



# Ministry of Forests and Range Mountain Pine Beetle Stewardship Research Strategy

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## **Implementation Framework:**

A delivery model for MPB  
stewardship research  
investment.

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## Executive Summary

This Implementation Framework is the second document that describes the current high priority Mountain Pine Beetle (MPB) stewardship knowledge gaps and identifies the key activities to address these gaps. The overall goal of the MPB Stewardship Research Implementation Framework (IF) project is to document at a high-level, the research activities needed to address the high priority stewardship knowledge gaps, with focus on the Chief Forester's highest priority gaps. These documents are intended to raise the awareness of the BC forestry research community and funding decision makers at the provincial and federal levels. The geographic focus of the two documents is BC but if the MPB infestation spreads beyond the BC borders, these documents may be helpful in other areas. These documents are not a request for funding, nor does it assume that the pool of available research expertise will be available to implement any one or more projects.

In September 2005, the first document [ 1] was presented to and accepted by the Ministry of Forests and Range Executive, including the Chief Forester of BC. It identified the gaps in knowledge relating to MPB stewardship issues and recommended a process for allocating funding, collaborating research and communicating these issues. This Implementation Framework outlines the key activities required to address the identified knowledge gaps [ 1]. The Framework begins by updating the MPB stewardship knowledge gaps and current projects defined in the 2005 *MPB Stewardship Research Strategy*, then describes the recommended key research activities needed to address the identified knowledge gaps. Finally, the budget, duration and implementation timeframe for the activities are estimated. The appendix summarizes the results of the analysis, including a full description for each high priority knowledge gap and associated key activities. Not included in this document are fire and First Nations-related research, which were not part of the original 2005 *MPB Stewardship Research Strategy*.



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## Introduction

This MPB Stewardship Research Implementation Framework (IF) follows logically from the *MPB Stewardship Research Strategy* [ 1] that has been extensively available to the BC forestry research community. The knowledge gaps and corresponding priorities will continue to evolve based on input from the research community for the duration of the MPB epidemic.

The overall goal of the MPB Stewardship Research Implementation Framework (IF) project is to document at a high-level, the research activities needed to address the high priority stewardship knowledge gaps, with focus on the Chief Forester's highest priority gaps. This document is primarily a decision support tool and is intended to raise the awareness of forestry research funding decision makers at the provincial and federal level. It allows research funding programs to target investments to address the high priority knowledge gaps; provides a link between the high priority research knowledge gaps [ 1] and the research activities required; and, provides funding agencies with decision support information about which projects to fund. This document is not a request for funding, nor does not assume that the pool of available research expertise will be available to implement any one or more projects.

This document summarizes the analysis of the current high-priority knowledge gaps conducted by seven forestry research discipline teams in May and June 2006, including the key research activities, implementation timeframes, duration and budgets required to address the gaps.



## Methods

The designated forestry Discipline Team Leaders were requested to review the published high-priority MPB stewardship research knowledge gaps and current MPB research projects [ 1],. The Discipline Team Leaders' feedback was used to update the published list of knowledge gaps and funded projects as of March, 2006 [ 2]. The functional scope of the MPB Stewardship Research Implementation Framework (IF) only includes the discipline areas with current high-priority knowledge gaps. These are: Entomology; Hydrology, Geomorphology, and Fisheries; Shelf Life; Silviculture, Growth & Yield; Soils; Strategic Analysis, Planning & Decision Support; and, Wildlife, Ecology, Range & Biodiversity.

We identified IF Project information requirements and used them to develop the MPB Stewardship Research Knowledge Gap Form. The Discipline Team Leaders identified appropriate research activities and confirmed or added knowledge gaps [ 5].

In addition, a peer review was conducted to validate the information. Experts in each discipline area who were not involved in the analysis process were invited to provide an unbiased, independent, critical assessment of the completed knowledge gap information forms submitted by Discipline Team Leaders. The reviewers were asked to respond to three specific questions: (1) Are the identified activities appropriate? (2) Will the activities address the knowledge gaps? (3) Are there any further activities that are required to address the knowledge gaps?

Finally, we synthesized the information from the completed knowledge gap information forms and the peer reviews and organized the results according to the following general topic areas: Knowledge Gaps and Projects Validation, Implementation Activities, and Timeframe of Implementation.



## Research Needs Assessment

### Knowledge Gaps & Projects Validation

This section documents the high priority MPB stewardship research knowledge gaps, and the current MPB stewardship research projects as of March, 2006. The designated Discipline Team Leaders, provided updates to the published high priority MPB stewardship research knowledge gaps [ 1]. The information sources used to identify the MPB stewardship research projects were the websites maintained by the funding sources, and discussions with key staff from the funding sources.

#### MPB Stewardship Research Knowledge Gaps:

The *MPB Stewardship Research Strategy*(2005) listed twenty-one consolidated high-priority MPB stewardship knowledge gaps [ 1]. Four research discipline areas revised their knowledge gaps resulting in an additional five high-priority MPB stewardship knowledge gaps.

The Entomology research discipline area modified the wording of two existing high-priority knowledge gaps and reclassified one knowledge gap from low to high. The Genetics research discipline area had no high priority knowledge gaps; however one of the low priority knowledge gaps was reclassified to moderate. The Strategic Analysis, Planning & Decision Support research discipline area reclassified one knowledge gap from low to high. The Soils research discipline area reclassified all knowledge gaps, resulting in three as high priority, one as moderate priority and six as low priority.

Table 1 shows the count of current (as of March 2006) knowledge gaps by priority category for each research discipline after the Discipline Team Leaders' review. The list of MPB stewardship research knowledge gaps are found in the *MPB Stewardship Research Strategy* [ 2].



• Table 1 Knowledge gaps priority ranking summary

Research Discipline Area	Priority Ranking		
	High	Moderate	Low
Climate <sup>1</sup>	0	5	3
Entomology	7	5	3
Genetics	0	1	1
Hydrology, Geomorphology, and Fisheries	5	1	6
Shelf Life <sup>2</sup>	1	0	0
Silviculture, Growth & Yield	3	1	3
Soils	3	1	6
Strategic analysis, Planning, Decision Support	5	5	1
Wildlife, Ecology, Range & Biodiversity	2	0	0

<sup>1</sup> Climate change issues are considered a high priority for the Ministry of Forests and are currently being addressed under the Future Forests Ecosystem Initiative.

<sup>2</sup> Shelf Life issues are considered a high priority for the Ministry of Forests and are currently being addressed by the Mountain Pine Beetle Initiative.

The following lists the MPB stewardship research high-priority knowledge gaps identified by the Chief Forester and MoFR executive in September, 2005. Executive recommended that these should be addressed first if resources are limited [ 2].

### Chief Forester's High Priority Knowledge Gaps

#### Hydrology, Geomorphology, and Fisheries

- Impacts of MPB infestation and salvage harvesting on the hydrological cycle (snow accumulation/melt, rainfall, evapo-transpiration, groundwater regime, water yield, and peak flows) at the watershed and landscape scale.
- Impacts of MPB infestation and salvage harvesting on riparian and stream channel physical processes (water quality, large woody debris dynamics, shade, air and water temperatures, understory vegetation, sediment production and delivery, channel stability/destabilization, and water chemistry).
- Modelling of potential impacts and generation of risk analysis for the hydrological, geophysical, and aquatic resources of MPB infested areas at the watershed and landscape scales.





### Silviculture, Growth & Yield

- Growth, development, and health of residual stands (overstory and understory) across a wide range of post-attack stand types and conditions (i.e., mixed species – salvaged; mixed species – unsalvaged; pine dominant – unsalvaged) in different BEC zones.
- Silvicultural treatments and regimes, such as fertilization of non-lodgepole pine stands and treatment of repressed lodgepole pine stands, to accelerate operability and enhance mid-term timber supply.

### Strategic Analysis, Planning, Decision Support

- Allocation of the post-attack live volume to harvesting schedules.
- Retention and salvage harvesting design at scales ranging from individual cutblocks through landscape units to entire management units (TSAs).

### Wildlife, Ecology, Range & Biodiversity

- Impacts of alternative patterns of salvage harvest and no harvest at the landscape and stand scales on ecological functioning.

## **MPB Stewardship Research Projects:**

In March 2006, we identified 71 projects that are directly related to MPB stewardship research; 56 funded by MPBI, 12 by FSP, and three by the FFT program. There was one identified project that had multiple funding sources (MPBI and FSP) but it was only counted once.

Table 2 shows a count of currently funded MPB stewardship research projects by forestry research discipline. A detailed list was created as an interim deliverable of the IF project [ 3] and the information sorted by lead researcher, funding source, and discipline area.



• **Table 2** Number of MPB stewardship research projects by discipline area (as of March 2006).

Research Discipline Area	Number of Projects			Total
	MPBI	FSP	FFT	
Climate	0	1	0	1
Entomology	11	0	0	11
Genetics	0	0	0	0
Hydrology, Geomorphology, and Fisheries	3	2	0	5
Shelf Life	5	0	0	5
Silviculture, Growth & Yield	7	4	2	13
Soils	0	1	0	1
Strategic analysis, Planning, Decision Support	9	3	1	13
Wildlife, Ecology, Range & Biodiversity	2	1	0	3
Other: Wood Quality, Phytosanitation, Inventory, Fire, Socio-economic	19	0	0	19
<b>Total</b>	<b>56</b>	<b>12</b>	<b>3</b>	<b>71</b>



## Framework Structure

The overall goal of the MPB Stewardship Research Implementation Framework (IF) project is to:

**Document at a high-level, the research activities needed to address the high priority stewardship knowledge gaps, with focus on the Chief Forester's highest priority gaps.**

The previous section (Research Needs Assessment) identified seven discipline areas with high priority MPB stewardship knowledge gaps. Although the low and medium priority knowledge gaps also pose problems in mitigating the impact of the MPB epidemic, the focus of the IF project is on the high priority knowledge gaps to create an implementation framework of manageable scope. These include eight knowledge gaps, identified by the Chief Forester of British Columbia, that should be addressed first if resources are limited [2].

The seven discipline areas within the scope of the IF are:

- **Hydrology, Geomorphology, & Fisheries** – research in fish-forestry interactions, watershed processes, and aquatic ecology.
- **Soils** – research to improve knowledge of soil and its role in forest ecosystem function, productivity, and effective management.
- **Wildlife, Ecology, Range, Biodiversity** – ecological research activities related to landscape biodiversity and wildlife habitat.
- **Silviculture, Growth & Yield** – research to provide the tools and information to make sound resource management decisions in the practice of controlling forest establishment, composition, and growth.
- **Strategic Analysis, Planning, Decision Support** – research to create and implement tools and information to facilitate landscape level planning.
- **Entomology** – research on the effects of insects on trees and forests, in particular focusing on the operational problems in managing affected stands and evaluating treatment options.



- **Shelf Life** – research into the length of time after death that a tree will have a productive use (e.g. sawlogs, OSB, pulp, bio-fuels, habitat).

## Implementation Activities

The *MPB Stewardship Research Strategy* is, and will continue to be implemented through, an evolving network of forestry research activities. Specific activities to be addressed will depend on provincial and federal research priorities, forestry researcher interest, available methodology, availability of funding and manpower, and other resources.

The Implementation Framework provides the structure to encourage collaboration between forestry researchers from different disciplines and activities, but is not intended to be prescriptive or subject to unreasonable restriction on participation. Rather, the Implementation Framework is designed to provide guidance to the research community as to how best to allocate limited resources, based on the best available information of scientific experts in each discipline.

The key research activities identified to address each high priority knowledge gap are provided in Table 5 at the end of this document. The Discipline Team Leaders identified sixty-four key research activities to address twenty-four of the twenty-five identified high priority knowledge gaps. There were no activities identified for one knowledge gap; *RS0513 - Allocation of the post-attack live volume to harvesting schedules*.

Eighty-six percent (55 of 64) of the identified key activities were classified as **quick win** (Table 3). These are high impact activities which can be completed in three years or less, and are small, well defined, and loaded for success (highly visible, achievable, and urgently needed). Seventy-five percent (19 of 29) of the activities assigned to seven of the eight Chief Forester selected knowledge gaps were also classified as **quick win**.

The Discipline Team Leaders estimated a requirement of 82.5 scientist person-years, and 94.6 person-years by technical assistants (i.e. grad students, etc.), along with a total funding requirement (including operating



expenses and salaries) of \$28 million over the three-year implementation timeframe.

- **Table 3 Number of research activities required to address a) all high priority knowledge gaps and b) the Chief Forester’s high priority knowledge gaps.**

Research Discipline Area	High Priority Gaps		Chief Forester’s High Priority Gaps	
	All Activities	Quick Win Activities	All Activities	Quick Win Activities
Entomology	14	12	0	0
Hydrology, Geomorphology, and Fisheries	22	18	15	12
Shelf Life	3	3	0	0
Silviculture, Growth & Yield	10	9	10	9
Soils	5	5	0	0
Strategic analysis, Planning, Decision Support	4	3	1	0
Wildlife, Ecology, Range & Biodiversity	6	5	3	2
<b>Total</b>	<b>64</b>	<b>55</b>	<b>29</b>	<b>23</b>

The appendix to this document [ 6] identifies the classification of each research activity required to address the identified knowledge gaps.

Table 4 lists the funding required to conduct research activities to address the knowledge gaps. Figure 1 and 2 summarize the identified key activities and estimated budget. The first shows the distribution of the estimated funding among research disciplines by funding year. The second shows the number of activities to be funded each year in the seven research discipline areas.

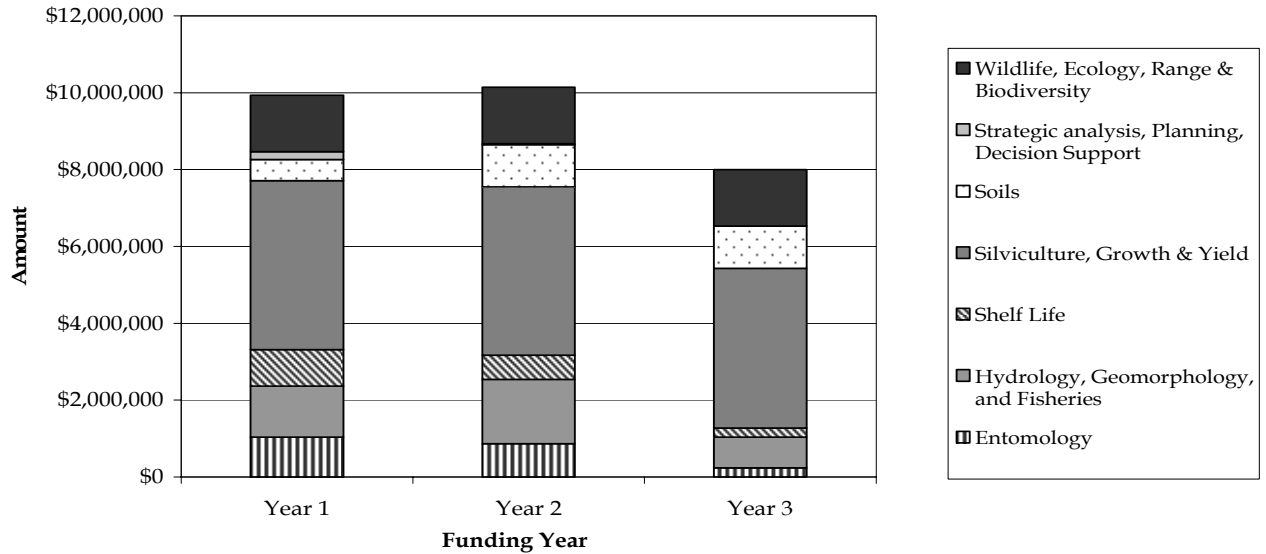


- **Table 4 Funding required (in millions of dollars) to conduct research activities to address over three years in a) all high priority knowledge gaps and b) the Chief Forester's high priority knowledge gaps.**

Research Discipline Area	High Priority Gaps		Chief Forester's High Priority Gaps	
	All Activities	Quick Win Activities	All Activities	Quick Win Activities
Entomology	2.1 (1.7)	1.4 (1.1)	0	0
Hydrology, Geomorphology, and Fisheries	3.8 (2.8)	2.7 (2.0)	1.6 (0.8)	1.2 (0.8)
Shelf Life	1.8 (0.9)	1.8 (0.9)	0	0
Silviculture, Growth & Yield	12.9 (6.1)	12.6 (5.9)	12.9 (6.1)	12.6 (5.9)
Soils	2.7 (2.5)	2.7 (2.5)	0	0
Strategic analysis, Planning, Decision Support	0.2 (0.01)	0.2 (0.01)	0.04 (0)	0
Wildlife, Ecology, Range & Biodiversity	4.4 (4.2)	3.3 (3.7)	2.2 (1.6)	1.7 (1.6)
<b>Total</b>	<b>28.1 (18.1)</b>	<b>24.7 (16.0)</b>	<b>16.8 (8.5)</b>	<b>15.4 (8.3)</b>

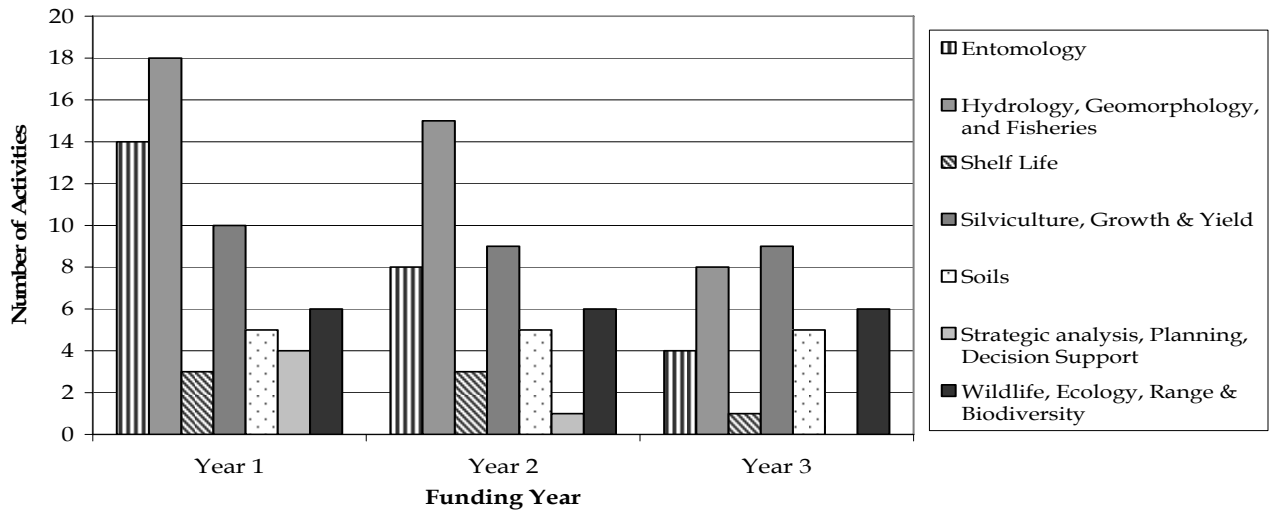


Figure 1. Distribution of the Estimated Funding



• Figure 1 Distribution of the Estimated Funding

Figure 2. Research Activities by Research Discipline Areas



• Figure 2 Research Activities by Research Discipline Area



The majority of the required research funding (46 percent) over the three-year implementation period will fund activities within the Silviculture, Growth & Yield discipline area. Consequently, this area also requires the greatest level of participation by scientists and technical assistants; 58.9 and 61.5 person-years respectively. However, all high priority knowledge gaps within this discipline are being at least partially addressed by existing projects, for which funding is expected to be continued.

Most activities are expected to be completed over more than 1 year. The Hydrology, Geomorphology and Fisheries discipline area has identified the highest number of activities (twenty-two), with the majority being multi-year activities. The Hydrology, Geomorphology and Fisheries discipline area will have an average of fourteen activities in progress each year throughout the period.

A summary of the research analysis, including a full description for each high priority knowledge gap, and associated key activities, is shown in the appendix to this document [ 6].

## **Timeframe of Implementation**

Table 5 specifies the implementation timeframe, duration, and budget for each key research activity, identified to address the high priority knowledge gaps within each discipline area. Cost estimates include salaries and operating funds and are first approximations only. Individual projects would be developed within an activity. The appendix to this document provides greater detail.





- **Table 5 Summary of Activities and Implementation Timeframe.** Chief Forester's Priority Knowledge Gaps are highlighted in green. Quick Win activities are highlighted in tan. Budget estimates are first approximations.

High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
<b>ENTOMOLOGY</b>						
<b>RS0619</b> - Understanding mechanisms of long-range and short-range dispersal of MPB and percent of population dispersing over long/short range in various stand types and conditions.	1. Synthesis of Existing Information - Literature review on mechanisms of long-range and short-range dispersal of MPB	\$30,000	12	♦		
	2. Surveys or Data Collection - Experiments involving the trapping, flight and emergence monitoring and simulated flight experiments of MPB	\$175,000	30	♦	♦	♦
	3. Modeling - Incorporate experimentation and survey data into models that can predict or simulate beetle dispersal in different situations	\$85,000	18	♦	♦	
<b>RS0620</b> - Influence of micro-climate factors from various stand types and ages on MPBs emergence.	1. Synthesis of Existing Information - Literature review about the influence of micro-climate factors from various stand types and ages on MPB emergence; and compilation of any unpublished data.	\$25,000	6	♦		
	2. Establishment of new experiments - establish climate monitoring stations, flight monitoring traps and tree monitoring for attack and brood development throughout those BEC zones where MPB is found.	\$240,000	30	♦	♦	♦
	3. Extension - prepare manuscripts for publication for information generated in activities 1 and 2.	\$15,000	6	♦		



## Implementation Framework

High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
RS0621 - Success of MPB attack in young stands and the impact to TSR.	1. Surveys or Data Collection - Conduct aerial and ground surveys in young stands to determine impacts on TSR from MBP.	\$400,000	24	♦	♦	
	2. Model Building or Enhancements - adjust the existing Shore-Safranyik susceptibility model to reflect the situation in young pine	\$40,000	12	♦		
	3. Extension - Report to the Chief Forester and publish the results	\$10,000	3	♦		
RS0622 - Effects of MPB in jack pine stands; insect physiology; brood success; fungal colonization; natural enemies etc.	1. Synthesis of Existing Information - Look at situations and condition of Jack pine stands that are similar to those of infested lodgepole pine.	\$22,000	6	♦		
	2. Establishment of New Experiments, Surveys and Extension - Effects of MPB on jack pine stands including insect physiology, brood success, fungi colonization, natural enemies etc.	\$340,000	30	♦	♦	♦
RS0623 - Impact of global warming on MPB survival, virulence and distribution.	1. New Research - Impact of global warming on MPB survival, virulence and distribution. This is a critical project that requires all aspects of research from literature review to new experimentation and modeling.	\$330,000	36	♦	♦	♦
RS0624 - Detection of green-attacked stands before they become red-attacked.	1. Application Enhancements - Detection of green-attacked stands before they become red-attacked trees using enhancements of existing remote sensing applications.	\$240,000	24	♦	♦	



High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
<b>RS0625</b> - Single tree or small patch control options (i.e. alternatives to methylarsonic acid (monosodium methanearsenate, <b>MSMA</b> ))	1. New Research – MPB Control Options. Review literature; establish new trials with new and known compounds to test for efficacy; test for effectiveness; and deliver training.	\$200,000	24	♦	♦	
<b>HYDROLOGY, GEOMORPHOLOGY, AND FISHERIES</b>						
<b>RS0501</b> - Impacts of MPB infestation and salvage harvesting on the hydrological cycle (snow accumulation/melt, rainfall, evapo-transpiration, groundwater regime, water yield, and peak flows) at the watershed and landscape scale.	1. Compilation and organization of existing 10 year data from the Stuart-Takla Fish/Forestry Project in the Mackenzie Forest District	\$40,000	1	♦		
	2. Analysis of the existing 10 year data from the Stuart-Takla Fish/Forestry Project to quantify the hydrological cycle over time as the MPB infestation increased	\$70,000	3	♦		
	3. Remeasurement of the hydrological cycle at established study sites within the Stuart-Takla Fish/Forestry Project to extend the data base and include areas with greater MPB infestation than in the 1990's.	\$220,000	5	♦	♦	♦
	4. Establish replications of the Stuart-Takla studies to extend the hydrological analysis to areas outside the MacKenzie Forest District	\$225,000	6		♦	♦
<b>RS0502</b> - Impacts of MPB infestation and salvage harvesting on riparian and stream channel physical processes (water quality, large woody debris	1. Analysis of existing data to assess MPB impacts on riparian and stream channel physical processes from four major research projects in areas currently infected with MPB.	\$150,000	18	♦	♦	



## Implementation Framework

High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
dynamics, shade, air and water temperatures, understory vegetation, sediment production and delivery, channel stability/destabilization, and water chemistry).	2. Effectiveness Monitoring - Determine pre-harvest riparian functionality of pine leading riparian areas, using the FREP Effectiveness Evaluation for streams and riparian areas	\$180,000	12	♦	♦	
	3. Analysis of Existing Data - Assess MPB impacts on in-stream large coarse woody debris from four major research projects in areas currently infected with MPB.	\$50,000	6	♦		
	4. Remeasure earth science attributes at four previously established major research projects that are now infected with MPB to allow comparisons with previously healthy forests.	\$230,000	12	♦	♦	
	5. Extension - Produce scientific reports and management applications products relating to the activities 1 to 5 above	\$30,000	6			♦
	6. Adaptive Management Project - Evaluate retention levels over a three-year period while building on existing small stream riparian zone studies to identify effective retention levels in MPB infested stands for key physical indicators.	\$255,000	30	♦	♦	♦
	<b>RS0504</b> - Modelling of potential impacts and generation of risk analysis for the hydrological, geophysical, and aquatic resources of MPB infested areas at the watershed and landscape scales.	1. Compilation and organization of existing 10 year fluvial sediment transfer data from the Stuart-Takla Fish/Forestry Project in preparation for it's use in a sediment routing model.	\$30,000	2	♦	
	2. Model Enhancements - Calibrate to interior conditions, a model that was developed, tested and refined for routing fluvial sediments through coastal watersheds.	\$30,000	2	♦		



High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
	3. Remeasurement of existing experiments – Collect fluvial sediment transfer from the Stuart-Takla Fish/Forestry Project.	\$30,000	3	♦		
	4. Modeling and Analysis – Run the model calibrated in activity 2 for pre-MPB, using post-MPB fluvial sediment transfer data collected in activity 3	\$65,000	4	♦	♦	
	5. Model sedimentation patterns using information generated in activities 1 to 4 above and the WilGan model on 3 Stuart-Takla watersheds to compare the pre MPB and post MPB periods. Determine if this model can be applied in other watersheds to determine their susceptibility to sedimentation problems resulting from MPB infestation and/or salvage logging.	\$37,000	6		♦	♦
<b>RS0603</b> - Impacts of MPB infestation and salvage harvesting on riparian and stream channel biological conditions and processes (alteration to fish spawning and rearing habitat, fish species composition and spatial distributions, and aquatic communities).	1. Assembly, synthesis, and summary of data on aquatic ecosystem/riparian biological conditions and processes including fish populations and habitats from existing (i) long-term process studies, (ii) historic short-term assessments and (3) synoptic (retrospective, multi-site) studies of streams & riparian areas, in both harvested and unharvested watersheds	\$200,000	12	♦	♦	
	2. Analysis of existing data – Determine effects of MPB infestation and salvage harvesting on aquatic ecosystem/riparian biological conditions and processes including fish populations and habitats.	\$360,000	17	♦	♦	



## Implementation Framework

High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
	3. New surveys or data on aquatic ecosystem/riparian conditions and functions under a regime of MPB infestation.	\$520,000	26	♦	♦	♦
	4. Effectiveness monitoring and adaptive management project - standards and practices for streams and riparian areas in and adjacent to MPB-salvaged cutblocks	\$540,000	30	♦	♦	♦
RS0605 - Development of indicators for riparian function, water quality, and aquatic ecosystem health to monitor the effects of beetles and salvage operations.	1. Organization and Synthesis of Existing Information on routine-level, and intensive-level indicator sets and assessment protocols for (i) riparian areas, streams, and fish habitats, and (ii) water quality; evaluate suitability for assessments of MPB and salvage harvest; test revised indicator sets in the field, and revise indicators as necessary; review outcomes and finalize indicators in a workshop	\$300,000	14	♦	♦	
	2. Extension – distribute indicator checklist and protocols and develop training on how to conduct field assessments using indicators and protocols.	\$160,000	5	♦	♦	♦
	3. Extension – generate paper-form and electronic versions of routine and intensive level indicator checklists and protocols for use as field tools.	\$120,000	12	♦	♦	
<b>SHELF LIFE</b>						
RS0626 - The shelf-life of MPB-killed trees for various forest products.	1. New surveys or data collection - Identification of decay fungi and associated rates of degradation in standing trees killed by MPB	\$635,000	30	♦	♦	♦



High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
	2. New surveys or data collection - Quantification of the rate of deterioration in wood quality following MPB attack.	\$950,000	20	♦	♦	
	3. New surveys or data collection - Quantification of lumber value recovery from beetle-killed trees.	\$250,000	20	♦	♦	
<b>SILVICULTURE, GROWTH &amp; YIELD</b>						
<p><b>RS0608</b> - Recruitment, growth, development and health of natural and planted regeneration across a wide range of post-attack stand types and conditions (i.e., mixed species stands – salvaged; mixed species stands– unsalvaged; pine dominant stands – salvaged; pine dominant stands – unsalvaged) in different BEC zones.</p> <p><b>RS0509</b> - Growth, development, and health of residual stands (overstory and understory) across a wide range of post-attack stand types and conditions (i.e., mixed species stands – salvaged; mixed species stands – unsalvaged; pine dominant stands – unsalvaged) in different BEC zones.</p>	1. Synthesis of existing information - Conduct literature reviews on i) recruitment, development and health of natural regeneration and ii) growth, development, and health of residual stands.	\$120,000	12	♦		
	2. Analysis of existing data to define stand structures in the overstory and understory of MPB affected or at-risk stands by subzone and site series.	\$400,000	36	♦	♦	♦
	3. Remeasurement and analysis of existing experiments - Develop an inventory and prioritize all the MoFR research experiments that pertain to knowledge gaps in i) recruitment, development and health of natural regeneration and ii) growth, development, and health of residual stands. Those experiments with the highest relevance will be measured and the data analysed	\$3,270,000	36	♦	♦	♦
	4. New surveys or data collection - After activity 3) has been completed, collect new data on specific research topics that address the data gaps for high priority topics.	\$2,700,000	36	♦	♦	♦



High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
	5. Modelling of MPB affected stands - Collect information and calibrate the appropriate models (SORTIE, TASS, PrognosisBC) to forecast stand development in MPB infested stands.	\$2,500,000	36	♦	♦	♦
	6. Extension of information derived from the activities described above to decision makers and operational personnel by extension specialists.	\$825,000	36	♦	♦	♦
RS0510 - Silvicultural treatments and regimes, such as fertilization of non-lodgepole pine stands and treatment of repressed lodgepole pine stands, to accelerate operability and enhance mid-term timber supply	1. Organization and synthesis of existing information - Develop an inventory and prioritize all the MoFR research experiments that pertain to this knowledge gap. The most relevant data will then be analyzed and synthesized to report the current state of knowledge of the applicability and benefits of various silvicultural activities to enhance long term timber supply.	\$500,000	36	♦	♦	♦
	2. Remeasurement and analysis of existing high-priority field experiments identified in activity 1 from which analysis and synthesis will address this gap and provide important information to land managers.	\$1,725,000	36	♦	♦	♦
	3. Extension of information derived from activities 1 and 2.	\$500,000	36	♦	♦	♦
	4. Establishment of New Field Experiments - After activity 1), determine if there are gaps in information that will only be addressed by the establishment of some very focused research provided by new field experiments	\$375,000	18	♦	♦	♦





High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
<b>SOILS</b>						
<b>RS0611</b> - Is soil disturbance higher in MPB-salvaged areas, particularly when salvage operations occur on wet soils.	1. New surveys or data collection - Assessment of the type and severity of soil disturbance in MPB-salvaged areas	\$550,000	27	♦	♦	♦
	2. New surveys or data collection - Determine if soil disturbance impairs regeneration or function of future forests	\$550,000	27	♦	♦	♦
<b>RS0612</b> - Can we assess the extent of wet-moist soils in salvage areas during the June harvesting window and would the use of different harvesting methods, or delay extraction until soils are drier be beneficial?	1. New surveys or data collection - Determine factors that can be used to predict soil moisture in June and use a predictive approach to determine whether sites can be harvested in June without excessive soil disturbance	\$550,000	27	♦	♦	♦
	2. New surveys or data collection - Determine if different harvesting methods or extraction delay are suitable on too-wet summer soils in MPB areas.	\$550,000	27	♦	♦	♦
<b>RS0613</b> - How will accelerated road building affect erosion, sedimentation, and landslides?	1. New surveys or data collection - Assess whether the acceleration of road building has led to an increased soil erosion, sedimentation and landslides. Determine how this can effectively and efficiently be assessed on the huge landscape affected by MPB. If problems are detected, determine what changes in management or policy are needed.	\$550,000	27	♦	♦	♦
<b>STRATEGIC ANALYSIS, PLANNING, DECISION SUPPORT</b>						
<b>RS0513</b> - Allocation of the post-attack live volume to harvesting schedules.	No activities identified.					



## Implementation Framework

High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
<b>RS0514</b> - Design of retention and salvage harvesting at scales ranging from individual cutblocks through landscape units to entire management units (TSAs).	1. Develop a planning framework for strategically identifying stands that should be retained to meet non-timber objectives and provide tools for locating those stands on the ground	\$40,000	6	♦		
<b>RS0614</b> - The effect of MPB management activities on the leading edge of the outbreak, and the rate of progress of the leading edge.	1. Organization or synthesis of existing information - Summarize the findings from the many projects relating to the effect of management activities at the leading edge of the outbreak..	\$50,000	6	♦	♦	
<b>RS0615</b> - Effect of forest management activities on the nature and extent of the current outbreak.	1. New surveys or data collection - Determine if management activities are more successful in slowing the spread of the infestation in landscapes with variable topography.	\$60,000	12	♦		
<b>RS0618</b> - Timber supply impacts of MPB in young stands.	1. Analysis of existing data - Predicting juvenile stand mortality in MPB impacted landscapes based on mortality of adjacent mature stands.	\$80,000	1	♦		
<b>WILDLIFE, ECOLOGY, RANGE &amp; BIODIVERSITY</b>						
<b>RS0507</b> - Impacts of alternative forest management activities, such as patterns of salvage harvest and no harvest, at the landscape and stand scales on ecological functioning.	1. Organization or synthesis of existing information - Identify important ecological functions that will likely be affected, the likely effects on range and other non-timber resource values and ways to minimize any negative effects at i) landscape and ii) stand scales.	\$1,100,000		♦	♦	♦
	2. New Surveys or Data Collection - Understand impacts of ecological system structure and functioning of alternative forest management activities at the landscape and stand scales.	\$550,000		♦	♦	♦



## Implementation Framework

High Priority Research Knowledge Gap	Research Activity	Total 3 Year Budget	Duration (Months)	Implementation Timeframe		
				Year 1	Year 2	Year 3
	3. Extension - Inform decision makers about the outcomes of activities 1) and 2) above. Conduct workshops to gather researchers to set priorities and develop integrated research strategies	\$550,000		♦	♦	♦
<b>RS0606</b> - Impacts of alternative patterns of management interventions, such as salvage harvesting and no harvest, at the landscape and stand scales on critical habitat for plants and animals. Research and extension should focus on identifying the impact of current salvage and subsequent harvesting on important spatial and temporal landscape patterns necessary to maintain critical habitat.	1. Organization and/or Synthesis of Existing Information and Analysis and Modeling - Understand critical habitat needs of key species that will likely be affected, and ways to minimize any negative effects at i) landscape and ii) stand scales.	\$1,100,000	6	♦		
	2. New Surveys or Data Collection - Understand impacts of alternative patterns of management interventions on critical habitat for plants and animals at the landscape and stand scales.	\$550,000	27	♦	♦	♦
	3. Extension - Inform decision makers about the outcomes of activities 1) and 2) above. Conduct workshops to gather researchers to set priorities and develop integrated research strategies.	\$550,000	36	♦	♦	♦



## References

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