OMINECA

REGIONAL FOREST HEALTH STRATEGY

2021-2024

PRINCE GEORGE, MACKENZIE, AND ROBSON VALLEY TIMBER SUPPLY AREAS

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EXECUTIVE SUMMARY

Forest health continues to have a large impact on timber supply and forest ecosystem resiliency in the Omineca Region. These challenges are exacerbated greatly by climate change. Although there are many possible worthy projects in forest health, this regional strategy identifies the top priority insects and pathogens to efficiently target limited fiscal and human resources. This is not an exhaustive list of insects and pathogens affecting Omineca forests. It is shortlist of priority forest health factors that can reasonably be addressed within the next three years and encourages commitment to specific activities and treatments that will serve as strong foundations for forest health management in the coming years. The recommendations within this strategy are designed to build strong working relationships within the region and province, and to improve the efficiency and effectiveness of science-based forest health management. The development and implementation of consistent and effective monitoring tactics, foundational tools and organizational support is required to enable an effective forest health program and ensure impactful investments.

For bark beetles, the strategic focus is to update our thinking and approach to beetle management to better reflect changing conditions and climate. Eruptive bark beetle populations are increasing in frequency and severity, with much of the provincial damage currently within the Omineca Region. To adapt to this "new normal", the bark beetle management unit (BMU) strategies have been updated to better reflect the dynamic response of bark beetle populations to the warmer, milder winters and longer growing seasons. Endemic levels of bark beetles are unlikely to be the dominant phase for the foreseeable future and therefore, it is imperative to integrate a clear understanding of insect biology and forest ecology into operational forestry and planning at all spatial scales.

The pathology program's strategic focus is to gather and compile detailed information on the influence of specific forest pathogens and the factors that support their establishment and persistence in the Omineca Region. This includes translating historical datasets into user-friendly tools and references, integrating research on climate change and priority pathogens, and examining pathogens and disease dynamics throughout stand development to identify and assess opportunities to improve management practices. The health of young stands (regenerating and post-Free Growing) is a specific priority that requires clear objectives, collaboration and coordinated efforts. Those interested in conducting forest health surveys in young stands are strongly encouraged to contact the Regional Forest Pathologist directly to ensure efforts are compatible with established data formats.

Due to the persistence of pine stem rusts in the Omineca Region, it is strongly recommended that all silviculture survey contracts consider and reflect the critical, annual survey period that corresponds with rust sporulation (May15th - July15th; site and weather dependent), and that forest health experience requirements are strengthened for surveyors working within stands with more than 30% lodgepole pine. It is also recommended that surveyors are supported to complete Free Growing surveys in rust prone areas within the rust sporulation window. Receiving up-to-date rust identification training to a standard of excellence and understanding the implications of incomplete and inaccurate survey data must be a continuing priority. Free Growing survey data in RESULTS is a primary input for stand development modelling and Timber Supply Analysis, and thus there are implications and exorbitant opportunity costs associated with inaccurate field identification of pine stem rusts and other forest health damage agents. With the ever-changing climate and local site conditions, frequent site visits and dedicated monitoring in rust-prone areas is strongly encouraged.

The Omineca Forest Health Program is focused on continued high quality, up-to-date training, aerial and ground survey methods, and communication within government and externally with partners to ensure that consistent, informative monitoring data is collected that can be incorporated into Annual Operating Plans, fundamental tools and resources, and larger provincial initiatives, like Timber Supply Review.

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MISSION

"Building strong working relationships to improve the efficiency and effectiveness of science-based forest health management"

VISION

Resilient and productive forested ecosystems that provide full-spectrum values and services, achieved through science-informed rationales and active management that recognize and reflect the critical role of natural disturbances in healthy ecosystems.

ACKNOWLEDGEMENTS

This document was prepared by Jeanne Robert, Regional Forest Entomologist, and Jewel Yurkewich, Regional Forest Pathologist at the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) Omineca Region. All unattributed pictures in this document were taken by either Jeanne or Jewel.

We would like to thank FLNRORD staff from the Prince George, Stuart-Nechako, and Mackenzie Districts as well as local licensees and consultants for shared information, ongoing feedback and support.

Front cover photo – A new spruce beetle adult just beginning to excavate a gallery under the bark in the Prince George TSA.

Above photo – Jewel Yurkewich (left) and Jeanne Robert (right).

1 PURPOSE OF THE FOREST HEALTH STRATEGY

The Regional Forest Health Strategy is designed to coordinate and guide forest health treatments and activities in the Timber Supply Areas (TSAs) within the Omineca Region while ensuring consistency with the Provincial Forest Health Strategy and funding priorities set by the Land Based Investment Strategy. The Regional Forest Health Strategy combines input and information about TSA priorities with principles of Integrated Forest Health Management at the landscape (regional) level to produce species-specific Action Plans that incorporate both proactive and reactive activities and projects. The Regional Forest Health Strategy and Action Plans are designed within the context of climate change (Section 2: Climate Change and Forest Health). Climate change is a major factor determining the near and mid-term forest health concerns in the Omineca Region. Therefore, the activities recommended within each Action Plan aim to:

- incorporate the principles of Integrated Forest Health Management at multiple spatial scales
- provide guidance on beneficial practices for managing priority pests and pathogens
- recognize and adapt to the interconnected nature of forest health factors with climate change lens
- support and fund operational projects coordinated and led by district and regional personnel as summarized in the Annual Operating Plans (Section 4: Strategic Linkages and Timeline)
- synthesize knowledge and data on impacts of forest health factors on timber supply and forest ecosystems (Section 8: Impact of Forest Health Factors on Timber Supply), and
- provide ecologically sound, scientifically based techniques for management of resource values.

Integrated Forest Health Management (IFHM)

IFHM is a variant of the internationally recognized approach to pest management known as Integrated Pest Management (IPM).

The principles of IPM have been modified within a forestry context to produce the principles of IFHM. These principles can be summed up briefly as:

- know the land-base and resource management objectives
- manage from an ecological perspective
- maintain or improve the current forest health condition and
- practice adaptive management.

The overarching goal of the Regional Forest Health Strategy is to guide the use of science-based reactive approaches for managing eruptive outbreaks of economically important forest health factors while increasing the integration of proactive approaches within an efficient investment framework to maintain and improve the health of forest ecosystems.

Reactive forest health measures focus on the suppression of expanding pest outbreaks using short-term direct control methods with the intent of lowering pest populations and protecting threatened resource values. In many recent situations, our management options have been limited to the reactive approach, but there is an opportunity now, with large portions of regenerating forests after major bark beetle outbreaks and unprecedented fire seasons, to integrate proactive approaches into the management regime.

Proactive approaches recognize the dynamic, interconnected relationships between the tree host species, the environment and forest health factors. Proactive measures require effective tools to predict risk and the associated consequences, efficient methods for early detection of forest health problems, thoughtful emergency response plans to guide prompt implementation of scientifically sound solutions, and efficient use of limited resources. A proactive management regime for forest health requires the application of "pest-aware" silviculture and harvesting practices, efforts to increase the amount of stand and landscape heterogeneity created by forest operations, use of cost/benefit analyses and knowledge of existing management techniques, and the willingness to explore new ideas and technologies. Management that integrates proactive forest health activities helps to mitigate extreme pest cycles, reduce future pest outbreaks, and supports the inherent resiliency of forests.

2 CLIMATE CHANGE AND FOREST HEALTH

Climate change is an enormous source of uncertainty for forestry and forest health. The effects of changing weather and climate is impacting forest health management now, and this will continue for the foreseeable future. The complexity of changing conditions in combination with ecological and species-level interactions will likely result in "an era of megadisturbance" in temperate forests (Millar and Stevenson, 2015). British Columbia has already endured an unprecedented mountain pine megadisturbance that impacted over 18 million hectares of lodgepole pine and included the range expansion of a major forest insect pest into Alberta. The amplified interactions between abiotic and biotic factors are apparent across the province, as witnessed in recent drought, flooding and unprecedented wildfires. To adapt to this new era of forest health, forest professionals and land managers must rely on the incomplete knowledge of insects and pathogens in uncertain and unprecedented conditions to plan for the worst-case scenario, while managing within available resources. This significant challenge will require proactive and thoughtful "monitoring, forecasting, planning and use of mitigating strategies" for years and decades to come (Sturrock et al. 2011).

Climate change is having a major impact on bark beetles in BC, increasing both the frequency and severity of the four major eruptive species: mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle. General warming trends, especially in northern BC, are demonstrably beneficial for bark beetle populations and stressful for host trees. Bentz et al. (2010) note that climate change will impact both the susceptible host species and insects resulting in larger outbreaks of eruptive native bark beetles. Specifically, they point to a likely increase in mountain pine beetle and spruce beetle, two of the Omineca Regions major pest species and natural disturbance agents.

With changing localized, seasonal weather patterns that influence host susceptibility and pathogen success, designing management approaches that account for and mitigate damage by forest pathogens is increasingly complex. Pine stem rusts and foliar pathogens are strongly responsive to changes in temperature and precipitation, and therefore understanding stand-level topography and microclimatic conditions is important when attempting to predict the hazard, incidence, severity and economic impact of these forest pathogens (Kliejunas et al. 2009; Sturrock et al. 2011). Other pathogens, such as root diseases, are closely linked to host tree distribution and take advantage of water-stressed host trees. Pathogens and other microorganisms in BC's forests will adapt faster to changing conditions than their long-lived tree hosts and will explore opportunities and advantages presented by climate change (Kliejunas et al. 2009; Sturrock et al. 2011).

In addition to major bark beetles and pathogens, climate change is having complex effects on less notorious forest health factors. Previously sub-lethal defoliators and parasitic insects (Pureswaran et al. 2018), and endemic pathogens, such as *Dothistroma septosporum* (Woods et al. 2005) have become much larger issues, with expanded ranges and intensification of damage in BC. The ability to predict the impact of biotic abiotic damage agents on forest health as climate change progresses, depends on the localized changes of climate variables, characteristics of the insect, pathogen and host species, ecological interactions, synchronicity of phenology and natural disturbance regimes (e.g. fire interval) (Sturrock et al. 2011; Volney and Fleming 2000). Thus, efforts to monitor the changing dynamics and integrate learnings through an adaptive management approach are critical in northern BC. Considerations of climate change implications must be integrated into resource management to support current and future ecosystem resilience, productive forests and sociocultural diversity and security.

3 SCOPE OF THE FOREST HEALTH STRATEGY

The Regional Forest Health Strategy applies to the three Timber Supply Areas (TSAs) within the Omineca Region, specifically the Prince George, Mackenzie, and Robson Valley TSAs (Figure 1). Together they cover approximately 15.84 million hectares and the combined, allowable annual cut (AAC) is 13,213,559 m^3/year.

For more information on the AAC by TSA and effective dates, please see: Timber Supply Review and Annual Allowable Cut.

Figure 1 – The Omineca Region and Timber Supply Areas (TSAs)

4 STRATEGIC LINKAGES AND TIMELINE

The new and improved Regional Forest Health program is underway and emphasizes collaboration and integration of leadership at all levels to promote, support and enhance forest health management in the Omineca Region. Anchored to the concept of adaptive management over the 3-year term, the Regional Forest Health Strategy provides the science-based vision and direction to help guide the development, implementation and review of government TSA-based Annual Operating Plans (AOPs) for forest health while linking to regional and provincial business priorities (Figure 2). This system, together with all the collaborators and refined timeline, facilitates and generates deliverables that address the strategic objectives of the region and province. The annual timeline (Table 1) summarizes the key actions to be taken by quarter and area of responsibility: project leads and Regional Forest Health Specialists.

Supplementary materials, funding request forms, current fiscal AOPs and previous fiscal Annual Operations Review and Recommendations Reports (AORR Reports) are available directly from the Regional Forest Health Specialists.

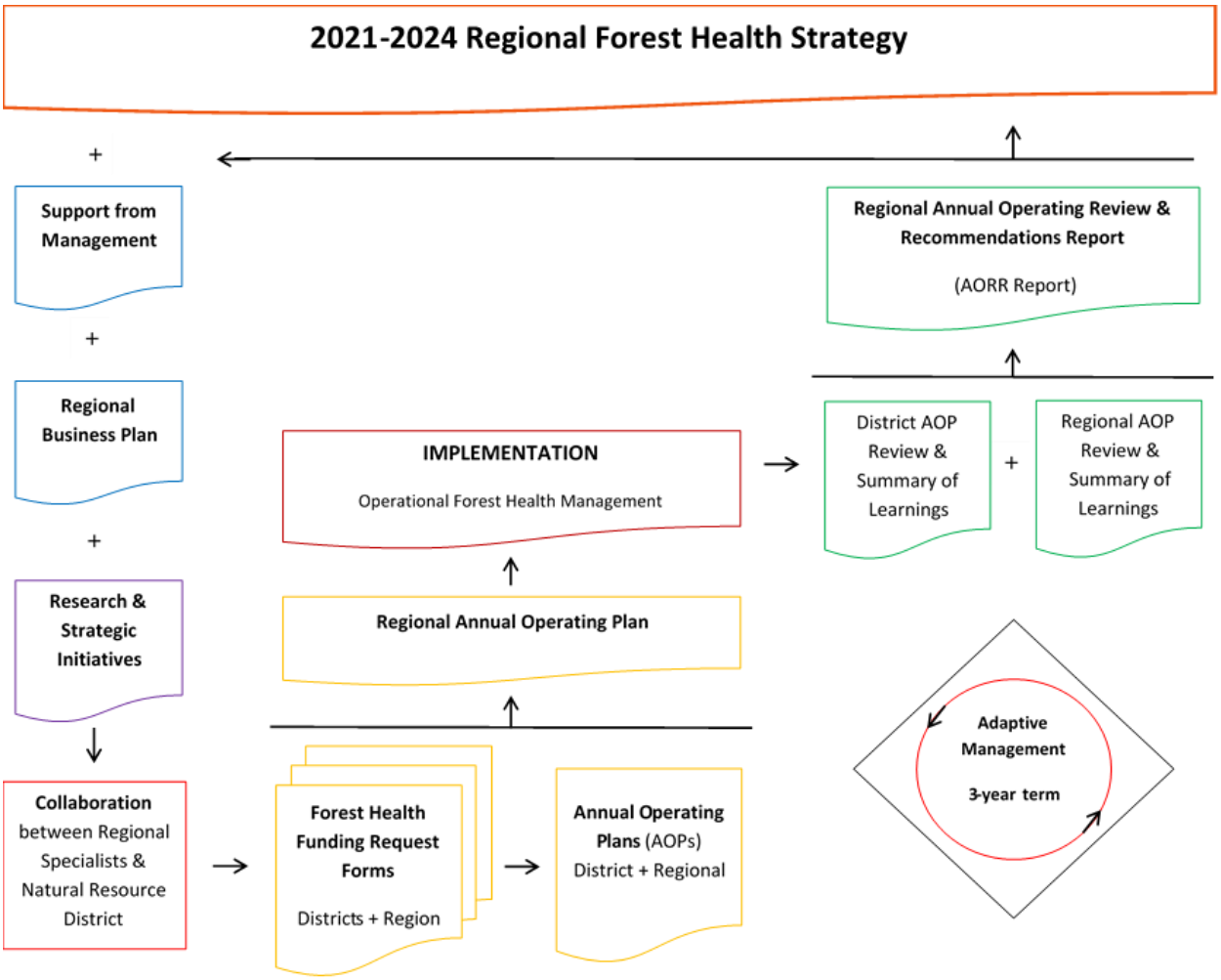

Figure 2 – Adaptive Management Flowchart of the annual workflow of the Regional Forest Health program and linkages to the 3-year Forest Health Strategy, regional business plan and provincial priorities.

Table 1 – Annual timeline of key actions for project leads and regional specialists

Annual Timeline	Key Actions for Project Leads	Key Actions for Regional Specialists
1st Quarter April 1st – June 30th	1. Initiate current fiscal AOPs 2. Track progress and performance measures 3. Engage with and update collaborators	1. Initiate update 2. Support technical aspects of AOP initiation 3. Present approved Regional AOP to RMT
2nd Quarter July 1st – Sept. 30th	1. Confirm allocation upon budget announcement 2. Execute current fiscal AOPs 3. Track progress and performance measures 4. Engage with and update collaborators	1. Initiate updates and report outs 2. Support technical aspects of AOP continuation 3. Communicate deadlines for completing AOPs and funding requests (FY+)
3rd Quarter Oct. 1st – Dec. 31st	1. Complete funding requests (FY+) and AOPs 2. Complete current fiscal AOPs 3. **Assess effectiveness and efficiency of AOP implementation** 4. Engage with and update collaborators	1. Initiate updates and report outs 2. Support technical aspects of AOP completion and assessment of effectiveness and efficiency 3. Support completion of Regional AOP proposal and funding requests (FY+) 4. Present Regional AOP proposal and funding request to RMT (FY+) 5. Submit regional funding request (FY+)
4th Quarter Jan. 1st – March 31st	1. Finalize current fiscal AOPs 2. Engage with and update collaborators 3. **Generate fiscal summary for management review and AORR Report**	1. Initiate update 2. Compile current fiscal summaries into the AORR Report and share 3. Support completion of fiscal year end activities

Table Interpretation:

- Items in black are associated with the current fiscal year
- FY+ items in red are core planning activities related to the following fiscal
- **Bold items in 3rd and 4th Quarter are intimately linked with performance measures and adaptive management cycle. Lessons learned will be integrated into AORR Report**

5 STRATEGIC FOREST HEALTH TRAINING AND EXTENSION

The forest health data collected by Ministry employees, contractors and forest licensees is essential to determine the extent, severity, and potential for spread for both insects and pathogens. Aerial and ground surveys and monitoring protocols require expertise, skill, experience, and attention to detail. In addition to accurate insect and pathogen identification, susceptible tree species identification and the characteristic signs and symptoms must be identified accurately. This often requires surveys to be conducted during seasonally constrained timeframes that are species-specific and reflect the presence of temporary diagnostic features evident only during the biological development window. Regular training with a standard of excellence and consistent application of knowledge are the foundations for accurate and effective forest health monitoring and assessment.

Given the importance of regular, specialized forest health training, the seasonal priorities for training and extension activities are:

SPRING/SUMMER

- Forest health agents in young stands: refresher workshops for field identification geared towards silviculture surveys and management training opportunities by TSA and Natural Resource District.
- Pine stem rusts: refresher workshops for field identification geared towards silviculture surveys and management training opportunities by TSA and Natural Resource District.
- Young Stand Monitoring (YSM): TSA-specific forest health training for contractors as requested by Forest Analysis and Inventory Branch.
- Stand Development Monitoring 2.0 (SDM 2.0): project specific forest health training and survey support as necessary to facilitate formal management projects (by request only).
- Diagnostic services and troubleshooting for insects, pathogens, drought and other abiotic damage provided to contractors, district staff, licensees, and any other interest groups (by request only).

FALL/WINTER

- Standardized North Area bark beetle training curricula, survey protocols, and data collection protocols for the four major bark beetles: mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle, with web-based, user-friendly data access portals.
- Collaborative and development of forest health tools and resources to support management and provincial initiatives such as Land Use Planning (LUP) and Forest Landscape Plans (FLPs).
- Collaborative review and development of standardized contract language for survey contracts to improve data collection consistency across North Area, and to ensure centralized, useable data use.

At this time, many of the training opportunities are by request only and require interested parties to contact the Regional Forest Health Specialists. Efforts to standardize forest health training in the region are ongoing and all feedback or inquiries are most welcome. Forest health training and extension in the region is provided directly by Regional Forest Health Specialists or qualified, delegated Ministry staff in order to ensure that all interested professionals have timely access to forest health training and expertise. For example, once standardized curricula and materials are developed for bark beetles, key local Ministry staff will be trained to provide bark beetle survey training courses (in Dawson Creek, Mackenzie and Prince George) according to expressed interest. New tools and resources are being developed to support online learning opportunities and to aid in introductory, intermediate, and advanced learning.

6 STRATEGIC ACTION PLAN FOR PRIORITY INSECTS

The strategic action plan is focused on the key insects of concern in the Omineca Region. In order to make the most of limited time and resources, the strategic plan focusses on the general management approach to each insect of concern, the development of consistent, useable tools to address long-standing program needs, the development hazard and risk-rating tools, and the development of tools to facilitate information transfer and communication across the North Area.

6.1 BARK BEETLES

Bark beetles are a high priority issue for forest health management in British Columbia. Proactive management for the major bark beetles, **mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle**, should be at the forefront of forest management, with a focus on the reduction of suitable breeding sites and careful planning of future forests to improve resilience.

Climate change, weather, and bark beetles: Periodic bark beetle outbreaks are a normal occurrence in the pine, spruce, and fir forests that dominate the landscape in the Omineca Region, but recent changing climate and weather patterns have resulted in conditions that allow for bark beetle populations to increase beyond the historical range and severity. A general trend towards warmer weather and most importantly warmer winter temperatures – the annual extreme minimum temperature has increased between 2.9-5.7°C in the Omineca Region since 1895 (Foord 2016) – means that bark beetle overwintering mortality due to early winter cold snaps has not recently been a strong natural population control. High overwintering survival, in combination with warmer summer and fall minimum temperatures, allow insects more time to grow and develop. These conditions result in multiple robust bark beetle populations throughout the region that are difficult to manage.

The impact of bark beetles: The Province of BC conducts an annual Aerial Overview Survey (AOS) to detect the extent and severity of forest health factors. The AOS tracks the areas and severity of bark beetle damage each year.

Aerial overview survey data is used to estimate Non-recoverable Losses (NRLs) to timber supply within the timber harvesting land base (THLB), which are calculated as a running average based on the past several years (5-15 years).

The impact from mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle are not limited to non-recoverable losses of the timber supply. Bark beetle outbreaks also result in positive (e.g. ecosystem diversity and resilience, Rupert et al. 2015) and negative changes to carbon sequestration, recreation, fish and wildlife, watershed management, range, landscape values and aesthetics, cultural heritage, and forest ecosystems in general (e.g. human systems and values, Morris et al. 2016).

The goal of bark beetle management is to mitigate the timber loss, but also to work *with* natural bark beetle disturbances in forest ecosystems to ensure healthy and resilient future forests.

The following sections outline and describe the strategic action plans for the Mackenzie, Prince George, and Robson Valley TSAs. First in section 6.1.1, the bark beetle management units are defined. Then for each beetle (mountain pine beetle, section 6.1.2; spruce beetle, section 6.1.3; Douglas-fir beetle, section 6.1.4; and western balsam bark beetle, section 6.1.5) the overall strategy is first described, beetle management unit (BMU) maps are provided and designated, and where applicable specific actions are recommended for each TSA.

6.1.1 BEETLE MANAGEMENT UNIT (BMU) STRATEGIES

Management unit boundaries for bark beetles were established in each of the TSAs as a basis for developing consistent pest-specific strategies, tied to actions, within each area for bark beetles. These Beetle Management Unit (BMU) boundaries were based on existing Landscape Units (LU). Although BMUs are designated independently, it is important to recognize that units are not isolated, and therefore may influence adjacent units. Currently, mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle are the forest health factors that have been assigned a management strategy in the Omineca using BMUs. The five BMU strategies (defined in section 6.1.1.1) are assigned based on the level of bark beetle infestation (area and severity), accessibility for treatment tactics, and the amount of susceptible host trees available in each unit (potential for spread).

Beetle management units are defined by the general goals for each landscape unit. Given the variation within a landscape unit, stand-level decisions for managing bark beetles must consider the unique situations for that site. These strategies are meant to be used as a guide to focus resources for efficiently treating bark beetle infestations at the landscape level. The goal is to achieve the BMU strategy for most, but not necessarily all, of the timber harvesting in that Landscape Unit. BMU maps are available to support strategic planning.

6.1.1.1 BARK BEETLE MANAGEMENT UNIT STRATEGY DEFINITIONS

Five bark beetle management strategies for BMU's are outlined with a visual representation of the factors governing outbreak dynamics shown in Figure 3.

1. **Proactive:** uses proactive management tactics and is applied where beetle populations are in the **endemic** population phase. The key goal of the Proactive strategy is to prevent beetle populations expanding to unmanageable levels.
2. **Targeted:** uses aggressive pest reduction tactics on beetle populations that are in the **incipient** population phase and is applied where pest populations are building but can still be effectively reduced before more widespread infestation occurs.
3. **Reactive:** uses tactics in response to pest populations that are in the **epidemic** population phase. The goal of the Reactive strategy is to reduce and mitigate widespread bark beetle-caused host tree morality.
4. **Salvage:** focuses on the harvesting of mostly dead or dying trees and stands to minimize timber value losses in widespread infestations and is applied where management efforts would be ineffective in reducing beetle populations and subsequent levels of damage. The Salvage strategy is most suited for beetle populations that are nearing the end of the **epidemic phase or in the post-epidemic** phase. The goal is to recover timber value, to regenerate impacted areas and to reduce fire risk to promote future more resilient forests.
5. **No Action**: is applied to designated areas where:
   a) natural disturbances are left unmanaged;
   b) management efforts would be ineffective in substantially reducing beetle populations and impacts;
   c) there is no short-term possibility of salvaging dead timber;
   d) access cannot be put in place before substantial merchantable degradation of the dead material (economically constrained areas); and,
   e) non-timber values or other management constraints such as wilderness areas, Parks or ecological reserves, culturally significant areas, supersedes that of timber or wood products.

   Areas designated as no action should be large enough to allow for the full range of ecosystem processes through time.

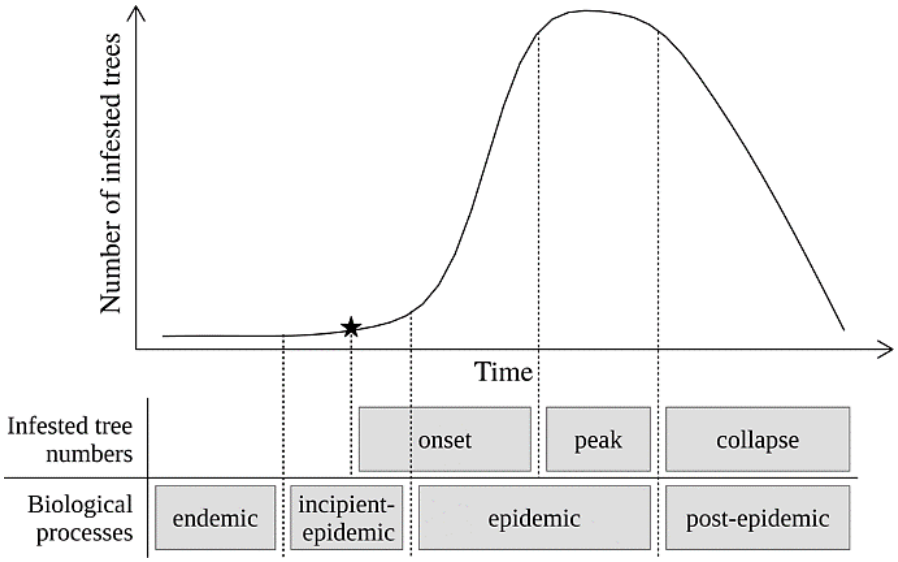

Figure 3 – Factors governing bark beetle outbreak dynamics. Each process during the outbreak corresponds to the bark beetle management unit strategy.

6.1.2 MOUNTAIN PINE BEETLE

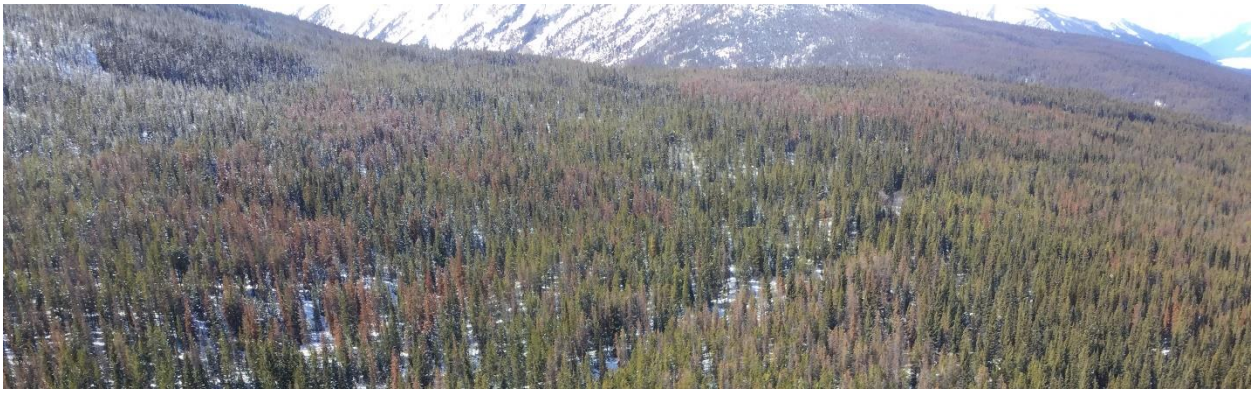

Figure 4 – Recent mountain pine beetle attack in the Robson Valley TSA.

Mountain pine beetle (*Dendroctonus ponderosae*) continues to infest a relatively small area after dropping down from an unprecedented outbreak peak covering almost 18 million hectares throughout British Columbia and Alberta. Although the extent of infestation is relatively small, some areas of the Omineca Region continue to sustain significant annual attack levels. The region has had the largest area of damage in the province for the last several years. Weather conditions and warm winter temperatures keeps this insect a priority forest health factor in the Omineca.

Because the current attack area is concentrated in relatively inaccessible areas of the Robson Valley TSA, there are few short-term pest reduction actions that can be applied. Many of the mountain pine beetle-killed stands in the Omineca Region died during the large outbreak peak in the early 2000s, and they are reaching the end of their economic viability or "shelf life". Where there is mostly older standing dead pine, the beetle management units are designed for salvage harvesting where it is economically feasible and ecologically reasonable. Where mature susceptible pine and spots of mountain pine beetle attacks are visible from the air

(e.g. in the Robson Valley TSA), targeted pest reduction strategies such as trap trees, fall and burning, and pest reduction harvesting for suppression are recommended.

Please see the following link to view the BMU map, host susceptibility mapping, and aerial survey data for mountain pine beetle:
https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/Omineca_BMUs/

In addition to BMU strategies and harvesting priority, the most effective action for mountain pine beetle is longer term planning of pine-dominated forests while keeping in mind the Strategic Action Plan for Pathogens. Re-planting of mountain pine beetle-killed stands must be conducted with foresight for prevention of future outbreaks in mind. In the long term, this insect population is only temporarily reduced, and given climate predictions for this region, a population outbreak will likely recur when the host population reaches susceptible age and diameter. Actions such as planting mixed stands, with deciduous component where possible, and updating stocking standards to reflect changing climate and weather patterns for areas that are suitable for the planting of lodgepole pine are strongly recommended.

6.1.3 SPRUCE BEETLE

Figure 5 – Spruce beetle infested trees in the Prince George TSA.

The current Omineca spruce beetle (*Dendroctonus rufipennis*) outbreak started in 2014, and it is continuing throughout the Omineca Region. Cumulatively, between 2014 and 2019, the total area impacted by spruce beetle (including 'trace' levels of attack) is 1,312,535 hectares provincially; most of the outbreak area is in the Omineca Region. In June 2020, the Office of the Chief Forester recently released the guidance document Chief Foresters Expectations for Prioritization in Response to Spruce Beetle Outbreaks. This includes general guidelines for both pest reduction harvesting and salvage (e.g. percentage mortality recommended for priority harvesting) in spruce beetle-attacked areas.

In the Mackenzie TSA, a reduction in the number of susceptible host trees means that the active infestations are likely to decline in this TSA over the next three years. As a result, most of the accessible BMUs in this TSA are designated as salvage, and likely will be managed as such in the future. Much of the scientific literature recommends against widespread salvage after bark beetle disturbances as this practice is detrimental to

ecosystem processes (Lindenmayer et al., 2004; Werner et al. 2006). Even though the BMU is designated as salvage, in order to maintain healthy forest ecosystems, widespread salvage of dead and dying timber is not recommended unless the economic benefit of salvaged wood is the clear priority. This is especially important in spruce ecosystems where mortality of the overstory spruce leaves space and resources for understory and non-spruce trees to release.

Within the Prince George TSA, there is a mix of salvage and targeted pest reduction BMUs. The salvage BMUs are likely to increase in area within the next three years as the current outbreak expands to the south and east of Prince George. Where there is active infestation, the BMUs will be designated as targeted or reactive pest reduction.

In the Robson Valley TSA, some of the areas with active spruce beetle infestations are designated as targeted pest reduction harvesting, where harvesting is practicable. The remaining areas are designated as no action because they are difficult to access for forest management, and do not yet contain widespread beetle infestations.

The focus of proactive pest reduction in the Prince George and Robson Valley TSAs should be on the reduction of breeding sites wherever possible. This includes the use of trap trees, anti-aggregation pheromones, and the prompt removal of, or application of anti-aggregation pheromones on, windthrown host trees. Early identification of new infestations is key to proactive spruce beetle management and therefore ground surveys of susceptible stands containing aerially recorded dead spruce will be conducted annually by the Ministry. This information will be shared with licensees at spruce beetle working group meetings so that pest reduction harvesting can be focused in areas of active infestation.

Fertilization of stands on the threshold of susceptibility (age class 4-6) should be minimized in areas with BMUs designated by targeted or reactive strategies.

Please see the following link to view the BMU map, host susceptibility mapping, and aerial survey data for spruce beetle:
https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/Omineca_BMUs/

In addition to BMU strategies, within the next three years, the government of BC will continue to offer training in spruce beetle ground identification and risk assessment. A spruce beetle ground survey course will be offered by ministry representatives, and at least two additional ministry employees will be trained to instruct spruce beetle survey courses to consultants, industry professionals, First Nations, municipal employees and community groups needing to understand spruce beetle infestations in local areas. For additional information on spruce beetle ground survey training, please contact the Regional Entomologist, Omineca Region.

As part of the response to the spruce beetle outbreak, licensees in the Omineca Region have produced an annual Licensee Spruce Beetle Action Plan. The ministry will develop and implement a harvest monitoring plan to report and update on the progress made towards achieving BMU strategy objectives by working with licensees to prioritize and target pest reduction harvesting activities.

6.1.4 DOUGLAS-FIR BEETLE

Like spruce beetle and mountain pine beetle, Douglas-fir beetle (*Dendroctonus pseudotsugae*) populations are high throughout its range, including in locations where the range of Douglas-fir extends northward into the Omineca Region.

The Ministry will continue to treat areas where it is possible to selectively remove current infestations using fall and burn techniques and work together with licensees to encourage targeted pest reduction harvesting wherever practicable. The majority of the BMUs for Douglas-fir beetle are designated as proactive pest reduction or as targeted pest reduction in the Omineca Region.

Please see the following link to view the BMU map, host susceptibility mapping, and aerial survey data for Douglas-fir beetle:
https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/Omineca_BMUs/

6.1.5 WESTERN BALSAM BARK BEETLE

Western balsam bark beetle (*Dryocoetes confusus*) causes widespread, but low intensity, mortality of *Abies lasiocarpa* (subalpine fir; locally referred to as "balsam fir") throughout British Columbia. The provincial infestation area for western balsam bark beetle was over two million hectares each year, since 2014. Most of this damage is recorded in the 'trace' severity category, but the cumulative impact on stands of subalpine fir over time, is potentially significant, and most of this damage continues to occur in the Omineca Region.

Although western balsam bark beetle does not historically rank highly for economic and ecological importance in the annual Forest Health Strategies, the scale of the provincial and regional damage, along with the significant increase in affected area, warrants further attention. Infested areas can be salvaged where feasible, especially where western balsam bark beetle is concurrent with other forest health factors like spruce beetle. Stands scheduled for harvest could be proactively baited with aggregation pheromones to help concentrate beetles in the stands scheduled to be harvested within a defined timeframe.

In order to obtain addition information on the impact of subalpine fir in the Omineca Region, at least one BMU in the Omineca Region will be selected for more intensive monitoring. Selected stands within this BMU will be surveyed to collect baseline information over time on the cause, incidence and severity of subalpine fir mortality where high numbers of western balsam bark beetles have been recorded in the AOS. Once a successful survey design is established, the survey area will be expanded to include a wider range of stands across the region.

Please see the following link to view the BMU map and aerial survey data for western balsam bark beetle: https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/Omineca_BMUs/

6.2 DEFOLIATORS

This section of the strategy is intended to provide information and context around the management of priority insects that may pose management challenges that are complicated and not easily resolved by increasing financial investment. In most cases, the management of these insects requires improved data collection procedures and site-specific approaches that incorporate ecological linkages and climate change.

6.2.1 TWO-YEAR CYCLE BUDWORM

Two-year cycle budworm (*Choristoneura biennis*) is a major insect defoliator of interior spruce and subalpine fir in central BC. Although the two-year cycle budworm's economic and ecological importance was ranked low in the Omineca Region, the population should be carefully monitored.

Currently, active management is not being implemented for two-year cycle budworm. *Bacillus thuringiensis* subsp. Kurstaki (Btk), a biological insecticide, is the only direct control measure that would be suitable for use and is registered for use against two-year cycle budworm. Limited use may be justified for localized high value stands that require protection, should this insect significantly increase in area or severity in the Omineca Region.

6.2.2 ASPEN LEAF MINER

Multiple successive years of infestation by aspen leaf miner (*Phyllocnistis populiella*) means this pest continues to be a moderate priority forest health factor in the Omineca Region. Although aspen can generally tolerate repeated defoliation over several years, the combination of widespread infestation of aspen leaf miner, infestation by other defoliators (e.g. large aspen tortrix), infection by Venturia blight, and/or drought may contribute to a general aspen decline. Continued information gathering into the potential impact of aspen decline and monitoring of disease complexes are priorities in the Northeast Region.

For more information on the strategy and activities for aspen decline please refer to the Northeast Regional Forest Health Strategy.

Figure 6 – Aspen serpentine leaf miner in the Mackenzie TSA

6.3 INVASIVE INSECTS

The following insects and pests are invasive and are presented here to highlight their current presence in the Omineca Region. Proactive and early detection of invasive species in new areas or with expanding distributions is essential for effective containment and management. Balsam woolly adelgid and poplar and willow borer are the two invasive insects in the Omineca Region that will be monitored over the next three years.

6.3.1 BALSAM WOOLLY ADELGID

Balsam woolly adelgid (*Adelges piceae*) attacks all true firs, including subalpine fir. Although this invasive insect has primarily been an issue in southern BC, the presence of the balsam woolly adelgid was confirmed outside its quarantine zone on the central and south coast areas of BC in 2015. It is not yet known how far this insect has spread into the interior of British Columbia, but it was positively identified near Kamloops BC. If you find a suspected attack, please notify the Regional Entomologist and/or the Provincial Entomologist. This is also one of the insects that will be monitored during the surveys of subalpine fir for western balsam bark beetle.

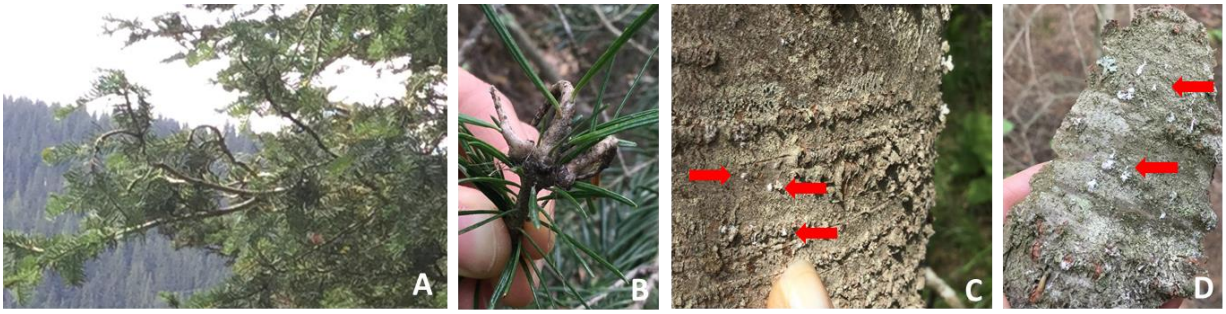

Figure 7 – Symptoms and signs of balsam woolly adelgids: (A) Curled infested branches with swollen nodes, (B) a close-up view of swollen branch nodes, (C) adult adelgids on an infested tree, they are small, white and fluffy, (D) adelgids on a piece of infested bark.

6.3.2 POPLAR AND WILLOW BORER

Figure 8 – Poplar and willow borer in the Prince George TSA

Poplar and willow borer (*Cryptorhynchus lapathi*) is an invasive species originating in Europe that was introduced to BC in 1923 (Broberg et al. 2001); this species continues to noticeably attack native willow species in the Omineca, especially along roadways. Although not a high priority forest health issue, an 'issues analysis' on the prevalence, severity, management and expansion of this insect will be conducted to better understand the impact of this insect within the Omineca Region.

7 STRATEGIC ACTION PLAN FOR PATHOGENS

The goal of this strategic action plan is to address the current needs related to forest pathogens in the Omineca Region. With increasing uncertainty due to climate change, the Pathogen Action Plans aim to identify potential areas of incremental improvement while providing baseline data and tools that will support the application of beneficial management practices.

The priority pathogens and the disease they cause include:

➢ *Cronartium comandrae*	Comandra blister rust
➢ *Cronartium coleosporioides*	Stalactiform blister rust
➢ *Endocronartium harknessii*	Western gall rust
➢ *Cronartium ribicola*	White pine blister rust
➢ *Dothistroma septosporum*	Red band needle blight
➢ *Elytroderma deformans*	Elytroderma needle cast
➢ *Arceuthobium americanum*	Lodgepole pine dwarf mistletoe
➢ *Onnia tomentosa*	Tomentosus root disease

These priority pathogens have specific Action Plans for the next three years, unless earlier revision is warranted, with the following objectives:

1) Assess current knowledge and data to address knowledge gaps and identify meaningful next steps to incrementally improve operational forestry
2) Develop baseline tools to support decision makers, planners and field staff
3) Revise and update the beneficial management practices while ensuring the information is easily accessible and in appropriate formats

Please note: pathogens that are not listed above are still of interest and will receive attention on an annual basis or as necessary. The strategy for addressing disease flareups focuses on detection, accurate identification, delineation of infected area and clear documentation for ease of reference in the future. It is anticipated that foliage pathogens will continue to persist at low to moderate levels.

Interested to learn more about tree diseases in BC?! Please see Forest Pathology Resources

Wondering how you can help?!

If you are interested in these activities or you have valuable information to contribute to the program objectives, please reach out! Some simple ways you can support the Pathogen Action Plan to improve include:

- Share your observations and notify the Regional Forest Health Specialists about new concerns
- Collect GPS coordinates and samples (paper bags only please!) when you see something odd
- Provide feedback on this strategy, the priority activities and target deliverables

Stay engaged and ensure this program supports you to address the challenges we are responsible to manage!

7.1 ENDEMIC STEM RUSTS

In the Omineca Region, the range of incidence of endemic pine stem rusts of lodgepole pine (*Pinus contorta* var. *latifolia*) is approximately 0-30% with some areas expressing higher levels of disease due to the compounding challenge of multiple damage agents. In response to the persistent diseases caused by these pathogens, many efforts have been made over the past 30 years to mitigate the losses.

To address this long-standing issue and complement ongoing efforts, the following activities will be initiated:

- Data mining to define knowledge gaps
- Assessment of ecological parameters, including climatic variables at multiple scales
- Refresh the hazard and risk mapping
- Develop adjustment factors for summarizing RESULTS survey data to increased accessibility
- Revise the Regional Rust Management Strategy
    - Engage with licensees, practitioners, and district staff
    - Integrate operational learning and new information into the strategy
- Review and revise standard survey methods for pine stem rusts to ensure compatibility with provincial programs and consistency across region
- Validate spatial assumptions that limit the integration of data into Timber Supply Review (TSR).

If you are interested to learn more, please see the online resource: Rust Management Strategy – Omineca Region (Draft) 2013.

Figure 9 – Stem cankers of lodgepole pine caused by *Endocronartium harknessii* (left), *Cronartium coleosporioides* (middle) and *Cronartium comandrae* (right).

7.2 WHITE PINE BLISTER RUST

Several alpine areas and upper mountain ranges in the Omineca are home to the northern extent of Whitebark pine (*Pinus albicaulis*). In addition to climate change impacts on alpine ecosystems and mountain pine beetle, these Whitebark pine ecosystems are being threatened by the **introduced** pathogen *Cronartium ribicola,* the cause of white pine blister rust. Currently, Whitebark pine is a blue-listed species (Special Concern) in BC and many efforts are underway to protect this valuable habitat and support the longevity of this keystone species.

To address this complex issue and complement ongoing efforts, the following actions will be sustained throughout the 3-year term of this strategy:

- Reassess long-term health monitoring plots (5-year remeasurement, multiple sites annually)
    - Conduct tree health screening and cone collection to support the breeding program
- Data mining to identify knowledge gaps
- Engage in development and revision of proposed management plans

If you are interested to learn more, please see the online resource: A tactical plan for the recovery of Whitebark pine in the Omineca Region.

Figure 10 – View from permanent sample plot on Tsitsutl Mountain (left) and sporulating infection on Whitebark pine (*Pinus albicaulis*) caused by *Cronartium ribicola* (right).

7.3 FOLIAGE PATHOGENS

The occurrence of foliage pathogens is intimately linked to localized weather that supports humid, warm conditions during the growing season and localized infection may persist over multiple years as long as suitable conditions continue. When this occurs, the inoculum potential within a site increases along with the risk to susceptible species. The two species of primary interest are *Dothistroma septosporum* (Red band needle blight) and *Elytroderma deformans* (Elytroderma needle cast).

Dothistroma septosporum Red band needle blight

There are several areas of moderate to high hazard within the Omineca Region due to the high component of lodgepole pine in plantations. "*Dothistroma* hotspots" have been detected during the AOS and are actively being monitored. To ensure up-to-date information and shared understanding of the dynamics in the Omineca Region, the following actions will be sustained throughout the 3-year term of this strategy:

- Review, ground check and verify all AOS polygons identified as DFS (*Dothistroma septosporum*)
- Data mining to define knowledge gaps
    - Comparing Omineca Region data with Skeena Region data
- Assessment of ecological parameters, including climatic variables at multiple scales
- Compile a cumulative map of occurrence to support management decision
- Monitor known "*Dothistroma* hotspots"

If you are interested to learn more about Dothistroma needle blight please see the online resource: British Columbia's Northern Interior Forests Dothistroma Stand Establishment Decision Aid.

Figure 11 – Symptoms and signs of Dothistroma (red band) needle blight, caused by *Dothistroma septosporum*, on lodgepole pine.

Elytroderma deformans **Elytroderma needle cast**

The symptoms and tree-level impacts of *Elytroderma* are highly variable in the Omineca Region ranging from infected foliage, that becomes stunted over time, to large stem cankers, that diminish wood quality in the first bole. The symptoms of this pathogen are rarely detected during the AOS. The most frequently observed infections are on lower branches or stem. Due to the similarity of appearance with other foliage pathogens, and how difficult it is to distinguish between species of foliage pathogens, the cumulative dataset is not robust.

To enhance data and understanding of the potential losses due to Elytroderma needle cast in the Omineca Region, the following actions will be conducted throughout the 3-year term of this strategy:

- Review literature and collaborate with specialists to increase understanding of biology and dynamics in different ecological systems
- Review, ground check and verify all AOS polygons identified as DFE (*Elytroderma deformans*)
- Data mining to define next steps
- Assessment of ecological parameters, including climatic variables at multiple scales
- Monitor known infected areas and generate spatial tools

If you are interested to learn more about Elytroderma needle cast in BC please see the online resource: Elytroderma needle cast on lodgepole pine in British Columbia.

Figure 12 – Symptoms and signs of Elytroderma needle cast, caused by *Elytroderma deformans*, on lodgepole pine.

7.4 LODGEPOLE PINE DWARF MISTLETOE

Due to the widespread mortality of lodgepole pine in the Omineca Region caused by the mountain pine beetle, it seems that dwarf mistletoe, *Arceuthobium americanum*, has gone off the radar. As pine plantations and understory of dead pine regenerate, it is anticipated that management of dwarf mistletoe may need to become more active. For example, dwarf mistletoe is persisting in the understory of retained areas or cut block boundaries adjacent to pine stands. If left unmanaged, the mistletoe can spread to new plantations.

To address this resurfacing issue, the following activities will be initiated:

- Data mining to define sub-populations at risk of infection
- Select and monitor stands identified by BC Timber Sales (BCTS)
- Assess feasibility of hazard mapping based on post-mountain pine beetle distribution
- Support dwarf mistletoe surveys as requested
- Increase awareness of new management recommendations
    - designing site preparation treatments with mistletoe in mind and not leaving unnecessary seed trees or retention patches where mistletoe is evident or suspected

If you are interested to learn more about dwarf mistletoe of lodgepole pine management in BC please see the online resource: Dwarf Mistletoe Management in British Columbia.

Figure 13 – Aerial shoots of dwarf mistletoe, caused by *Arceuthobium americanum*, on lodgepole pine.

7.5 ROOT PATHOGENS

Root disease is not the prominent issue in the Omineca Region when compared with other areas of the province. However, there is a need to better understand where root diseases are negatively affecting stand productivity, the culprit and how to support practitioners to improve management practices.

In addition to the pathogen-specific activities below, other goals of the Action Plan for Pathology include:

- Compile knowledge of the extent and spatial location of root diseases

If you are interested to learn more about root disease management in BC please see the online resource: Managing Root Disease in British Columbia.

Onnia tomentosa — Tomentosus root disease

Tomentosus has been found to have inconsistent above ground symptoms and its distribution is not captured by the AOS. To ensure up-to-date information and improved spatial tools for the Omineca Region, the following actions will be sustained throughout the 3-year term of this strategy:

- Data mining to define knowledge gaps
- Collect and compile the spatial location of known "Tomentosus hotspots"
- Ground truth known "Tomentosus hotspots"

Figure 14 – Fruiting body of *Onnia tomentosa* and the pitted decay of hybrid spruce roots – typical of tomentosus root disease.

8 IMPACT OF FOREST HEALTH FACTORS ON TIMBER SUPPLY

As governed by the Forest Act (Section 8), the Chief Forester must consider forest health as it relates to the value of timber in the determination of the AAC. Therefore, information on the presence and severity of forest health factors and the impact they have on the timber supply is paramount. The inclusion of such information in Timber Supply Reviews (TSRs) has resulted in recommendations for improvement by the Chief Forester. The recommendations from the Implementation section of the *Rationale for Allowable Annual Cut (AAC) Determination* documents have been summarized and used to develop specific priorities to be addressed in the Regional and District Forest Health Strategies.

8.1 INCORPORATING FOREST HEALTH INTO TSR

Forest health factors are generally accounted for in TSR in the following three ways:

1) Endemic pest levels are often accounted for in growth and yield modeling. In unmanaged stands, yield estimates are made using the Variable Density Yield Projector (VDYP) which includes the impacts of endemic pests;

2) Pest losses in managed stands are accounted for through the use of Operational Adjustment Factors (OAFs) during the yield predictions generated by the Tree and Stands Simulator (TASS) and Table Interpolation from Stand Yields (TIPSY) programs; and

3) Accounting for pests is through non-recoverable (or unsalvaged) losses (NRLs).

Within OAFs there are two categories: OAF 1 and OAF 2. OAF 1 reduces the potential yield by a constant percentage and is used to account for small stocking gaps incapable of growing trees; the default value for OAF 1 is 15%. OAF 2 is used to account for specific factors that increase over time such as the impact from root disease. The default value for OAF 2 of 5% only accounts for losses from decay, waste, and breakage.

Forest Health Specialists provide data and analyses to support incorporation of forest health impacts for timber supply review.

8.2 CHIEF FORESTER'S RECOMMENDATIONS

The priorities mentioned below have been selected from the Implementation section of the *Rationale for Allowable Annual Cut (AAC) Determination* documents of recent TSRs in the Prince George (Table 2), Mackenzie (Table 3) and Robson Valley (Table 4) TSAs. These priorities are addressed through the Regional Forest Health Program, Forest Health Strategy and Annual Operating Plans that guide operational activities, research projects and resource management to best align with the provincial goals for forest management. The relative status of each recommendation (not initiated, initiated, ongoing, on hold, or completed) is provided and further inquiries can be made directly to the Regional Forest Health Specialists. The Chief Forester's recommendations that are not specific to forest health or those that are highly collaborative may not be reflected in this document. For access to the full TSR reports please see: Timber Supply Review and Annual Allowable Cut.

Table 2 – Recommendations for forest health in the Prince George TSA.

Year	Priorities for the Prince George TSA	Status
2011	• Ministry of Natural Resource Operations (MNRO) staff should determine the incidence of hard pine rusts in the Vanderhoof Forest District and should monitor the growth and early tree survival or mortality of managed stands. • MNRO staff should continue monitoring the performance of managed stands by strata by examining each analysis unit and applying a systematic approach, as opposed to random sampling, a stratified sample would provide improved information on what is happening in each stand type. • MNRO staff should monitor the development of young, MPB affected stands to determine the stand development trajectory. • MNRO staff should refine the application of NRL estimates by distinguishing between pine and non-pine stands for the next timber supply review.	INITIATED INITIATED ONGOING COMPLETED
2017	• Ministry staff to continue to support data collection and analysis for the Young Stand Monitoring program. • Ministry staff to work with licensees to maintain the focus on spruce beetle sanitation harvesting, and the removal of live infested trees at the leading edge of the outbreak. • Work with provincial forest health and forest practices specialists to develop appropriate management guidelines for retention and harvest techniques to use in spruce beetle areas, taking into consideration constraints and retention targets related to other values including wildlife, fisheries sensitive watersheds and biodiversity.	ONGOING ONGOING COMPLETED

Table 3 – Recommendations for forest health in the Mackenzie TSA.

Year	Priorities for the Mackenzie TSA	Status
2014	• "I request that FLNR [Ministry of Forests, Lands, Natural Resource Operations] staff review the available information in order to better estimate the timber volume losses associated with western balsam bark beetle infestation." • "Climate change: climate change may impact site productivity estimates, forest health and other factors that were addressed in this determination. I encourage staff to try and understand projected climate change impacts in the TSA so that this important consideration can be factored into the next determination."	INITIATED ONGOING

Table 4 – Recommendations for forest health in the Robson Valley TSA.

Year	Priorities for the Robson Valley TSA	Status
2006	• Unsalvaged losses: To maintain a current perspective on forest health in relation to these losses, I have noted in "Implementation" a recommendation that MoFR [Ministry of Forests] staff work with licensees to obtain updated information on unsalvaged losses for use in the next analysis and AAC determination.	ONGOING

9 ONLINE FOREST HEALTH RESOURCES

Aerial Overview Survey (AOS)

Non-Recoverable Losses (NRLs)

Field Guide to Forest Damage in British Columbia

Northwest Invasive Plant Council (NWIPC)

Provincial Forest Health Strategy

Regional/District Forest Health Strategies

9.1 FOREST ENTOMOLOGY RESOURCES

Bark Beetle Management Guidebook

Chief Foresters Expectations for Prioritization in Response to Spruce Beetle Outbreaks

9.2 FOREST PATHOLOGY RESOURCES

Common Tree Diseases of British Columbia

Introduction to Forest Diseases

Rust Management Strategy – Omineca Region (Draft) 2013

A tactical plan for the recovery of Whitebark pine in the Omineca Region

British Columbia's Northern Interior Forests Dothistroma Stand Establishment Decision Aid

Elytroderma needle cast on lodgepole pine in British Columbia

Dwarf Mistletoe Management in British Columbia

Managing Root Disease in British Columbia

Review of literature on climate change and forest diseases of western North America

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11 GLOSSARY OF ABBREVIATIONS

AAC - Allowable Annual Cut

BEC – Biogeoclimatic Ecosystem Classification

BMU - Beetle Management Unit

CFS - Canadian Forest Service

FPC - Forest Practices Code

IFHM - Integrated Forest Health Management

IPM - Integrated Pest Management

NRFL - Non-Renewable Forest License

NWIPC - Northwest Invasive Plant Council

PSP - Permanent Sample Plots

SEDA - Stand Establishment Decision Aid

SOP - Standard Operating Procedure

TSA - Timber Supply Area

UNBC - University of Northern British Columbia

12 REGIONAL RESEARCH CONTACTS

Table 5 – Regional Research Contacts

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