-

compilations of existing PSP data. This idealized target sample may be adjusted to ensure that the selected plots are located in areas identified as having a high risk of imminent attack. The target sample may include plots attacked from 2006 onwards (Category A), as well as high-risk plots with no known attack (Category B).

2. Consideration will be given for installing new plots in strata that contain less than 30 existing plots, or where the distribution of available PSP's is not well proportioned.
3. All Category A plots, and a sub-set of the category B plots (preferably those that have been recently measured by the FMA holder or SRD), will be scheduled for "baseline" supplementary assessments on receipt of project funding and completion of project design. "Supplementary" assessments will involve site, soil, vegetation and dendrochronological measurements NOT included in the current PSP measurement protocols or data.
4. The remaining category B plots will be scheduled for supplementary measurements during the remainder of the 3-year initial project term. (They will be checked annually, and switched to Category A if and as soon as attack is detected).
5. A "minimum" target sample of 50 Category A plots will be identified, with stratification criteria relaxed if necessary, for baseline assessment over the first year of the project. These selections may not meet the ideal sample distribution scheme (i.e. they will depend on where attacks occur), but will ensure that we acquire early data on post-attack stand development. Should less than 50 attacked plots be identified throughout the entire project area within the next year, MPB-induced mortality may be simulated by tree-girdling (and possibly blue-stain inoculation) within a controlled sub-set of sample plots, following baseline assessment.

Table 2 shows the site types of primary relevance to lodgepole pine silviculture that will be used to stratify the "ideal" target sample. The stratification scheme is similar to that used in the FGYA post-harvest regeneration monitoring network. The broad strata cover the predominant range of soil nutrition and moisture regimes occupied by lodgepole pine in Alberta. We expect there to be significant differences in post-attack stand dynamics between these types. The scheme results in 8 strata based on prevalent combinations of ecosite groups and natural sub-regions. Table 3 shows the approximate breakdown of pine-leading forested area contributing to FGYA members' long-term timber supply by Forest Management Area. The percentages in Table 3 will be used as a further aid in distributing plot selections across as wide a geographic range as possible, but the proportional allocation of plots by forest management area will be secondary to the selection of plots at imminent risk of attack in all 8 strata. Not shown in Table 3 are areas of pine-leading stands in Crown management units C5, E8 and R11. These units include significant areas of pine stands, and also contain government PSPs. They will be added to the candidate areas for baseline assessment and monitoring.

3.2.2. *Projection*

Forest managers require information immediately on probable stand development following MPB attack, and cannot wait for projections validated by monitoring outcomes from future outbreaks or research trials. Projections must therefore initially be made using the best currently available information, and continually improved as more information becomes available. Application of available growth models, research results and operational experience from B.C. and elsewhere, and other expert opinion to the baseline assessment will provide the initial basis for predicting stand development following MPB attack.

Table 2. Site Stratification

Ecosite (and Edatopic) Type	Ecosites[10]	NSR[11]	Stratum #
1. Bearberry / lichen / hairy wild rye (submesic / subxeric, medium – low)	b, c	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

Table 3. Pine-leading Areas within FGYA Member's Harvestable Land Base

FGYA Member	Net area (ha)	% of total
Alberta Newsprint Company	106,870	5.2
Blue Ridge Lumber	180,323	8.8
Canadian Forest Products	106,271	5.2
Millar Western Forest Products	112,406	5.5
Spray Lake Sawmills	114,988	5.6
Sundance Forest Products	121,848	6.0
Sundre Forest Products	293,655	14.4
Hinton Wood Products	451,713	22.1
Weyerhaeuser Canada	557,433	27.3
Total	2,045,507	100.0

Prerequisites to projection will be assembly and (to the extent possible) verification of:

- Prevalent stand structures as defined by the baseline assessment and pre-compilations of FGYA members' PSP data;
- Information on the shelf life of killed timber, and associated influences and risks;
- Growth models applicable to predicting the performance of residual secondary structure and post-attack regeneration;
- Knowledge of stand development pathways and how they are likely to be affected by post-attack conditions and management interventions

Models used for projections will include GYPSY, TASS and MGM. TASS and GYPSY have undergone extensive development and validation for lodgepole pine, and development of both has drawn heavily on data from the project area. MGM has been developed with a strong focus on Alberta mixed-wood stands, and therefore may have applicability for projection of secondary

[10] Ecosites as classified by *Field guide to ecosites of west-central Alberta*, J.D. Beckinhham, 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.)

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

structure. The models are currently being tested under separately funded FGYA and other projects. Although TASS has not been formally available for public use, the release of a Windows version is expected in 2008.

3.2.3. *Monitoring*

The information required to verify and improve initial projections will be acquired by monitoring the continued development of permanent sample plots selected for baseline assessment. Funding is being sought for a minimum of one detailed re-measurement of 50 category A (attacked) plots during the third year of the project, in addition to support reconnaissance and status checks of a larger number of plots during years 1 to 3 (see Table 5).

Two (not necessarily mutually exclusive) options for assessing impacts of MPB-induced mortality on stand development were considered:

1. Wait for actual infestation and track changes in plots affected by the outbreak;
2. Simulate MPB-induced mortality by tree-girdling (and possibly blue-stain inoculation) within a controlled sub-set of sample plots.

Unfortunately, the extent of, and spread following, 2006 attacks within the project study area suggest that option 2 may be unnecessary. Alberta PSP's are already infested and (for example) Weyerhaeuser foresters in Grande Prairie expect plots initially infected in 2006, such as that shown in Figure 3, to be at advanced red-stage infestation within 2-3 years. The work plan is therefore primarily designed around option 1. Option 2 will be retained in the event that substantive areas of key strata do not experience attack within the first 1 - 2 years of the project, as described in Section 3.2.1.

Figure 3. Alberta government PSP cluster infested by MPB in 2006

Photo: Weyerhaeuser Company, August 2, 2007

Data collection will include those variables previously measured in the baseline assessment. The condition and response of existing trees, plus regeneration of trees and non-tree vegetation, will be tracked carefully. The ideal re-measurement interval is expected to be usually 2-years for the first few years following attack, but this will be varied based on expert knowledge of site

productivity and dynamics in order to avoid unnecessary sampling in the less dynamic stand types. Some destructive sampling in buffers or replicate plots will be necessary for monitoring degrade. Monitoring will include assessments of:

- Understorey tree and non-tree vegetation response to canopy mortality;
- New regeneration of trees;
- Competitive effects of grass and shrub vegetation on tree regeneration;
- Changes in soil moisture regime;
- Cone opening and seed condition;
- Fall-down rates and ground fuels.

3.2.4. *Synthesis*

The focus of this synthesis will be development of:

- Quantitative stand-level projections for predominant post-attack conditions and management intervention alternatives, that planners can incorporate quickly into aggregate timber supply forecasts;
- Interim silvicultural guidelines for mitigating negative impacts on mid and long-term supply. Such guidelines can subsequently be refined through improved answers to the identified questions (as provided for by ongoing monitoring), and adjusted to reflect local or regional aggregate timber supply situations.

A decision support systems (DSS) approach will be used. DSS are typically computer-based systems for integrating data base management systems with analytical and operational research models, visualization techniques etc. and the expert knowledge of decision makers, to assist in solving specific problems. As DSS are based on formalized knowledge, their application in the decision making process facilitates decisions that as rational as possible in dealing with ill-defined complex situations.

The synthesized product will be referred to as a decision support tool rather than complete DSS, because in actuality it will be applied as a tool and input into the individual decision support systems of users. The tool will integrate:

- Analysis of the baseline and monitoring data;
- Projections by simulation models such as TASS, GYPSY and 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 MPP attack over a range of site and treatment conditions including:

- The strata identified in Section 3.2.1;
- 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 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.

An initial synthesis of assembled information, consisting of a preliminary information report, will be prepared within 18 months of funding and staffing the project. Funding and staffing are sought for 2.5 years (“Phase 1”) to facilitate continual improvement of the required information and decision support tool during that period. During this period, and depending the progress of

infestation, additional funding and staffing may be secured to provide for further development of the decision support in years 3 to 5.

3.3. Scientific Review

During and following the visit to B.C. referenced in Section 1.6, the FGYA received presentations, papers, comments and other inputs from over 12 scientific and management experts. The FGYA acknowledges in particular the contributions of:

- Jeff Burrows, Michael Pelchat, Dave Coates, Craig DeLong, Ken Hodges, Robert Hodgkinson, John Pousette and John Rex of the Ministry of Forests and Range;
- Doug Routledge of the Council of Forest Industries;
- Jodi Axelson, René Alfaro and Brad Hawkes of the Canadian Forest Service;
- Ellen Macdonald of the University of Alberta;
- John Stadt and Ken Greenway of SRD.

The information was incorporated into a tour report which was circulated to the 42 participants and others. The report[12] and feedback received provided the basis for developing and assessing the project methodology.

3.4. Funding Requested and Overall Budget

This urgent project requires immediate ("Phase 1") funding and support from a number of sources. Continued funding ("Phase 2") may be necessary and justified for a longer period of time depending on the scale and persistence of infestation. Table 4 shows the estimated costs for both Phase 1 and Phase 2. The budget is based on the activity schedule shown in Table 5. However, the requirements become uncertain after the third year, because the level of monitoring required during Phase 2 will depend on the level of infestation. The immediate urgency is for the establishment of a monitoring network and decision support capability. This is a major deliverable of this proposal and is achievable within the 2.5 years of Phase 1.

Note in Tables 4 and 5 that "year" refers to the operating period commencing April 1 of the named year and ending March 31 of the following year.

The FGYA is proposing support from the FRIAA Open Funds Provincial Projects Initiative for the period from project approval in 2007 to March 31, 2010 ("Phase 1"). Funding is requested for the following components (bolded in Table 4a):

- Supplementary baseline field measurements to be conducted between 2007 and 2009 at a projected cost of $120,000. These measurements are "supplementary" in that they are additional to and will build on measurements and data provided by industry and government project sponsors.
- Monitoring: this involves checking and re-measurement of plots attacked by MPB, as required to track changes in stands following MPB damage. The type and frequency of measurements required differ from, and are additional to, those associated with conventional growth sampling programs already in place. The level of funding required is estimated at $38,400 during the remainder of 2007 and 2008, increasing to $106,700 in 2009.

[12] Tour of Mountain Pine Beetle Affected Areas in the Prince George Forest District, July 11 and 12, 2007, Report and Recommendations, compiled by W.R. Dempster, Foothills Growth and Yield Association July 28, 2007 (www.fmf.ca/pa_FGYA.html)

- Synthesis of information into a decision support tool. This will require $31,000 during 2008 and 2009.

Thus the total funding requested from the FRIAA Provincial Initiative is therefore $296,100.

Table 4. Budget ($) by phase, year, activity and funding source

(a) Phase 1

Activity by Funding Source	Phase 1			
	2007	2008	2009	Total
Baseline assessment - FMF	13,500	59,800	10,000	83,300
Baseline assessment - FRIAA Open Funds	**45,000**	**45,000**	**30,000**	**120,000**
Projections - FMF	0	37,000	13,000	50,000
Monitoring - FRIAA Open Funds	**19,200**	**19,200**	**106,700**	**145,100**
Synthesis - FRIAA Open Funds	**0**	**21,000**	**10,000**	**31,000**
Technical input and management - FGYA	18,240	18,240	18,240	54,720
Administration - FMF	12,000	12,000	12,000	36,000
Sub-total - FRIAA Open Funds	**64,200**	**85,200**	**146,700**	**296,100**
Sub-total - FGYA	18,240	18,240	18,240	54,720
Sub-total - FMF	25,500	108,800	35,000	169,300
Grand Total - all funding sources	107,940	212,240	199,940	520,120

(b) Phase 2

Activity by Funding Source	Phase 2 (provisional)		
	2010	2011	Total
Projections - FMF	13,000	13,000	26,000
Monitoring - unidentified	69,200	66,700	135,900
Synthesis - unidentified	20,000	48,000	68,000
Technical input and management - FGYA	18,240	18,240	36,480
Administration - FMF	12,000	12,000	24,000
Sub-total - FGYA	18,240	18,240	36,480
Sub-total - Foothills Model Forest (FMF)	25,000	25,000	50,000
Sub-total - unidentified	89,200	114,700	203,900
Grand Total - all funding sources	114,200	139,700	253,900

Table 4 does not include in-kind contributions of individual FGYA members, SRD or the CFS mentioned in Section 3.5 below.

3.5. Other Funding and In-kind Contributions

The Foothills Model Forest, utilizing an SRD grant for its MPB Fire Ecology Program (MPBFEP), will administer the proposed project. It will also financially support components of the baseline assessment and the simulations and projections that will provide early direction to the development of the decision support tool (see Tables 4 and 5). The MBPFEP has committed the requested funding (see Table 4) for fiscal years 2007, 2008 and 2009 (i.e. until March 31, 2010).

Specialists in silviculture, ecology and biometrics from the Forest Management Branch of SRD will contribute their services at no cost to the project. The Canadian Forest Service will contribute a portion of the salaries of 3 specialists (see Section 3.6).

Inputs by the FGYA will be partly supported by FRIP funding under FRIAA Project # FOOMOD-01-03 (*Foothills Growth and Yield Association – Second Five-year Term*) and partly by FGYA industrial sponsors.

The members of the FGYA, collectively representing the majority of the pine-based industry of Alberta, and the Alberta government are already the holders of a huge bank of information on the growth and yield of lodgepole pine. Further, their system of long-established permanent sample plots represents a unique opportunity to link this historic source of information to the immediate and pressing questions associated with the impacts of MPB. The entire resource of over 4000 plots will be used as the basis for this study. Just the 240 plots and associated existing data selected for projection and ongoing monitoring have a cost value of over $1.4 million, incurred by industry and the government of Alberta with non-FRIAA funds. This sum does not include the continued commitment to plot maintenance and standard measurements provided by members under their corporately sponsored growth and yield programs.

It will be noted that for the baseline assessments the project will rely heavily on measurements taken by partners under their own growth and yield programs. The requested funds will pay for supplementing these to provide some additional measures required by the project objectives. In the monitoring stage industry partners will continue to maintain the plots, and re-measure them in future years at their normal interval. For the specific purposes of the project, a shorter re-measurement interval is required for several years following MPB attack. This will be partly addressed by the requested funding, but potential additions may be required depending on the level of infestation.

The cost value of the existing data on the 240 plots is at least $1.4 million. Subject to definition of other MPBFEP projects and approval by the FGYA steering committee, the data would be available for other linked MPBFEP research, e.g. the impacts of MPB on habitat for species at risk such as the woodland caribou and grizzly bear. These datasets give the project an enormous advantage over approaches for addressing or researching MPB mitigation that rely solely on new data.

3.6. Sub-contracts and Collaborative Research Agreements

The bulk of technical services will be provided by qualified Alberta-based forestry consulting firms selected by competitive bid. These services include field data collection and analytical and systems support, at an estimated cost of $204,800 during Phase 1. A number of companies have developed strong capabilities in these areas, with skills ranging from PSP and ecological field data collection to yield analysis using sophisticated computer modeling and projection techniques. The selection process will be competitive and transparent. Terms of reference and work specifications will be designed by the core technical management team (see Section 3.8) and the requesting and selection of proposal will be overseen by the Project Manager who is also the FMF's MPBFEP leader.

Design and analysis of understorey and special vegetation assessments will be assisted by Dr. Ellen Macdonald of the University of Alberta – estimated cost $17,500 during Phase 1 (total cost over 5 years estimated at $31,500).

Specialized dendrochronological investigations will be conducted under a Collaborative Research Agreement with the Pacific Forestry Centre of the Canadian Forest Service (CFS), Victoria, BC. A Memorandum of Understanding will be developed between the FMF and the CFS for this purpose. The investigations will be conducted in 2008 at an estimated cost of $73,800. They will

involve dendrochronological analyses and stand reconstruction of a sub-sample of the sample plots to establish:

- The disturbance history of the stands, i.e., establishes the occurrence, duration and intensity of previous fire and beetle disturbances in the sample stands.
- Dating of fire scars, coarse woody debris and regeneration to establish cycles of regeneration and mortality in the sample stands
- These analyses will also establish growth rates before disturbance periods and will quantify growth releases occurring after canopy thinning by beetle.
- Based on the above CFS will prepare conceptual models of stand dynamics, including mortality and regeneration episodes as well as and growth suppression and release factors for utilization by growth modelers.
- Preparation of a final report detailing stand disturbance history, regeneration, mortality in present and past disturbances and growth rate dynamics

The CFS will contribute a portion of the salaries of one Scientist (René Alfaro), a Fire Research Officer (Brad Hawkes) and a Dendrochronologist (Jodi Axelson)

3.7. Activity Schedule

A project activity schedule is shown in Table 5.

Table 5. Project work schedule by activity and year

Activity Group	Funding Source[13]	Activity	Unit	Phase 1			Phase 2	
				# Units 2007	# Units 2008	# Units 2009	# Units 2010	# Units 2011
Baseline assessment	FMF	PSP pre-compilation	days	20				
	FMF	Supplementary assessment design	days	5				
	FMF	Compilation of existing and supplementary data	days		20			
	FMF	Database, documentation and baseline report	days			20		
	FMF	Dendrochronological sampling	CRA[14]		1			
	FMF	Dendrochronological analysis	CRA		1			
	OF	Baseline supplementary field mensuration	plot	90	90	60		
Projections	FMF	Projections using existing models	days		10	10	10	10
	FMF	Stand dynamics	CRA		1			
	FMF	Other vegetation analysis	days		10	10	10	10
Monitoring	OF	Status checks (reconnaissance support)	plot	48	48	48	(48)	(48)
	OF	Re-measurements of attacked plots - minimum sample	plot			50	(25)	(25)
	OF	Compilation, management and reporting of data	days			25	(25)	(20)
Synthesis	OF	Assessment, report and decision support tool	days		30	20		
		Analysis and decision support tool refinement	days				(40)	(40)
		5-year assessment and information report	days					(40)
Management	FMF	Administration	days	24	24	24	24	24
	FGYA	Technical input and management	days	24	24	24	24	24

[13] FMF = Foothills Model Forest, OF = Open Funds (applies to Phase 1 only)
[14] Collaborative Research Agreement

The schedule includes a projection of activities for a second phase. It should be noted that the schedule, particularly Phase 2 monitoring, is necessarily tentative because it will depend in part on the rate and locations of MPB attacks. Additional levels of monitoring activity may be required depending on the level of MPB attack experienced during Phase 1.

3.8. Project Management

Overall responsibility for project implementation will reside with the Project Manager. The Project Manager will be **Don Podlubny,** RPFT, the MPB Fire Ecology Program Leader of the FMF. In addition to administering this Project, he will also coordinate activities under this Project with those other MPB projects in the Model Forest. Don Podlubny's career has encompassed most of the range of applied forest management in Alberta's forests and he has considerable experience in the management of finances, personnel and projects. Among his more recent assignments he was Director of the Hinton Training Centre, from which position he was seconded to the Foothills Model Forest as General Manager, a position he currently holds. He is currently also the Program Lead of the Mountain Pine Beetle Fire Ecology Program at the Model Forest.

The project management responsibilities include:

- Recruitment and direction of required staff and sub-contracted services, and preparation of a collaborative research agreement with CFS;
- Financial administration of the project;
- Ensuring that work is completed on time and within budget, consistent with a staged activity and delivery schedule;
- Timely reporting of project progress;
- Ensuring that work is coordinated with related initiatives being conducted in Alberta and elsewhere;
- Liaison with the FGYA Steering Committee to ensure that the project remains aligned with priorities of forest managers dealing directly with the MPB infestation;
- Communication and distribution of project results.

The Project and Program Manager will be assisted by the Director of the Foothills Growth and Yield Association. The Director, **R.W. (Bob) Udell,** R.P.F., will work with the Project Manager and the FGYA Research and Development Associate to facilitate achievement of goals and timelines; he will oversee the reports to FRIAA on the Project and provide the linkages between the Project, the Program Manager and the Steering Committee of the FGYA. He is a graduate forester with considerable experience in forest management and forest policy development in Alberta.

The Research and Development Associate of the FGYA, **W.R. (Dick) Dempster**, Ph.D., R.P.F., will be accountable to the Project Manager and FGYA Director for providing technical coordination of all scientific and technical services provided under sub-contract, and for liaison with the technical representatives of the FGYA. He will also provide technical input to the analysis, interpretation and synthesis of results. He will act as secretary and chair to a project Technical Management Committee, consisting of the technical experts, representatives and advisors listed below. Dr. Dempster has a background in forest policy, resource inventory, integrated forest management planning, and growth and yield. His current work and interests are focused on development of decision support tools for the management of forest regeneration following harvesting.

The SRD Forest Management Branch (FMB) will be a project partner and collaborator.[15] The Executive Director of the FMB will assign suitably qualified staff experts in forest ecology (John Stadt), silviculture (Ken Greenway) and biometrics to assist in project activities, particularly but not necessarily limited to:

- Ongoing development and refinement of the project design and monitoring protocols;
- Selection and stratification of plots for baseline assessment and monitoring, including assessments of MPB attack risk;
- Adaptation of existing Crown PSP measurement protocols, and selection and design of supplementary measurement variables;
- Advice and assistance in application of Alberta growth and yield models (e.g. GYPSY) to projecting stand development following MPB damage;
- Interpretation of results;
- Review of deliverables and assessment of their adequacy;
- Design and evaluation of decision support tools.

John Stadt will act as the lead Alberta government technical representative to the project, and will coordinate inputs by other government personnel.

Ellen Macdonald, Ph.D. is a professor of forest ecology with interests in forest regeneration, stand dynamics, and responses of understorey plant communities to disturbance. Her research has involved characterizing how understorey plant communities respond to natural disturbance and to various types of forest harvesting. In turn, she has examined the influence of understorey plants on forest regeneration and successional development. As Forest Ecology Advisor to the project, she will provide input to the design and analysis of understorey and special vegetation assessments.

René Alfaro, Ph.D., Research Scientist, Forest Entomology, will lead the team from the Pacific Forestry Centre, Canadian Forest Service, Victoria, British Columbia. Dr Alfaro cconducts research aimed at quantifying the damage caused by pests to the forests of British Columbia and researches genetic resistance to pests. He has a B.Sc.F., 1974, University of Chile; M.Sc. (Pest Management), 1977, and Ph.D. He will be assisted by Dr. Brad Hawkes, Forest Fire Research Officer, and Jodi Axelson, M.Sc., Forest Biologist and Dendrochronologist, both also from the Pacific Forestry Centre.

3.9. Required Authorizations

Most of the project field work will involve non-destructive field measurements. The limited amount of destructive sampling will be permitted through the FGYA members' FMA dispositions. The project plan will be submitted to the Senior Manager, Forest Operations Section, Forest Management Branch of SRD, for review, endorsement, and coordinated referral to the Local Area Managers. Local Area Managers will be notified of all activities. The member companies will obtain (from the Local Area Managers) authorizations under their Annual Operating Plans for any scheduled activities involving destructive sampling.

3.10. Impact on Other Resources and Users

The Project will not have any adverse impacts on any other forest resources or the environment. The destructive sampling activities will be on a very small scale, widely dispersed, and not conducted within 30m of water bodies.

[15] See letter of October 5, 2007, reference 5235-001, from D. Sklar, Executive Director, FMB, included in submission package.

3.11. Project Deliverables

The following products and reports will be delivered during Phase 1 with support by the FRIAA Provincial Initiative and the FMF.

1. Baseline assessment

- Database for selected plots (compilation of existing data by March 31, 2008; annual updates March 31, 2009 and March 31, 2010)
- Baseline report including basic stand descriptions and reconstructed histories (preliminary assessment March 31, 2008; detailed report March 31, 2009)

2. Projection

- Modeled quantitative projections of stand development following lodgepole pine mortality (September 30, 2009)

3. Monitoring

- Network of monitoring plots and associated database established throughout study region (schedule as per Table 5 with completion by March 31, 2010)
- Status reports (March 31 of 2008, 2009 and 2010)

4. Synthesis

- Preliminary assessment and report (March 31, 2009)
- Decision support tool - information report and computer program (March 31, 2010)

The following additional deliverables (not part of this Project proposal for funding) are scheduled for Phase 2 subject to funding support:

Projections

- Validated projections of stand development under range of post attack conditions (2011)

Monitoring

- Expanded network of monitoring plots established throughout study region (2010, 2011)
- Annual status reports (2010, 2011)

Synthesis

- Refined decision support tool - information report and computer program (2011)

3.12. Availability and Publication of Deliverables

Communication, unfettered information exchange, and feedback will be essential to success of the project. All information and knowledge gained, however preliminary, will need to be quickly synthesized and shared with FGYA members, other forest managers, and for general public use. Meeting this need must be balanced by the provision of rigorous peer review to ensure that the forecasting and decision-support tools produced by the project are scientifically sound. This will be achieved by:

- Interim publication on the FMF website;
- Preparation and submission of results to scientific and professional journals and / or conferences;
- Requiring that information and results from work in any way supported by the project be made immediately available to MPBFEP and FGYA sponsors.

4. Project Schedules

4.1. Progress Reporting Schedule

Expenditures and work progress will be reported on an annual basis, in reports detailing how much money has been spent and how much of the Project has been completed. Progress reports will be submitted as follows:

- March 31, 2008 – financial and work progress report for 2007 operating year;
- March 31, 2009 – financial and work progress report for 2008 operating year;
- March 31, 2010 – preliminary project completion report;
- June 30, 2010 – final consolidated project completion report

Technical reports will be scheduled as indicated in Section 3.11.

4.2. Proposed Payment Schedule

It is proposed that FRIAA will forward Project funds to the Foothills Model Forest in advance of expenditures (see Table 4(a)) on an annual basis, subject to:

- Submission of an annual work plan (for the period April 1 to March 31 of the following year);
- Submission of the annual report as per Section 4.1 (applicable for operating years 2008 and 2009);
- A holdback of 10% each year, pending submission of the annual report and any other deliverables scheduled for the year.

This would result in the following payment schedule, consistent with Table 4(a) after holdbacks:

On approval:	$57,780
April 1, 2008:	$83,100
April 1, 2009:	$140,550
June 30, 2010:	$14,670
Total Project:	$296,100

4.3. Work Schedule

The scheduling of project work and activities is described in Section 3.7. Table 5 shows the work schedule by activity units (days, plots etc.) and by year. Outputs are scheduled in Section 3.11.