OMINECA REGION

PRINCE GEORGE, MACKENZIE, AND ROBSON VALLEY TIMBER SUPPLY AREAS

FOREST HEALTH STRATEGY 2018-2019

BC MINISTRY OF FORESTS, LANDS, NATURAL RESOURCE OPERATIONS, AND RURAL DEVELOPMENT

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ACKNOWLEDGEMENTS

This strategy was written 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 our sources of input and information including FLNRORD staff from the Prince George, Stuart-Nechako, and Mackenzie Districts as well as local licensees and consultants. The collaborative effort was instrumental in the successful revision of this annual strategy.

Front cover photo – New spruce beetle adults ready to fly in the Prince George TSA.

Above photo – Jewel (left) and Jeanne (right) participating in the Douglas fir beetle course held in Quesnel; photo credit: Leo Rankin.

1 MISSION STATEMENT

The Omineca Forest Health Strategy provides a framework to co-ordinate and guide forest health activities within the Omineca Region and is aligned with, and driven by, the Provincial Forest Health Strategy. The vision and mission statement for the Omineca and Northeast Regional forest health programs is:

"To build strong working relationships to support the collection, analysis, and distribution of science-based operational forest health information."

1.1 INTRODUCTION

The Omineca Forest Health Strategy provides a framework to coordinate and guide forest health activities within the TSAs of the Omineca Region while ensuring consistency with the existing legislative objectives and the provincial forest health strategies and guidelines. The strategy aims to:

- incorporate the principles of Integrated Forest Health Management (IFHM) in order to effectively mitigate the risks and impacts of priority pests and pathogens on resource objectives;
- provide guidance in the form of best practices for managing priority pests and pathogens;
- summarize the current knowledge with regards to the impact of forest health factors on timber supply; and
- provide ecologically sound, scientific techniques for the protection and enhancement of resource values.

The Forest Health Strategy establishes a proactive approach that emphasizes the early detection of forest health problems, promptly implements scientifically sound solutions, and ensures that expenditures of resources are necessary, efficient, and cost effective.

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 situation; and
- practice adaptive management.

1.2 SCOPE OF THE FOREST HEALTH STRATEGY

This strategy applies to the Omineca Region, which contains three Timber Supply Areas (TSAs). The TSAs are located in the north central interior of BC and include: Prince George, Mackenzie, and Robson Valley (Figure 1). Together they cover approximately 15.84 million hectares and for the purposes of this report the combined, current allowable annual cut (AAC) is 13,213,559 m^3/year. For more information on the AAC by TSA and effective dates, please see: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/timber-supply-review-and-allowable-annual-cut

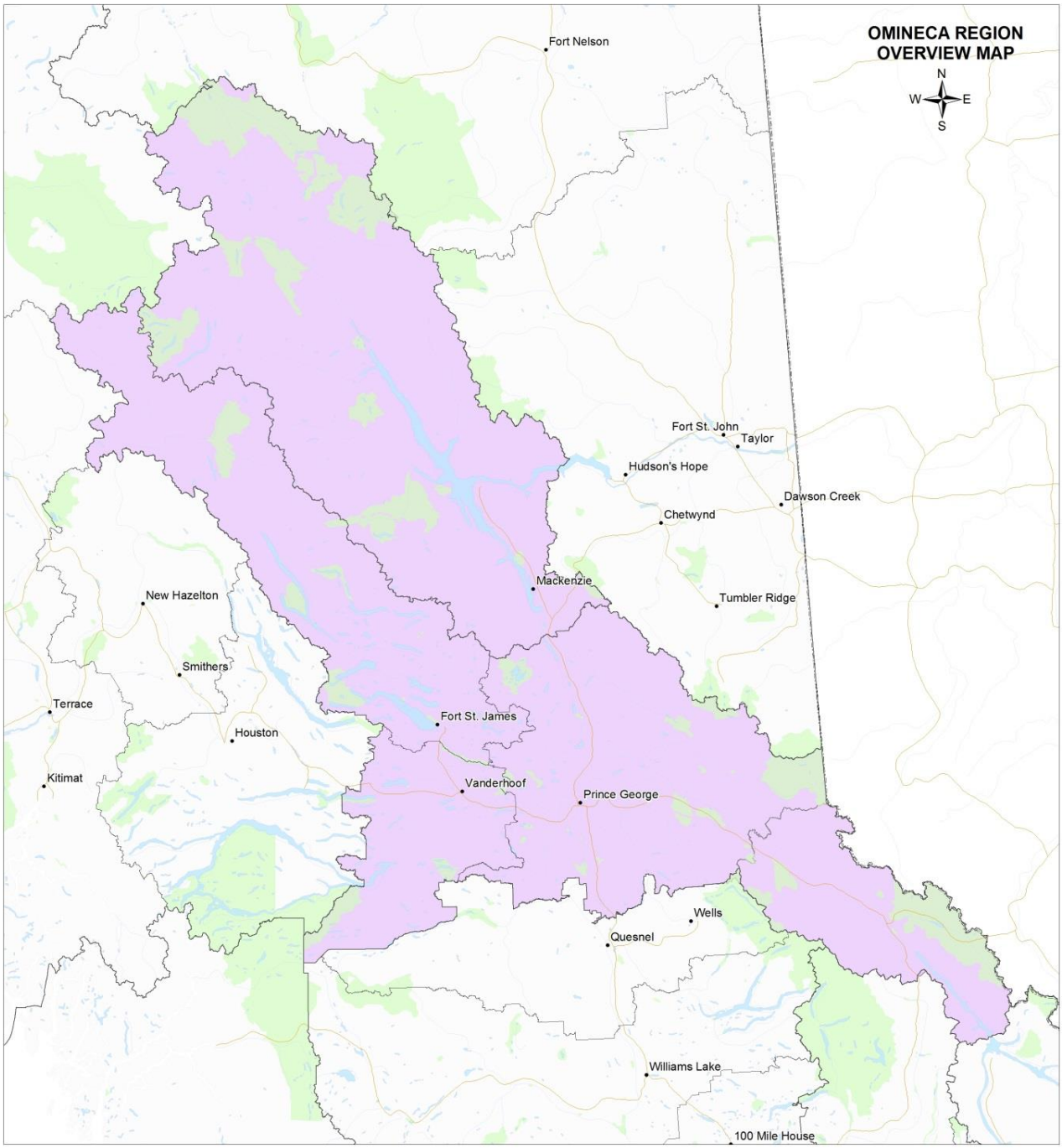

FIGURE 1 – THE OMINECA REGION.

1.3 OVERVIEW OF TIMBER SUPPLY AREAS

Prince George TSA

The Prince George TSA covers approximately 7.97 million hectares and extends from the Alberta border in the southeast, to the Spatsizi Plateau Wilderness Park in the northwest and Tweedsmuir Provincial Park in the southwest (Figure 2). The Prince George TSA contains eight timber supply blocks (A through H) and two natural resource districts: the Stuart Nechako Natural Resource District and the Prince George Natural Resource District. The current AAC is 8,350,000 m^3/year (effective as of 2017; until 2022) and is one of the largest timber management units in the province. More information about the AAC determination and partitions is available at the link below.

https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/timber-supply-review-and-allowable-annual-cut/allowable-annual-cut-timber-supply-areas/prince-george-tsa

Mackenzie TSA

The Mackenzie TSA is located in the north central interior of BC and covers approximately 6.41 million hectares (Figure 3). The TSA is administered from the Mackenzie Natural Resource District. The Mackenzie TSA extends just beyond the Rocky Mountains in the east, the Omineca Mountains in the west, the Village of McLeod Lake in the south and beyond the headwaters of the Kechika River in the north. Central to the TSA is the Williston Reservoir. The current AAC is 4,500,000 m^3/year (effective as of 2014). More information about the AAC determination and partitions is available at the link below.

https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/timber-supply-review-and-allowable-annual-cut/allowable-annual-cut-timber-supply-areas/mackenzie-tsa

Robson Valley TSA

The Robson Valley TSA is located east central BC in the interior wet-belt (Figure 4). The total area including parks is approximately 1.46 million ha and includes highly variable terrain that encompasses four biogeoclimatic (BEC) zones. The current AAC is 363,559 m^3/year (effective as of 2016). This TSA is administered from the Prince George Natural Resource District in Prince George and a field office in McBride. More information about the AAC determination and the 2016 adjustment is available at the link below.

https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/timber-supply-review-and-allowable-annual-cut/allowable-annual-cut-timber-supply-areas/robson-valley-tsa

PRINCE GEORGE TIMBER SUPPLY AREA

FIGURE 2 – THE PRINCE GEORGE TSA.

MACKENZIE TIMBER SUPPLY AREA

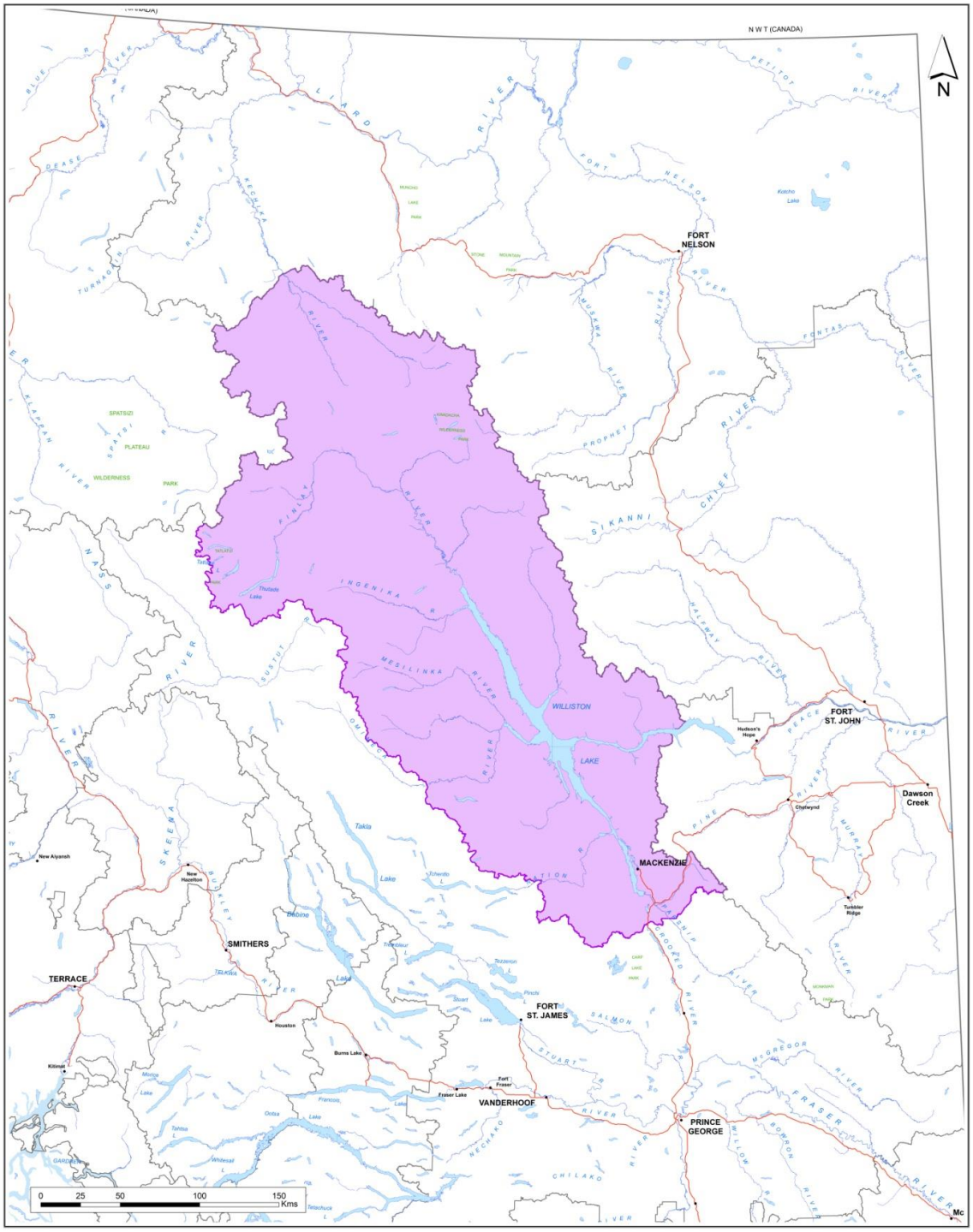

FIGURE 3 – THE MACKENZIE TSA.

ROBSON VALLEY TIMBER SUPPLY AREA

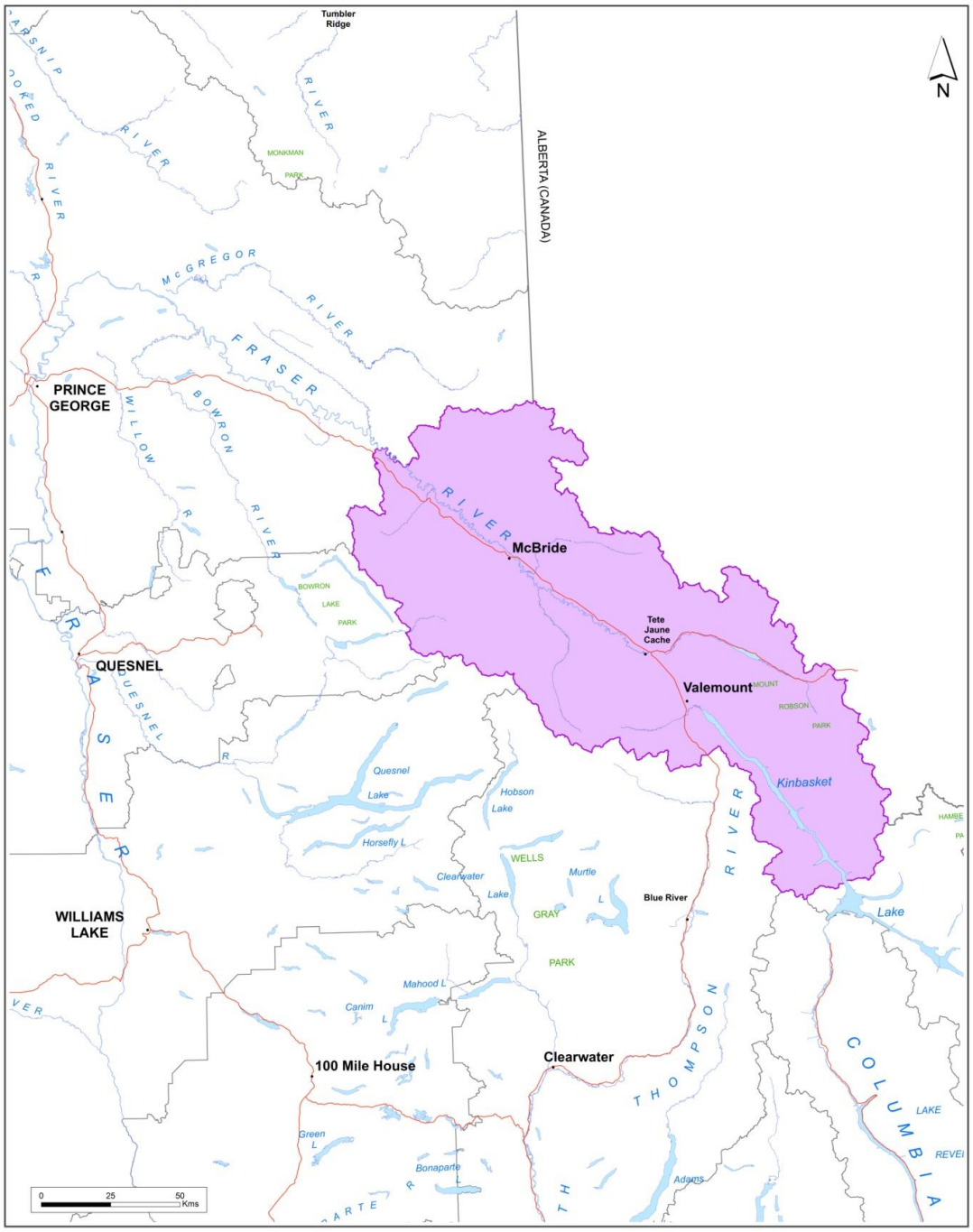

FIGURE 4 – THE ROBSON VALLEY TSA.

2 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 of forest health factors in forested ecosystems and the impact 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. These recommendations have been translated into priorities that must be used to help guide operations, research and management strategies to best align with the provincial goals for forest management. Forest health factors are generally accounted for in Timber Supply Review (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.

2.1 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 for the recent TSRs in the region. The recommendations from the Chief Forester that are not specific to forest health or those that are highly collaborative may not be represented by the priorities listed in this document. For access to the full TSR reports please visit: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/timber-supply-review-and-allowable-annual-cut

In addition to the TSR specific recommendations below, the Chief Forester has asked 3 questions related to information gaps in the province since 2015:

1) What is the influence of drought on the presence and impact of forest health factors on forests?
2) What are the impacts of drought on stand regeneration and the distribution of losses due to drought?
3) What is the impact of forest health factors on young conifer stands?

Prince George TSA

Year	Priorities from the Chief Forester's Recommendations
2011	• 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.
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.

Mackenzie TSA

Year	Priorities from the Chief Forester's Recommendations
2001	"Attempt to quantify the extent of isolated areas in the special planning cells, and any impacts to timber supply."
2014	"I request that FLNR staff review the available information in order to better estimate the timber volume losses associated with western balsam bark beetle infestation."
2014	"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."

Robson Valley TSA

Year	Priorities from the Chief Forester's Recommendations
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 staff work with licensees to obtain updated information on unsalvaged losses for use in the next analysis and AAC determination.

2.2 NON-RECOVERABLE LOSSES (NRLS)

NRLs are calculated for a specific list of forest health factors (see table below) and are often used for catastrophic events such as fires, blowdown, or beetle outbreaks. Aerial overview survey data is commonly used to estimate NRLs over the THLB, which are calculated as a running average based on the past several years (5-15 years). Losses due to mountain pine beetle are accounted for separately and are modeled using the BC Mountain Pine Beetle Model (http://www.for.gov.bc.ca/hre/bcmpb/).

For more information about non-recoverable losses and the current values please visit the FTP site: https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/NRLs/

Disturbance Description (forest health factor)	Disturbance Code	Affected Tree Species Code
Fire	NB	All Species
Drought	ND	All Species
Flooding	NF	All Species
Mountain Pine Beetle	IBM	Pl, Pw, Pa, Pf
Western Balsam Bark Beetle	IBB	Bl
Spruce Beetle	IBS	Sx
Douglas-fir Beetle	IBD	Fd
Fir engraver Beetle	IBF	Ba, Bl
Engraver Beetle (Ips species)	IBI	Pl
Lodgepole Pine Beetle	IBL	Pl
Twig Beetle	IBP	Pl
Red Turpentine Beetle	IBT	Pl
Western Pine Beetle	IBW	Py
Douglas-fir Tussock Moth	IDT	Fd
Yellow cedar decline	NCY	Yc
Unknown Beetle	IB	All conifers

3 OMINECA PEST ALERT!

New or noteworthy pests and pathogens in the Omineca Region.

The **Omineca Pest Alert** highlights new or unusual forest health issues. This includes invasive species with a potential for northern spread or lesser known pests and pathogens of interest to forest professionals and the general public in the Omineca Region. We will also use the pest alert to request samples or documentation of sighting of rare or new pests and pathogens.

For information on invasive plants for this region, please see http://nwipc.org/.

For information on additional invasive pests, please see:
http://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/invasive-pests-and-biosecurity

3.1 ENDEMIC INSECTS AND PATHOGENS

The following insects and pests are endemic. They are presented here to highlight their current presence in BC and to bring attention to our efforts to collect specific information to improve management efforts.

3.1.1 Birch leaf skeletonizer (*Bucculatrix* sp. or *Lyonetia* sp.)

An infestation of birch leaf skeletonizer, (possibly *Bucculatrix sp or Lyonetia sp*.), was identified attacking birch near McBride. Birch leaf skeletonizer not a priority insect in the Prince George TSA, but Figure 5 shows the damage and the caterpillar for this defoliator of birch. The affected birches are visible from the highway 16, around and east of McBride.

FIGURE 5 – BIRCH LEAF SKELETONIZER, PHOTOGRAPHED IN DUNSTER, BC.

Photos: (A) “Brown birch” visible from highway 16 near McBride – note that the aspen is unaffected, (B) Infested leaves, (C) skeletonizer larvae on the truck of an infested birch, (inset) a close-up view of the larvae, and (D) silk cocoons on the underside of a curled birch leaf.

3.1.2 Large-spored spruce-labrador tea rust (*Chrysomyxa ledicola*)

In late summer (2017), the first calls regarding *Chrysomyxa ledicola* began and were followed by inquiries by our Aerial Overview Survey (AOS) Contractors. Two areas in the Mackenzie TSA were identified. The first site was near the tip of the Omineca Arm (west side of Williston Reservoir) and the second site was on the east side of the Williston Reservoir. Jeanne Robert (Regional Entomologist) and Jewel Yurkewich (Regional Pathologist) visited the first area and were able to positively identify the fungal species on hybrid spruce (*Picea glauca* X *engelmannii*) and the alternate host, Laborador tea (*Ledum groenlandicum*) (Figure 6). The second area was not easily accessible by road, and therefore was not ground checked.

Since 1999, the only recorded occurrences of *C. ledicola* identified during the AOS were in 2011 and 2012 with 12,153.3 ha and 3,354 ha of infection in the Fort Nelson TSA (Northeast Region), respectively. This year the AOS captured 131 ha in the Mackenzie TSA (Omineca Region). Due to the abundance of inoculum on the alternate host an increase is expected for 2018. At this time, this is not considered a threat to stand productivity or merchantability. In cases of severe infection that occurs over many consecutive years there may be site specific growth implications.

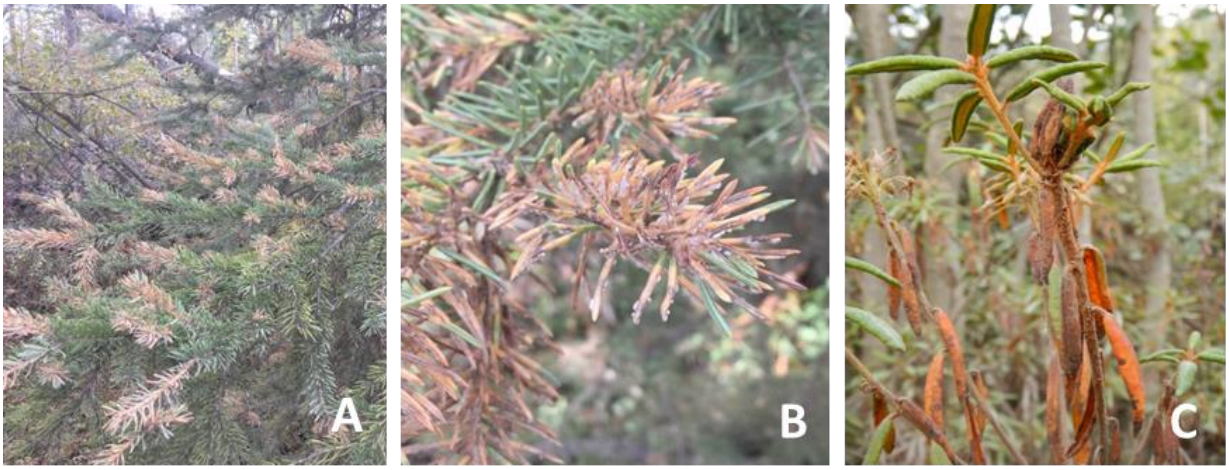

FIGURE 6 – INFECTED BRANCH TIPS OF SPRUCE AND LEAVES OF THE ALTERNATE HOST, LABRADOR TEA.

3.2 INVASIVE INSECTS AND PATHOGENS

The following insects and pests are invasive and are presented here to highlight their current presence in BC, and to invite others to watch for them during the field season. Early detection of invasive species in new areas or with expanding distributions is essential for effective containment and management.

3.2.1 Satin moth (*Leucoma salicis*)

According to our AOS records since 1999, the first occurrence of satin moth was reported in 2016 with 9,122 ha reported, possibly representing the most northern occurrence recorded. The 2017 AOS captured an alarming 107,088.6 ha which represents an 11.7 fold increase from last year. Reports of a continuing satin moth infestation suggest that defoliation may continue in the western half of the Prince George TSA Figure 7 shows the identifiable life stages for this defoliator.

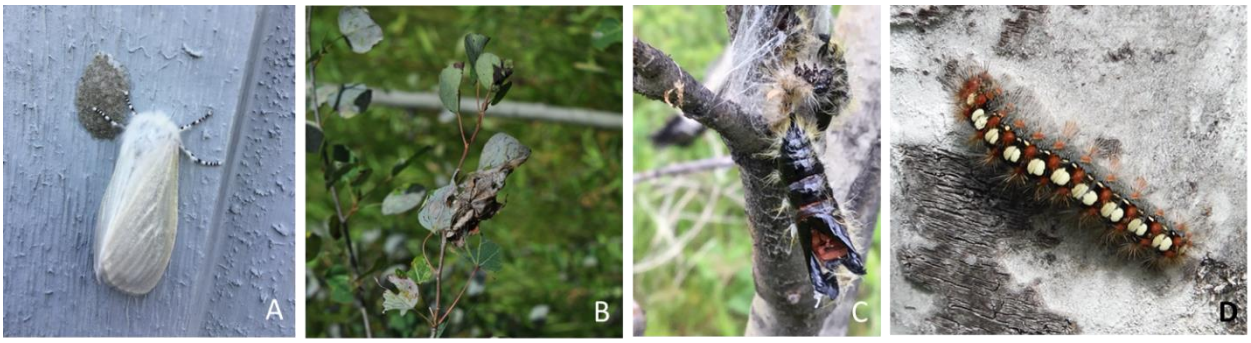

FIGURE 7 – LIFE STAGES OF SATIN MOTH.

Photos: (A) An adult satin moth with egg mass, (B) pupal case wrapped in 'satin' and aspen leaves; photo credit: Joan Westfall, Entopath Management Ltd., (C) a recently vacated pupal case, and (D) a satin moth caterpillar; photo credit: Tom Foy, Industrial Forestry Service Ltd.

3.2.2 Balsam woolly adelgid (*Adelges piceae*)

Balsam woolly adelgid attacks all true firs, including *Abies lasiocarpa* (subalpine fir; however, locally referred to as "balsam"). Although this invasive insect has primarily been an issue in southern BC, mostly in Christmas tree farms, 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 this year near Kamloops BC. Figure 8 shows the symptoms and signs of balsam woolly adelgid infestation. If you find a suspected attack, please notify Jeanne Robert (Regional Entomologist) and Babita Bains (Provincial Entomologist). Any additional questions about balsam woolly adelgid can be directed to Tracy Hueppelsheuser, Susanna Acheampong, Dave Woodske, or Dave Trotter at the BC Ministry of Agriculture at AgriServiceBC: 1-888-221-7141. Because infestations are difficult to diagnose, a piece of bark containing suspected adelgid samples should be sent to the Plant Health Laboratory: http://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/plant-health-laboratory

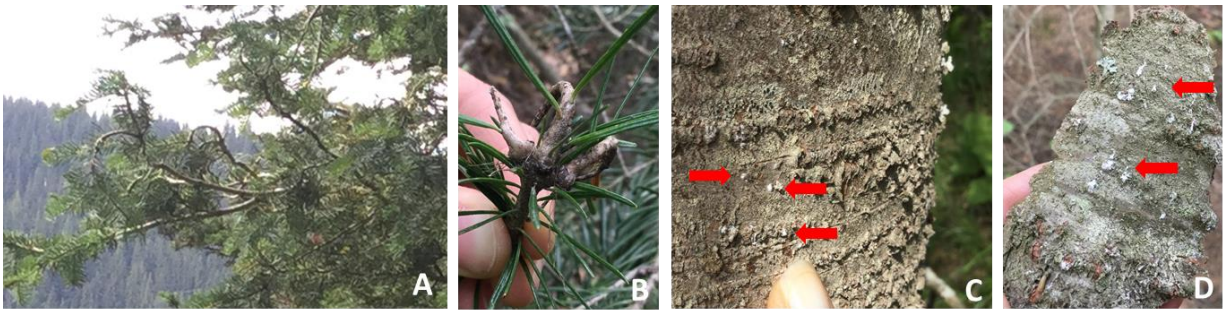

FIGURE 8 – SYMPTOMS AND SIGNS OF BALSAM WOLLY ADELGID.

Photos: (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.

3.2.3 European gypsy moth (*Lymantira dispar*)

The European gypsy moth is an invasive species that is accidentally introduced from infested areas in eastern Canada into BC. It is not established anywhere in western North America at the moment due to intensive monitoring and eradication efforts by federal and provincial agencies. The Province of BC has programs underway to prevent the further establishment of this invasive defoliator. Although it has not been identified in the Omineca, we are participating in a province wide trapping program to monitor for new introductions.

For more information on the European gypsy moth in BC, please see:
http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/invasive-forest-pests/gypsy-moth

3.2.4 Poplar and willow borer (*Cryptorhynchus lapathi*)

Poplar and willow borer is an invasive species originating in Europe. Although the insect has been established in Northern BC for decades (introduced in 1923, Broberg et al. 2001), this species continues to noticeably attack native willow species in the Omineca, especially along roadways. Concern was expressed in the Stuart-Nechako district where roadside willows are showing widespread damage.

Poplar and willow borer populations can be reduced through the removal (cutting or burning) of the host material. Because this insect will reproduce in most species of poplar and willow, it is difficult to control over large areas. Infested plants can be recognized by the orange-coloured frass kicked out of ventilation holes by developing larvae on the larger diameter stems (see arrow in accompanying image). Inside the stem, burrowing by the C-shaped weevil larvae will eventually cause the stem to break. Infestations can occur in a localized area with adult weevils laying eggs on stems over many years as they grow to susceptible size within a copse of hosts.

3.2.5 White pine blister rust (*Cronartium ribicola*)

White pine blister rust is an invasive pathogen that primarily affects western white pine (*Pinus monticola*) and whitebark pine (*Pinus albicaulis*); however, this pathogen is responsible for the decline of several 5-needle pines in North America.

In the Omineca, whitebark pine is threatened by white pine blister rust. Whitebark pine only occurs at high-elevation, subalpine locations and several locations in the Omineca Region represent the most northern extent of its distribution. The significance of this damage to the population of whitebark pine is primarily derived from the ecological and social implications, with emphasis on wildlife cover and food, watershed protection, ecological succession, subalpine biodiversity, visual aesthetics and recreational considerations (Tomback et al. 2001). It is important to note that whitebark pine is federally listed as *Endangered* and is a blue-listed species (*Special Concern*) in BC.

In 2017, Randy Moody established a permanent monitoring plot in the Sibola range, 70 km south west of Houston. The stand is unique in that it occurs at low elevation (~1200 m). In addition, the Whitebark Pine Ecosystem Foundation 2017 Science and Management Meeting was held in Jasper and brought together many experts to share information related to the conservation of whitebark pine. For more information about the Whitebark Pine Ecosystem Foundation please visit: http://www.whitebarkpine.ca/

The continuation of the project has been funded by the Landbase Investment Strategy (LBIS) and the Society for Ecosystem Restoration in Northern BC (SERN BC). In 2018, the project is focused on health assessments, cone collection, and the identification of punitively resistant parent trees for collection. For more information contact Kevin Hoekstra, Senior Ecosystems Biologist (Kevin.Hoekstra@gov.bc.ca).

Information on the tactical plan for managing whitebark pine in the Omineca can be found here: http://www.whitebarkpine.ca/uploads/4/4/1/8/4418310/wbp_management_in_omineca.pdf

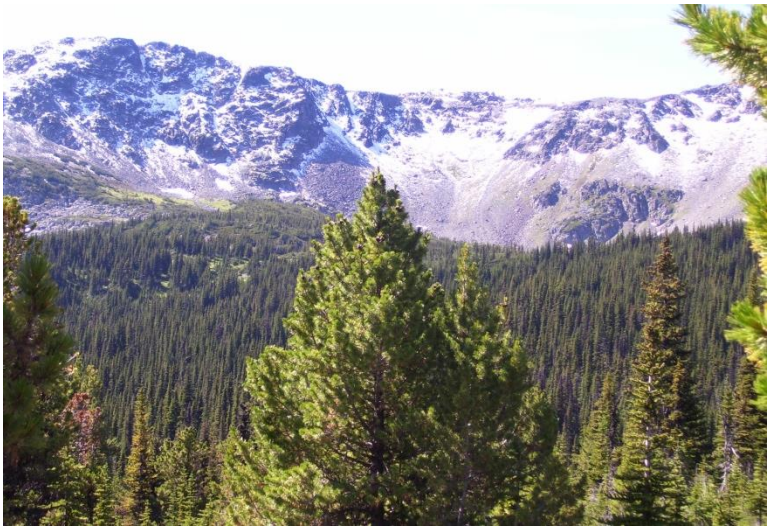

PHOTO: MOUNT SIDNEY WILLIAMS IN FORT ST. JAMES. CREDIT: DON PIGOTT.

4 INTERPRETING THE OMINECA FOREST HEALTH STRATEGY

This Forest Health Strategy has been developed using information and input from experienced personnel with knowledge and insight into the priority pests (e.g. bark beetles) and/or pathogens (e.g. rusts) for each TSA. Forest health factors are prioritized within each TSA using this information and input. For the priority pests and pathogens, specific proactive and reactive measures are incorporated whenever possible.

Proactive forest health measures require an awareness of potential problems, an ability to analyze hazard and risk for damaging agents and stand types, "pest-aware" silviculture and harvesting practices, use of cost/benefit analyses, knowledge of existing management techniques, and the willingness to explore new ideas and technologies. Proactive forest health measures help to moderate extreme pest cycles, reduce future pest outbreaks, and ensure the sustainability of forest resources.

Reactive measures are an unavoidable part of the forest health program due to the relatively unpredictable nature of existing and new forest damaging agents. 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 preserving resource values.

Our goal is to develop pest or pathogen-specific strategies that contain both proactive and reactive activities. The specific strategies are designed to help practitioners and tenure holders respond to forest health situations in a timely and appropriate manner.

4.1 MANAGEMENT UNIT BOUNDARIES AND DESIGNATIONS

Management unit boundaries for bark beetles were established in each of the TSAs as a basis for developing consistent pest-specific strategies within each area. These Beetle Management Unit (BMU) boundaries were based on existing Landscape Units. Management units do not exist for all priority forest health factors due to population dynamics, ephemeral expression of signs and symptoms, knowledge gaps, issues of accessibility or limitations of current monitoring programs (i.e., forest health factors that are undetectable from the height of the Aerial Overview Survey [AOS]).

Currently, mountain pine beetle (pest code: IBM), spruce beetle (IBS), and Douglas-fir beetle (IBD) are the forest health factors that have been assigned a management strategy in the Omineca using BMUs. Although BMUs are designated independently, it is important to recognize that units are not isolated, and therefore may influence adjacent units. Furthermore, the strategy selected for a unit must be compatible and logical with those of adjacent units and with the overall integrated resource use plans for the TSA (detailed information on assigning strategy designations to BMUs is in Appendix 1).

4.2 RANKING OF FOREST HEALTH FACTORS

To allocate resources effectively, forest health factors relative to the Prince George, Mackenzie and Robson Valley TSAs have been ranked by merging online survey results with local experience and knowledge; the ranking includes both major bark beetles, and other priority insects and pathogens. Additional information considered in order to validate the rankings included:

- known or suspected impacts on forest resource values;
- distribution of pest and current incidence levels;
- resources required to obtain missing information necessary for management; and
- overall level of knowledge about the hazard and risk zones.

As this strategy is evaluated and revised annually, the 2017 rankings represent a unified direction for forest health management in the Omineca Region. As additional information and analyses regarding the impacts become available, the information will be integrated into the rankings and development of the management strategies reflected in the annual Forest Health Strategy.

There are four tables, the first contains the ranking from high importance to low importance of forest insects in the Omineca, the second contains the rankings for forest pathogens, the third contains the rankings of abiotic and animal damage, and the fourth contains a ranking of declines and complexes (forest health issues influenced by multiple factors). For example, more information on aspen decline can be found through the following link: https://cfs.nrcan.gc.ca/projects/124.

TABLE 1 – RANKING OF ECOLOGICAL AND ECONOMIC IMPORTANCE OF COMMON FOREST INSECTS OCCURING IN THE OMINECA REGION.

Pest	High importance	Moderate Importance	Low importance
Major Bark Beetles:			
Douglas-fir beetle		☑	
Mountain pine beetle		☑	
Spruce beetle	☑		
Western balsam bark beetle		**research needed	
Other Insect Pests:			
Aspen leaf miner		☑	
Birch leaf miner			☑
Bruce spanworm			☑
Conifer aphids / adelgids			☑
Forest tent caterpillar			☑
Hemlock looper			☑
Large aspen tortrix			☑
Pine needle sheath miner			☑
Sawfly damage			☑
Satin moth			☑
Spruce/white pine weevil			☑
Two-year cycle budworm			☑
Warren root collar weevil			☑

***monitor**: although this pest is of low importance in the Omineca, there is potential for an increase of spread within the next year or two and so the population should be carefully monitored.
****research needed**: the full extent of the potential economic or ecological impact of this pest requires more research.

TABLE 2 – RANKING OF ECOLOGICAL AND ECONOMIC IMPORTANCE OF COMMON FOREST PATHOGENS OCCURING IN THE OMINECA REGION.

Pathogen	High importance	Moderate importance	Low importance
Stem Rusts / Damage:			
Comandra blister rust		☑	
Stalactiform blister rust		☑	
Western gall rust		☑	
Mistletoe		☑	
Foliar Diseases:			
Dothistroma (red band)			☑
Venturia spp.			☑
Root Diseases:			
Tomentosus root rot			☑

TABLE 3 – RANKING OF ECOLOGICAL AND ECONOMIC IMPORTANCE OF ANIMAL OR ABIOTIC DAMAGE OCCURING IN THE OMINECA REGION.

Animal and Abiotic damage	High importance	Moderate importance	Low importance
Animal:			
Moose			☑
Hares / rabbits			☑
Abiotic:			
Drought			*monitor
Frost			☑
Snow press			☑
Windthrow**		☑	

***monitor**: although this pest or pathogen is of low importance in the Omineca, there is potential for an increase of spread within the next year or two and so the population should be carefully monitored.
****windthrow** of mature spruce is the primary cause of spruce beetle outbreaks, and therefore it is crucial that district staff are actively monitoring stands to provide information for rapid salvage to reduce the risk of initiating an outbreak.

TABLE 4 – RANKING OF DECLINES AND COMPLEXES (FOREST HEALTH ISSUES INFLUENCED BY MULTIPLE FACTORS – ABIOTIC AND BIOTIC) IN THE OMINECA REGION.

Decline / complex	High importance	Moderate importance	Low importance
Cedar flagging			☑
Aspen/birch/cedar decline			☑

5 MAJOR BARK BEETLES IN THE OMINECA

Projected climate change data, combined with favourable weather conditions, indicate that bark beetles will continue to be a high priority issue for forest health management for the foreseeable future. Proactive prevention for all bark beetles should be at the forefront of forest management – especially with a focus on the reduction of suitable breeding sites and careful planning of future forests to reduce susceptibility.

Climate change, weather, and bark beetles: Regular bark beetle outbreaks are a normal occurrence in the pine, spruce, and Douglas-fir forests that dominate the landscape in the Omineca Region, but recent changing climate and weather patterns have resulted in very good conditions for bark beetle populations to increase beyond the historical range and severity. A general trend towards warmer and wetter weather, 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 the rate of 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 control.

The impact of bark beetles: The impact from mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle are not limited to timber loss. There are also significant impacts on carbon sequestration, recreation, fish and wildlife, watershed management, range, landscape and aesthetics, cultural heritage, and other resource values. Bark beetle pest reduction strategies have been developed and implemented with consideration for these other resource values while sustaining a strong economic approach rooted in providing a long-term supply of fiber to local mills. The goal of bark beetle management must be to minimize the spread of bark beetles, to minimize the loss of crown timber, and to protect non-timber resource values.

5.1 MOUNTAIN PINE BEETLE (*Dendroctonus ponderosae*)

Mountain pine beetle continues to decline in the Omineca after the unprecedented 2007 peak outbreak covering 10 million hectares in BC. The Omineca continues, however, to sustain the highest area of damage in the province. In 2017 there was a small decline of mountain pine beetle infested trees to 53,511 hectares. The continuing decline is positive, but weather conditions will keep this insect in the 'moderate' category for forest health factor ranking in the Omineca (Table 1).

At the tail end of an unprecedented outbreak, there is little short term action that can be applied beyond the continued salvage of beetle-killed pine where it is economically feasible and ecologically reasonable. The general strategy for mountain pine beetle should be longer term planning of pine-dominated forests while keeping in mind other forest health factors (for example, please see blights [Section 6.2.1], mistletoe [Section 6.2.3], and rusts [Section 6.2.5). **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 ages and diameters.

The mountain pine beetle is now established in Alberta. It continues to spread and has now established in southwest Saskatchewan.

Prince George TSA

Mountain pine beetle has been displaced by spruce beetle and Douglas-fir beetle as the top priority in the Prince George TSA. The area infested by mountain pine beetle continues to decline; 7,999 hectares of trace to severe infestations were mapped in 2017. The volume lost to mountain pine beetle has steadily decreased since the peak of the infestation in 2007. Most of the Prince George TSA BMU strategies for mountain pine beetle remains in salvage (Figure 9).

Mackenzie TSA

Like the Prince George TSA, mountain pine beetle is generally declining, but increased slightly in 2017 from 9,465 hectares to 11,116. This may be an underestimate of the actual infestation in the Mackenzie TSA because a portion of the TSA was not surveyed in 2017 due to poor flying conditions. This area will continue to be a priority for survey in 2018. Most of the Mackenzie TSA BMU strategies for mountain pine beetle remains in salvage (Figure 10).

Robson Valley TSA

To date, the majority of the BMU's for mountain pine beetle within the Robson Valley TSA are identified as salvage (Figure 11); however, sanitation harvest (and other suppression or holding methods, see Appendix 1: Beetle Management Control Strategies) could be applied to pockets of currently infested trees. Since the majority (34,396 hectares) of the remaining current attack is located in the Robson Valley TSA, some areas may warrant suppression or holding tactics.

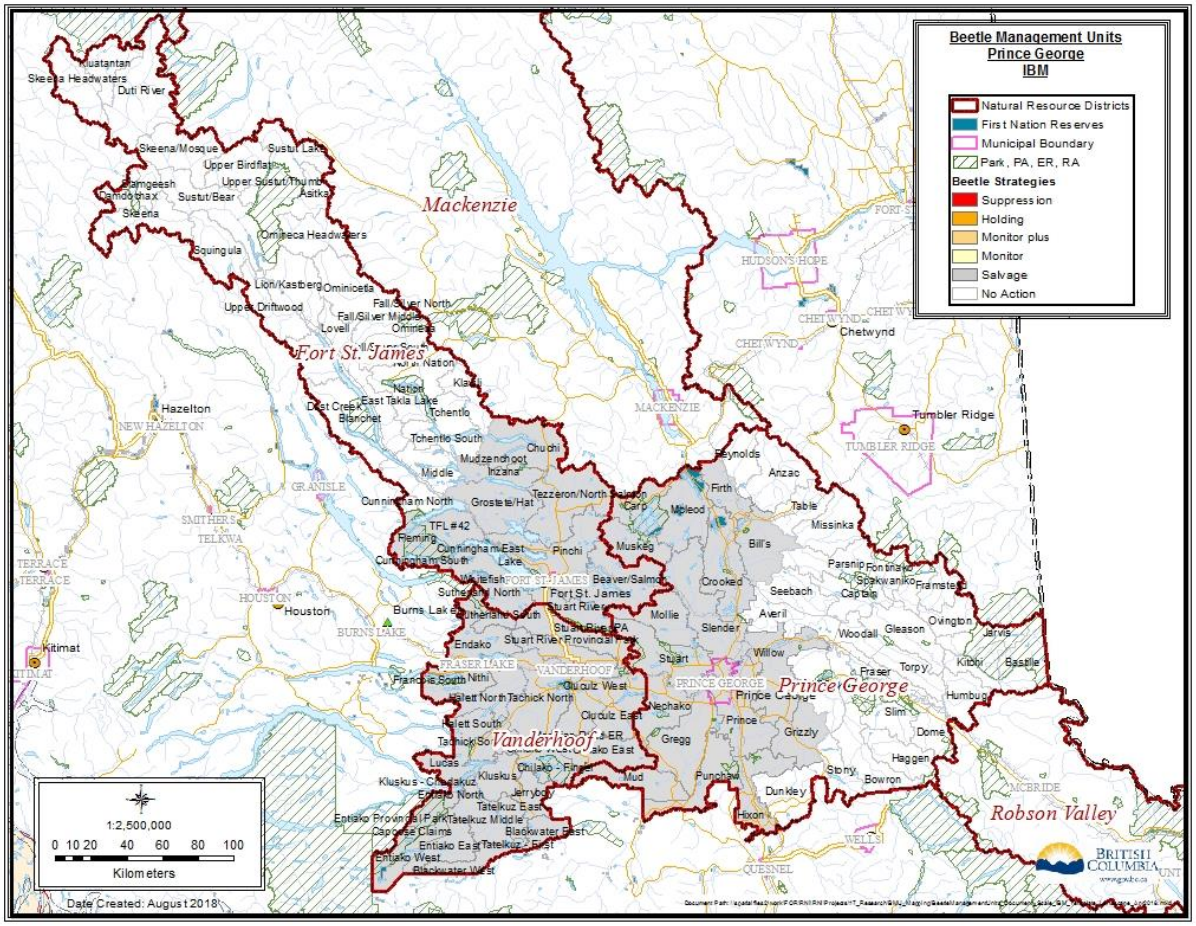

FIGURE 9 – PRINCE GEORGE TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE.

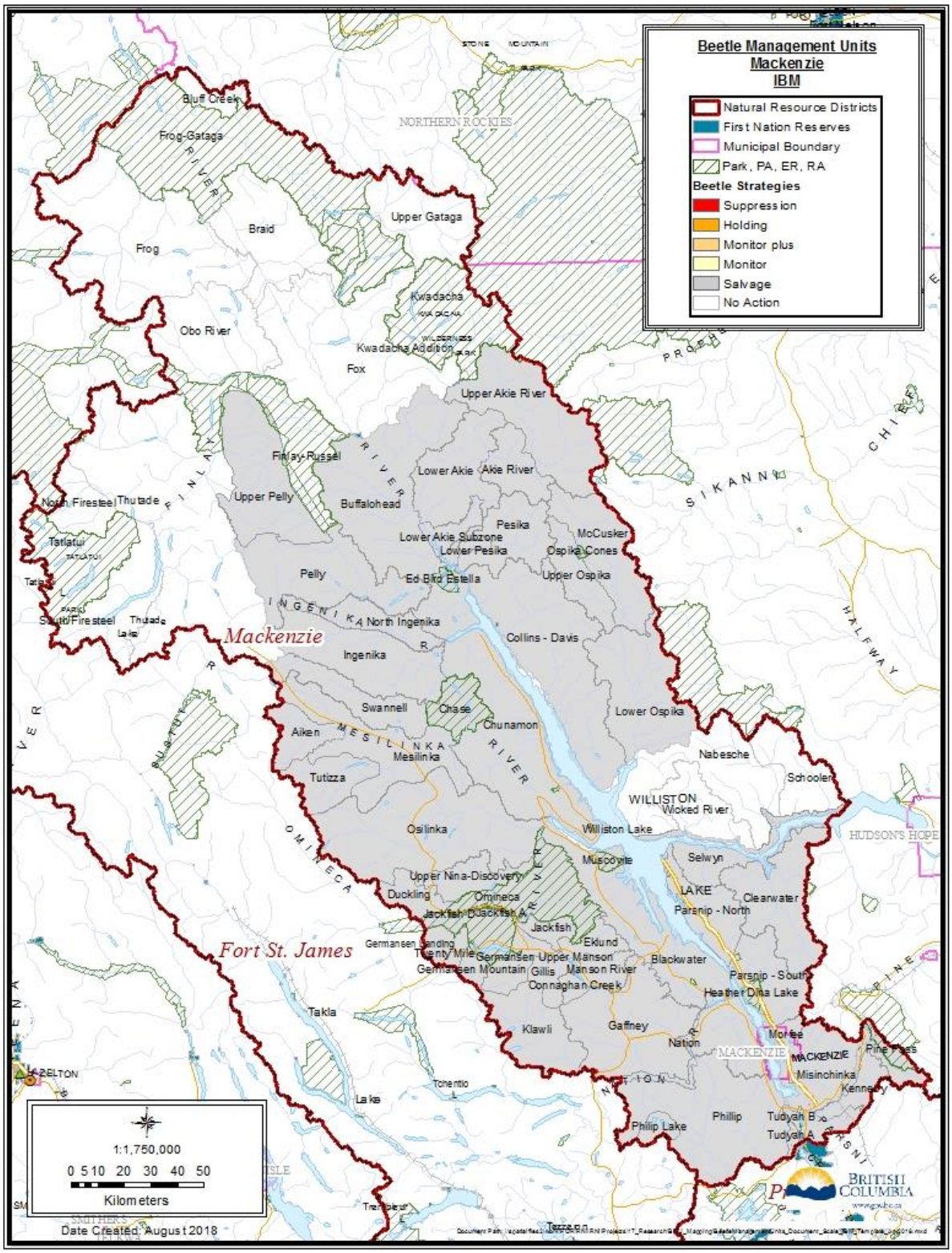

FIGURE 10 – MACKENZIE TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE.

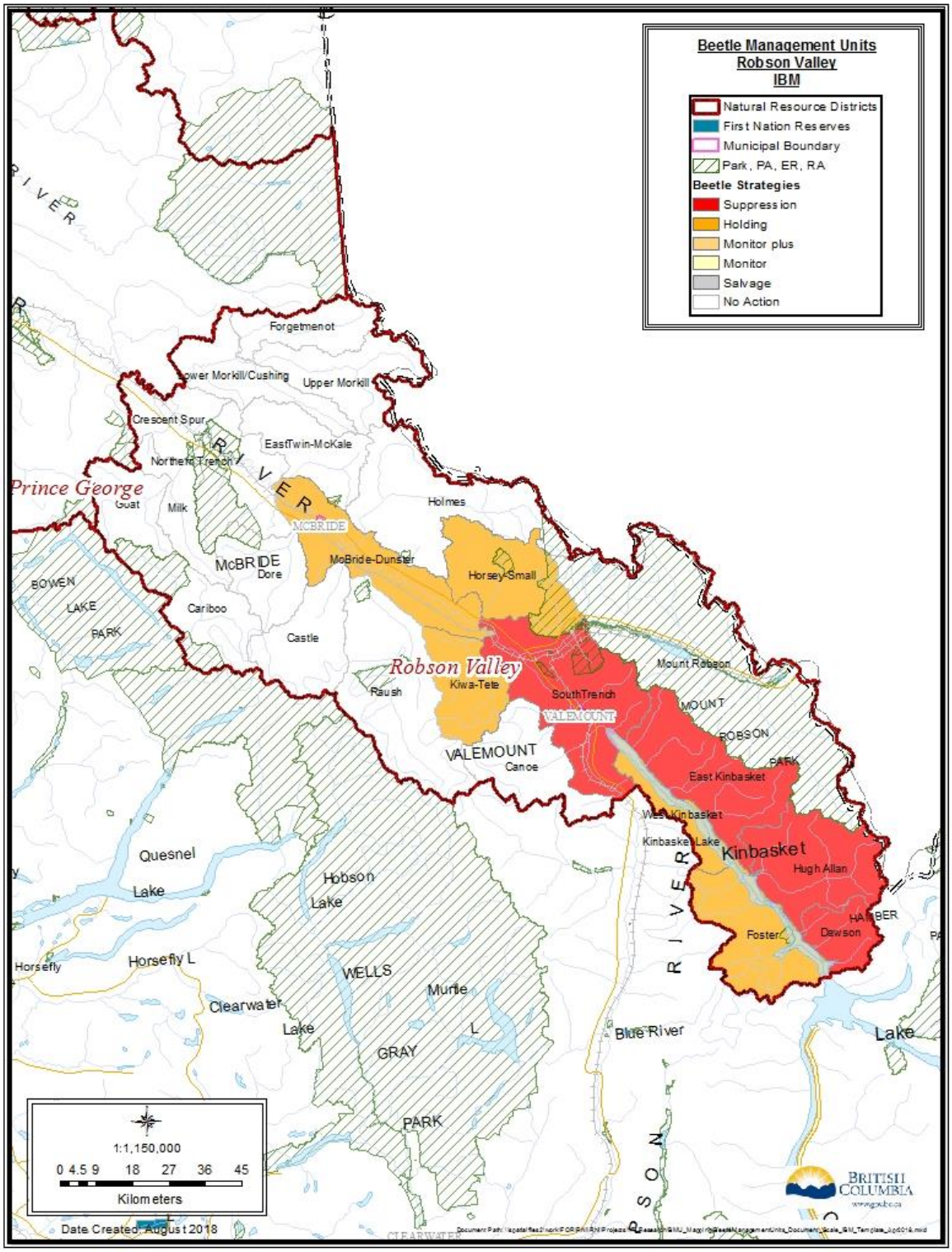

FIGURE 11 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE.

5.2 SPRUCE BEETLE (*Dendroctonus rufipennis*)

Outbreak update: Warmer spring and summer temperatures in the Prince George and Mackenzie TSAs since 2014, combined with reduced precipitation and windthrow events have culminated in a 372,483 hectare outbreak of spruce beetle in the Omineca Region in 2017. A prolonged and rainy 2018 spring may reduce flight effectiveness and therefore population in 2018, however in areas where the populations are very high, the outbreak will continue in 2018-2019.

Tools: A wide range of tools exist to mitigate spruce beetle damage. Some of the available tactics include: overview and detailed aerial and ground surveys; single tree treatments of conventional trap trees; fall and burn; fall and peel; pheromone baiting; sanitation/salvage harvesting; hazard and risk rating; and high hazard host removal. In addition, a spruce beetle working group for the Omineca was formed with licensees in order to coordinate the response to the spruce beetle outbreak. The spruce beetle contact for the Omineca working group is Dave Banham, Resource Manager (Dave.Banham@gov.bc.ca), FLNRORD.

The link below contains additional information on the current management initiatives, maps showing the extent of the current outbreak in Prince George and Mackenzie districts, and provides links to guidance documents for beneficial management practices, trap tree use, and hauling and milling restrictions. This website will be updated as new information and guidance becomes available.

http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/spruce-beetle/omineca-spruce-beetle

Training A spruce beetle probing course using these guidelines is offered by UNBC continuing studies in Prince George (see: http://www.unbc.ca/continuing-studies/courses-workshops). This is a practical course designed for forest consulting personnel who intend to conduct ground detection surveys for spruce beetle. It will be instructed by Robert Hodgkinson (FLNRORD Forest Entomologist Emeritus: Robert.Hodgkinson@gov.bc.ca). Should the outbreak population continue to increase and spread in the Northeast, trained and experienced beetle-probing professionals are a key resource for timely and effective monitoring of infestations. In order to avoid a shortfall of qualified beetle probing surveyors, we strongly encourage consulting professionals, licensees, and government employees involved in on-the-ground spruce beetle management to complete the 2018 training course.

The communication and management response included the formation of a public advisory committee to provide input into developing and implementing a spruce beetle management plan. For more information please contact Jeanne Robert, Regional Entomologist (Jeanne.Robert@gov.bc.ca) or John Huybers, Spruce Beetle Project Lead (John.Huybers@gov.bc.ca).

Prince George TSA

Historically, spruce beetle population peaks occur regularly in the Prince George TSA. Recent windthrow events in the Willow Valley allowed for an increase in the local spruce beetle populations located within high value mid-term supply timber areas. This has elevated the economic and ecological importance of spruce beetle in the forest health factor rankings to high. Current population levels have increased from 93,768 infested hectares identified in 2015 to 142,837 hectares in 2016, and 275,108 hectares in 2017. All accessible BMUs in the Prince George TSA are identified as suppression, holding or monitoring (Figure 12).

Mackenzie TSA

Spruce beetle has also been a problem in the Mackenzie TSA with the last major outbreak occurring in 1991. There was a major wind storm in November 2010 that blew down approximately 300,000 m^3 of widely scattered hybrid white spruce (*Picea engelmannii X glauca*) host trees and likely contributed to the current outbreak population in this area. BMU's containing the spruce windthrow and active beetle infestations have been assigned a suppression strategy (Figure 13). Current population levels have increased substantially relative to 2013 – 2014 levels in the Prince George and Mackenzie TSAs, up to over 72,919 infested hectares identified in 2016 and 90,193 hectares in 2017. Some of the most severely attacked areas were designated as 'salvage' BMU's for 2018-2019.

Robson Valley TSA

Spruce beetle is not yet a major concern in the Robson Valley TSA and the strategy for this TSA is primarily monitoring (Figure 14), but a spruce beetle outbreak is occurring in the adjacent Prince George and Mackenzie TSAs, where current population levels are increasing substantially relative to 2013 – 2014 levels. The Robson Valley had only 7,182 hectares of spruce beetle infested trees in 2017. However, the Robson Valley should continue to be carefully monitored for pockets of increasing spruce beetle populations in 2018-2019.

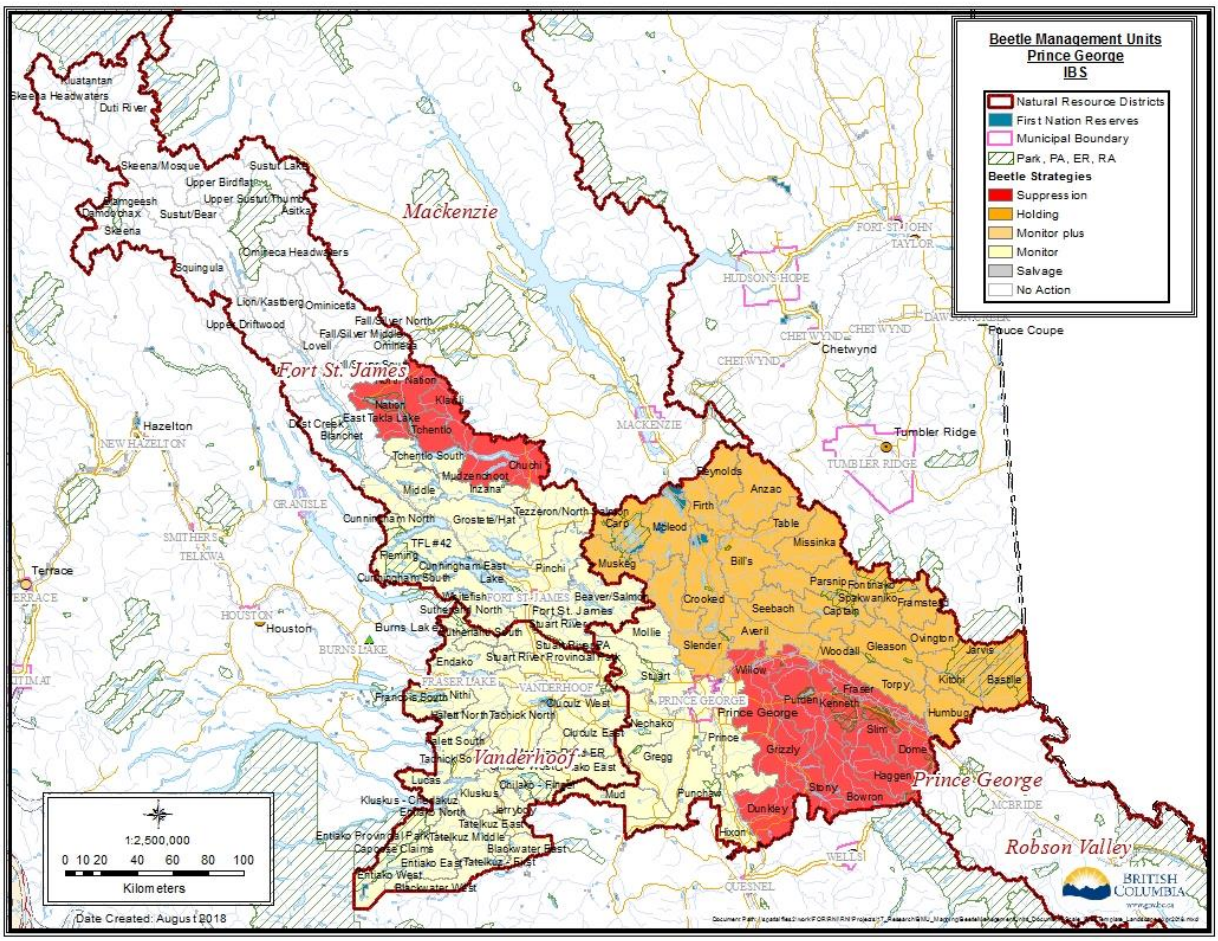

FIGURE 12 – PRINCE GEORGE TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE.

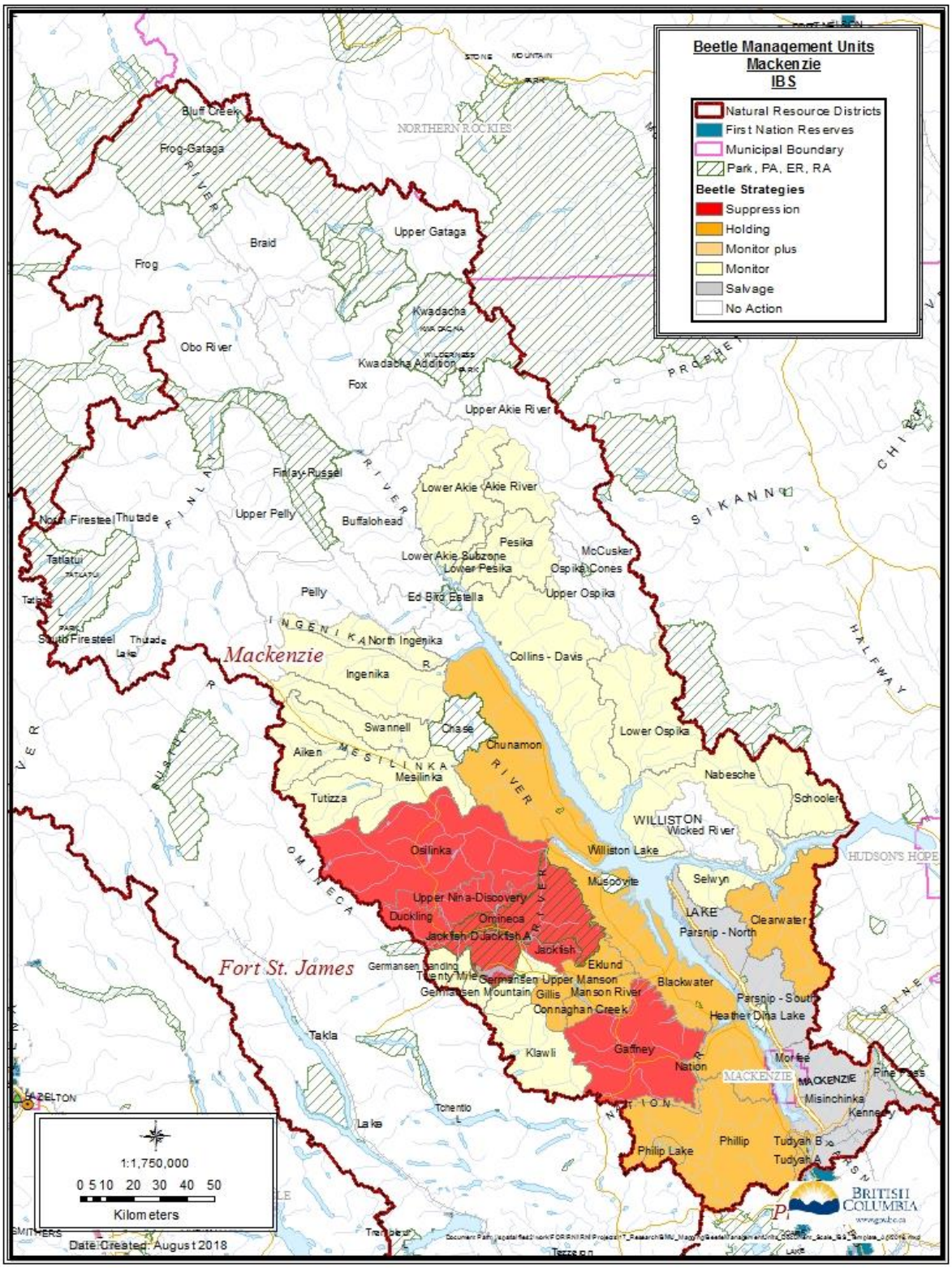

FIGURE 13 – MACKENZIE TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE

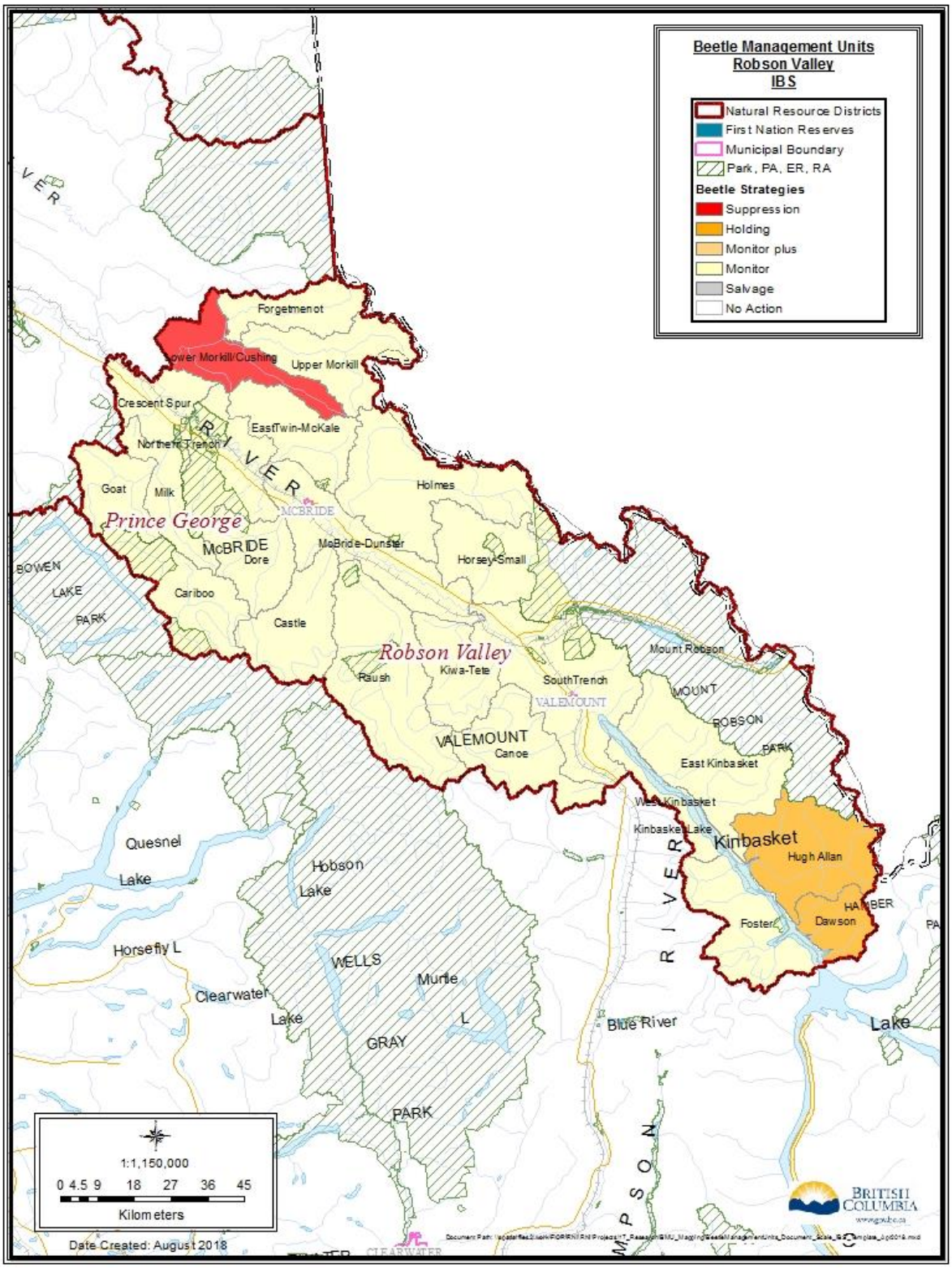

FIGURE 14 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE.

5.3 DOUGLAS-FIR BEETLE (*Dendroctonus pseudotsugae*)

This is the most significant bark beetle on Douglas-fir (*Pseudotsuga menziesii*) throughout its range, and populations of Douglas-fir beetle in southern BC are increasing. The provincial infestation area for Douglas-fir beetle doubled within a year to 90,826 hectares in 2016, and it is now 119,096 hectares in 2017. The majority of this infestation is located in the Cariboo Region (65,446 hectares), but where the range of Douglas-fir extends northward into the Omineca Region, there was a sharp increase in Douglas-fir beetle-killed trees to 8,127 hectares in 2016 and 36,249 hectares in 2017.

Prince George TSA

Large increases in Douglas-fir beetle where there are concentrations of susceptible hosts combined with favourable weather conditions are conducive to very high levels of attack. Continued suppression efforts including the selective removal of infested trees, removal of windthrown Douglas-fir, and use of anti-aggregation pheromones (MCH) on high-value trees should be used with an aim of reducing the population before the 2018 flight. As a result, Douglas-fir BMUs in the Prince George TSA were assigned a suppression strategy this year (Figure 15).

Mackenzie TSA

The Mackenzie TSA is generally located outside the range of Douglas-fir, and therefore, Douglas-fir beetle is not a priority species for management in this area.

Robson Valley TSA

As a result of the provincial population increase for Douglas-fir beetle, this beetle should be monitored where it occurs in the Robson Valley although there has been little recorded impact in recent years; one BMU has been designated as suppression in this area (Figure 16).

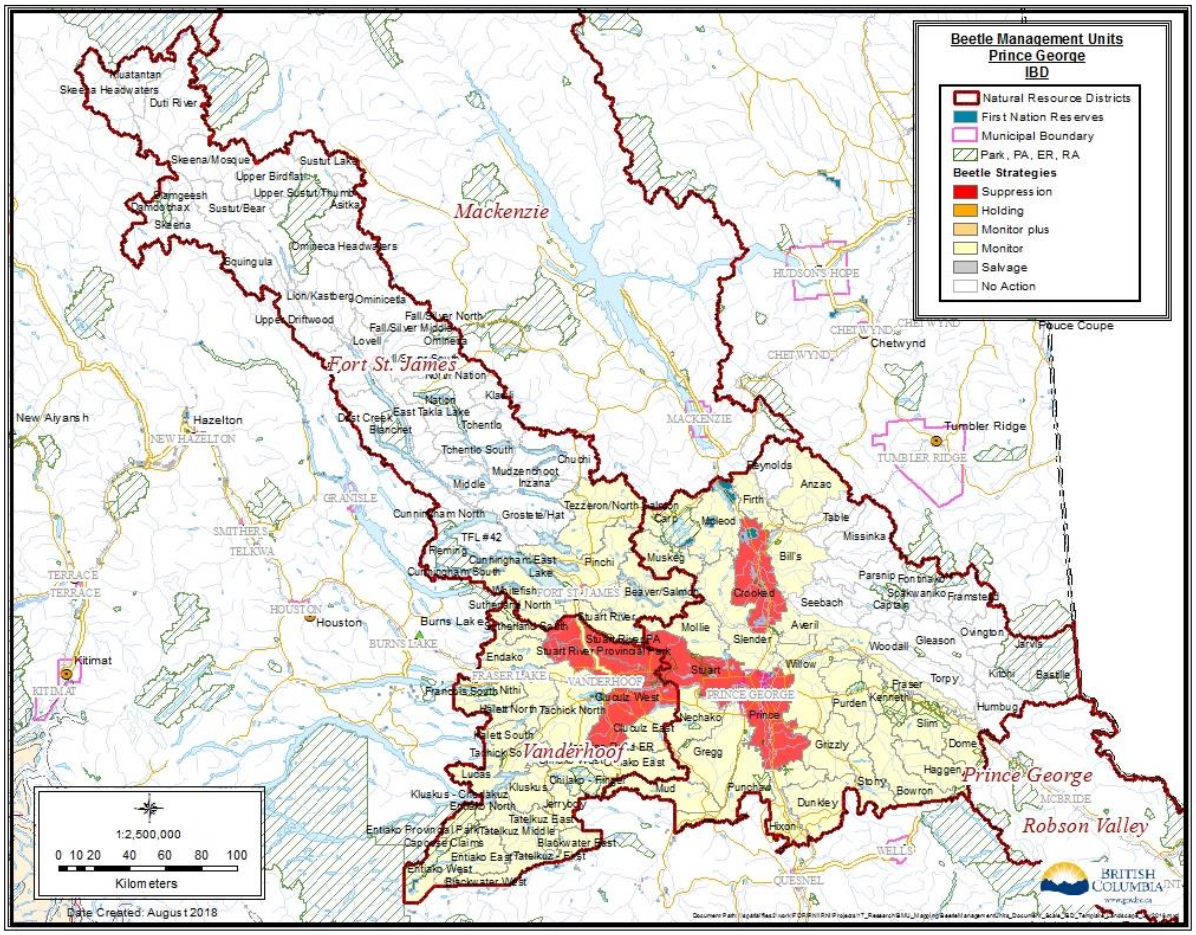

FIGURE 15 – PRINCE GEORGE TSA FOREST HEALTH STRATEGIES FOR DOUGLAS-FIR BEETLE.

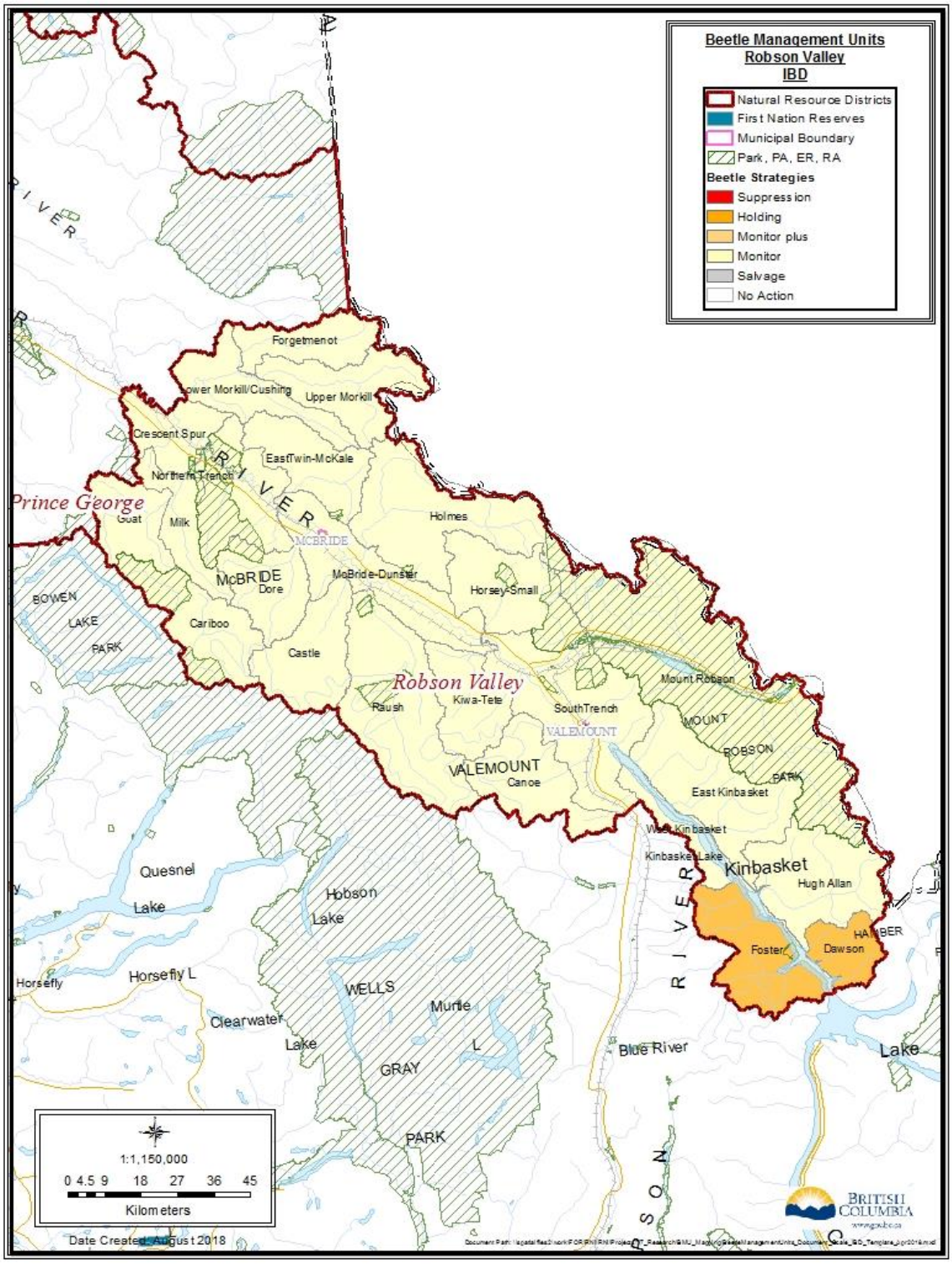

FIGURE 16 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR DOUGLAS-FIR BEETLE.

5.4 WESTERN BALSAM BARK BEETLE (*Dryocetes confusus*)

Western balsam bark beetle causes significant mortality of *Abies lasiocarpa* (subalpine fir; however, locally referred to as "balsam") throughout British Columbia. The provincial infestation area for western balsam bark beetle increased again in 2017 to **over 3.7 million hectares**. The majority of this damage occurred in the Omineca Region with over 1.6 million hectares damaged.

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 investigation. Difficulties with management arise from the scattered nature of attack over susceptible host types, and the low level of management currently employed against the bark beetle. Infested areas can be salvaged where feasible, especially where western balsam bark beetle is concurrent with other forest health factors, such as 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.

6 OTHER PRIORITY INSECTS, PATHOGENS AND PARASITIC PLANTS IN THE NORTHEAST

This section of the strategy is intended to provide information and context around the management of priority insects and pathogens that are not accurately represented by the Aerial Overview Survey (AOS) and those that may pose management challenges that are complicated and not easily resolved by increasing financial investment. In most cases, the management of these insects and pathogens requires improved data collection procedures, further research, and a site-specific approach that incorporates ecological linkages and a climate change lens.

TSA-specific information is presented for some of the pests that our monitoring efforts (AOS, detailed surveys, on-site data collection) have captured clear differences. In cases where such differences have not been captured, the knowledge gaps and best management practices have been identified. This provides an opportunity to engage in constructive conversation with district staff, licensees, tenure holders, and the public regarding how to improve the management of forest pests or mitigate the impacts within the Omineca.

6.1 PRIORITY INSECTS

6.1.1 Two-year cycle budworm (*Choristoneura biennis*)

Two-year cycle budworm is a major insect defoliator of interior spruce (*Picea engelmannii X glauca*) and subalpine fir (*Abies lasiocarpa*) in central BC. The provincial infested area increased slightly to 179,294 hectares from 160,143 hectares in 2016. Although the two-year cycle budworm's economic and ecological importance was ranked low in the Omineca Region for 2018-2019, the population should be carefully monitored, given an increase in infested area for two consecutive years.

Currently, active management is not being implemented for two-year cycle budworm, except to expedite salvage harvesting based on the prioritization of defoliation levels. Strategic planning to optimize salvage harvesting, will be the most successful approach for recovering timber volumes in defoliated stands. *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.

Prince George & Mackenzie TSAs

The infested area in the Omineca is concentrated in the Prince George TSA (120,613 hectares), but 36,303 hectares was also defoliated in the Mackenzie TSA. The lack of visible defoliation in 2016 suggests that at least some of the populations were in the first year of the two-year life cycle in northern BC, and that more visible defoliation in these areas is likely to occur in 2018.

Robson Valley TSA

A 14,639 hectare infestation adjacent to the Prince George TSA infestation was mapped in the Robson Valley TSA in 2016, but the infestation was light in 2017. Defoliation episodes in the Robson Valley have occurred roughly every 30 to 40 years over the past 300 years, with episodes lasting for about 10 years (Zhang et al. 2001).

6.1.2 Large aspen tortrix (*Choristoneura conflictana*)

There were no significant populations of large aspen tortrix recorded in the Omineca Region mapped in the 2017 aerial overview survey. These defoliators are not expected to cause significant damage on aspen or secondary host species (including balsam, poplar, birch, and willow) in 2018-2019.

6.1.3 Aspen leaf miner (*Phyllocnistis populiella*)

The size of the area infested by aspen leaf miner decreased in 2017 to 116,382 hectares in the Omineca. Multiple successive years of infestation means this pest remains as 'moderate' in the forest health factor rankings (Table 1).

Although aspen (*Populus tremuloides*) can generally tolerate repeated defoliation over several years, the combination of widespread infestation of aspen leaf miner, infestation by large aspen tortrix (Section 6.1.1), infection by Venturia blight (Section 6.2.2), and/or drought may contribute to a general aspen decline (Section 7.1). Continued research into the potential impact of aspen leaf miner and monitoring of disease complexes are priorities for 2017-2018.

6.1.4 Lodgepole pine terminal weevil (*Pissodes terminalis*)

This weevil has the potential to set back plantations severely by attacking at least two years of growth and potentially reducing timber quality by creating dead leaders in the juvenile trees which may or may not result in more serious defects at rotation. Localized areas have high occurrences; therefore monitoring this pest in areas of known infestations is important in 2018-2019, but this pest was not identified as a priority forest health factor in the Omineca as a whole. For more information, please see the terminal weevil guidebook: https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/weevil/we-toc.htm.

6.1.5 Spruce/white pine weevil (*Pissodes strobi*)

The spruce weevil is a low to moderate pest in the Prince George TSA, affecting the growth and development of younger interior spruce. Repeated weevil attacks to the leading shoots of young interior spruce trees can result in suppressed height growth and stem deformities. Planting genetically resistant seedlings, appropriate provenances, and mixtures of different species, as well as the use of nurse crops, can help reduce the damage from this pest. Characteristics of susceptible stands include open, sunlit, fast-growing stands of interior spruce, 8–30 years of age, 0.5–12 m tall, with terminal diameters of 5 mm or more. Denser stands have slightly lower attack rates and subsequent damage results in fewer deformities. Spruce plantations are at risk if adjacent stands have been heavily attacked. For more information, please see the terminal weevil guidebook: https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/weevil/we-toc.htm.

6.1.6 Warren root collar weevil (*Hylobius warreni*)

Warren root collar weevil is an ever-present concern in regenerating stands but, in general, the economic and ecological impact associated with this insect is relatively low.

This insect is receiving more notice as one of the potential downward pressures on the mid-term timber supply in the Prince George TSA.

Warren root collar weevil attacks lodgepole pine, Engelmann spruce, and white spruce. Usually trees over two cm in diameter at the root collar are attacked. The weevil may exist in mature stands and may subsequently attack the plantations with random mortality of single or groups of trees, especially if an adjacent mature stand has been recently harvested (Klingenberg et al. 2010). Mixed species and planting higher densities will reduce the damage impacts from this insect.

6.2 PRIORITY PATHOGENS AND PARASITIC PLANTS

6.2.1 Armillaria root disease (*Armillaria ostoyae*)

The Robson Valley TSA contains the northern extent of the known distribution of Armillaria root disease and is the only TSA in the Omineca with Armillaria root disease. Data was collected from aerial flights (AOS and detailed flights) completed by former Regional Pathologist Richard Reich, and ground assessments., and forms the initial hazard and risk rating digital layer and database encompassing the susceptible biogeoclimatic (BEC) subzones within the Robson Valley TSA. The recommended method for Armillaria root disease detection is ground surveys at the operational planning stage where Armillaria root disease is delineated based on the confirmed presence of disease. This data and resources are available from Jewel Yurkewich (Regional Pathologist) upon request. For more information please refer to the Forest Health Stand Establishment Decision Aid (SEDA) for Armillaria root disease: https://www.for.gov.bc.ca/ftp/DSQ/external/!publish/forest%20health/SEDA_SIR_Armillaria.pdf.

6.2.2 Aspen, poplar leaf and twig blight (*Venturia* spp.)

In the Omineca, the AOS Summary reported 370 ha of infected aspen all of which were mapped in the west portion of the Prince George TSA north of Francois Lake.

When moist weather conditions prevail during the previous and current growing season, Venturia can kill most shoots in aspen stands regenerating by sprouting. Repeated infection results in stem deformity and growth reduction. These diseases are most severe in young stands and have the greatest impact in intensively managed plantations.

Although the area affected is minimal compared with other forest health damage agents, Venturia blight may become more important if the overall health of aspen continues to be challenged by drought and other forest health factors in the Omineca Region. For more information please refer to Section 7.1 Aspen Decline.

6.2.3 Dwarf mistletoe of lodgepole pine (*Arceuthobium americanum*)

Lodgepole pine dwarf mistletoe is one of the most damaging disease agents in mature lodgepole pine in north central BC. This disease agent causes suppressed growth, decreased wood quality, and increased tree mortality (Hawksworth & Dooling 1984; Ramsfield et al. 2002). Older trees with well-developed, vigorous crowns may not show appreciable effects from the parasite for years after initial infection. However, as the parasite spreads through the crown, the tree's growth slows; eventually the crown dies and then the tree. Dwarf mistletoe also reduces the seed production of the host trees and can cause commercially unacceptable deformities such as cankers and knots (Hawksworth & Dooling 1984).

Although the mountain pine beetle epidemic eliminated the majority of overstory pine across a broad area in the north, it is important to consider how we will manage mistletoe as the proportion of pine-leading stands increases and matures across the region. We can expect that mistletoe is persisting in the understory of retained areas or cut block boundaries in areas where mistletoe was present in the past. **Thus, it is crucial that we identify the stands at risk and that the age class is monitored to ensure that we are managing proactively rather than reactively. This entails designing site preparation treatments with mistletoe in mind and not leaving unnecessary seed trees or retention patches where mistletoe is evident.**

In order to detect and quantify mistletoe experienced forest health surveyors can use a walkthrough survey or the formal Hawksworth survey. The Dwarf Mistletoe Management Guidebook provides guidance on how to deal with mistletoe infection within both clearcut and partial-cut harvesting systems, and for pre-commercial and commercial thinning in young stands. The Hawksworth six-class dwarf mistletoe rating system survey is also explained within the guidebook. This guidebook can be found at the following website: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/dwarf/dwarftoc.htm.

6.2.4 Red band needle blight (*Dothistroma septosporum*)

In 2017, Dothistroma continued to be the foliar pathogen that caused the most damage in conifer stands. The area impacted increased from 5,559ha to 18,773 ha in the Omineca with the majority occurring in the Prince George TSA. This disease has persistently increased since 2015 and the predictions for 2017 based on the wet spring proved correct.

Epidemic levels of Dothistroma needle blight can develop rapidly, and the severity and extent of the damage cannot be predicted. Dothistroma needle blight in young lodgepole pine plantations should be seen as a warning of the potential risk that foliar diseases might pose, particularly when species diversity is not maintained.

The 2017 workshop on foliar pathogens (attended by the provincial team of pathologists and AOS specialists) resulted in increased capacity for identification of foliar pathogens by providing an opportunity to conduct the AOS earlier in the spring and verify the observations via ground checks during the window of expression for select foliar pathogens. Monitoring stands in the early spring is an ongoing priority and additional efforts to improve the spatial distribution of Dothistroma in the Prince George and Robson Valley TSAs will proceed in the coming years. Please notify Jewel Yurkewich (Jewel.Yurkewich@gov.bc.ca) if you are aware of other areas: 1) with suspect Dothistroma infections; 2) where Dothistroma has been identified in new areas; or 3) where the severity of infection is of concern. Formal surveys and sample collection for DNA analysis are planned for spring 2018.

Prince George & Mackenzie TSAs

Dothistroma is a low to medium priority forest health factor in the Prince George and Mackenzie TSAs though incidence levels should continue to be monitored and their priority reassessed at the annual review stage. Information pertaining to the hazard rating of Dothistroma was collected during an aerial overview survey completed by former Regional Forest Pathologist Richard Reich in the Prince George and Fort St. James Districts. In general, the SBSvk biogeoclimatic subzone is high risk, the SBSwk is moderate, and everything else is low. Areas in close proximity to rivers and flat to concave/toe of slope landforms are at highest risk. Slopes greater than 10% are low risk.

Robson Valley TSA

Future monitoring of Dothistroma is a priority, especially within susceptible areas and locations that may be influenced by climatic changes, such as changes to seasonal precipitation patterns.

6.2.5 Stem rusts of lodgepole pine

Forest Analysis and Inventory Branch (FAIB) has developed models for the Tree and Stand Simulator (TASS) in order to incorporate the impacts of comandra blister rust (Comandra Rust Impact Module Evaluator - CRIME) and western gall rust (Gall Rust Impact Module - GRIM) into timber supply analysis. The models are being incorporated into the current timber supply review for the Lakes TSA and there are plans for continued application of the models. For GRIM, the next step involves taking the model outputs and tracking them through the sawmill simulator to determine the impact of western gall rust on lumber yield. For more information please contact Jewel Yurkewich, Regional Pathologist (Jewel.Yukewich@gov.bc.ca) or Derek Sattler, Research Scientist (Derek.Sattler@gov.bc.ca).

For operational purposes, if any species of rust (western gall rust, comandra blister rust or stalactiform blister rust) is identified at a regenerating site, it is important to visit the site regularly to monitor the mortality rate. Please see the Pine Stem Rust Management Guidebook for more information. If these diseases are found in an area for the first time, please contact Jewel Yurkewich, Regional Pathologist.

Collectively, the pine stem rusts cause more losses than any other pest in young stands. A hazard and risk rating system is currently in development to help identify localized areas of concern. District specific rust incidence maps have been generated from the 2012 RESULTS database and examples are provided in Appendix 4: Examples of rust incidence maps by district. Please contact Jewel Yurkewich (Regional Forest Pathologist) for access to georeferenced pdfs or spatial files, and the incidence maps corresponding to specific rust species. Additional information may be found in the 2013 Rust Management Strategy for the Omineca Region which is also available upon request and contains information regarding reforestation recommendations and hazard for related ecosystems.

A rust management strategy and a Standard Operating Procedure (SOP) for ground detection were developed for the Mackenzie TSA by the Mackenzie Rust Working Group in 2006, and later adopted by the Omineca as a whole in 2012. Members of this working group include: private industry and District and Regional levels of Ministry of Forests, Lands, Natural Resource Operations, and Rural Development. The control measures from the SOP are focused on promoting a greater awareness of rusts and associated alternate hosts, reforesting to higher densities and planting non-susceptible species where ecologically appropriate.

6.2.5.1 COMANDRA BLISTER RUST (*Cronartium comandrae*)

Comandra blister rust is a persistent and lethal stem rust of lodgepole pine. It girdles and kills young trees rapidly and can occur at very high levels locally, and therefore it is important to keep in mind that the majority of mortality on moderate-high hazard sites is most likely to occur in the first 5 years. Since spread by spores from the alternate host to pine is typically over a short range, infection is highly clustered and generally corresponds to the distribution of the alternate host, *Geocaulon lividum* (Bastard toadflax)*****. Risk is several times higher within close proximity (a few meters) to the alternate host (Feng et al. 2013). Resistance in lodgepole pine is not believed to be common, although resistance screening holds potential for identification of resistant families.

***Please note**: throughout the distribution of comandra blister rust in North America there are two documented alternate hosts. In the Omineca Region the most likely host is *Geocaulon lividum*. Please ensure that all reference materials used for planning and operational purposes report *G. lividum* as the alternate host.

PRINCE GEORGE & MACKENZIE TSAS

Impact can be serious, especially where stocking is insufficient to compensate for mortality, therefore overstocking is recommended on high risk xeric sites. Species mixes are recommended on mesic and moister sites. Projected rust levels can be estimated using a three step approach (source: Richard Reich). Infection is largely a function of weather, with elevation determining the general hazard. In the SBS biogeoclimatic zone, risk is assessed as high (greater than 20% incidence), moderate, or low based on elevation:

Risk	High	Moderate	Low
Elevation (m)	< 800m	800-1200	> 1200

Note: Incidence rarely exceeds 5% in the ESSF probably due to low night time temperatures.

At the site level, the presence of the alternate host, *Geocaulon lividum*, can dramatically increase risk. Distribution and percent cover are key factors to assess during a pre-harvest reconnaissance, prior to developing a management plan. The incidence of rust in adjacent young stands is also a key factor when interpreting the overall risk posed by elevation and alternate host abundance

6.2.5.2 STALACTIFORM BLISTER RUST (*Cronartium coleosporioides*)

Stalactiform blister rust can be locally abundant, but is not widespread. Alternate hosts for stalactiform blister rust include members of the Orobanchaceae family. Most notable are common red paintbrush (*Castilleja spp.*), cow wheat (*Melanpyrum lineare*), and yellow rattlebox, (*Rhinanthus minor* L.). These plants are common on disturbed sites and distributed by contaminated equipment. Significant mortality can occur on sites with moderate to high levels of alternate hosts, particularly if trees are infected at a very young age. Pre- and post-harvest monitoring is ongoing.

6.2.5.3 WESTERN GALL RUST (*Endocronartium harknessii*)

The distribution of western gall rust is widespread throughout the range of its pine host in the province of BC (Ziller 1974). On average it occurs at low to moderate levels in the Prince George TSA, but may be as high as 60% incidence (stem infection) locally. In the Prince George TSA, western gall rust accounts for approximately 70% of all rust infection.

Free growing surveys conducted as early as age 15 should capture 90% of infection on high risk sites (source Richard Reich). Main stem galls are generally lethal when infection occurs at a very young age, with mortality typically leveling off somewhat by age 20 to 25. Stem deformities persisting into late rotation may result in breakage, cull, and volume loss depending on the severity of infection.

Variation in genetic predisposition is strongest in western gall rust, compared to other stem rusts. Natural resistance to western gall rust has been incorporated into the BC Tree Improvement Program. The main source of resistant seed is from select orchards, and from a new orchard established in 2010 for the sole purpose of reforesting high risk sites with gall rust resistant material.

6.2.6 Tomentosus root disease (*Onnia tomentosa*)

Tomentosus (*Onnia tomentosa =Inonotus tomentosus)* has been found to have inconsistent above ground symptoms and its distribution is not captured by the AOS or other detailed surveys. Therefore, further documentation of the location of specific infection centers is required to improve management. If an area is impacted by tomentosus or is suspected of having high hazard rating please send the location and stand descriptors to Jewel Yurkewich, Regional Forest Pathologist. **A new reference document *Managing Root Disease in British Columbia* has been released in May 2018. The document covers best practices, and the strategies and tactics for managing root disease, including tomentosus.**

For additional information please refer to the Stand Establishment Decision Aid (SEDA) for tomentosus: http://www.jem-online.org/forrex/index.php/jem/article/view/562

7 ABIOTIC FACTORS, DECLINES & DISEASE COMPLEXES

Abiotic factors, declines, and disease complexes are often a result of cumulative environmental and biotic damaging agents over time. Declines and disease complexes are particularly difficult to identify using the aerial overview survey. However, changing climate and weather conditions suggest that interactions of abiotic factors such as drought or changes in local hydrology combined with widespread favorable conditions for many insects and diseases (e.g. warmer minimum winter temperatures) may increase the incidence of declines and disease complexes.

7.1 ASPEN DECLINE

FIGURE 17 – INDICATORS OF POOR ASPEN HEALTH NEAR DAWSON CREEK, BC.

In 2016, reports of aspen decline (on *Populus tremuloides*) in the Yukon and Northwest Territories caught our attention. The NRCAN project on *Climate Impacts on Productivity and Health of Aspen* (CIPHA) highlighted that these observations were being collected for many years in other provinces and territories; however, the AOS has captured very few records of aspen decline between 1999 and 2017 in the Omineca Region.

Although there was no aspen decline reported in the Omineca in 2017, the prevalence and combination of other biotic stressors and drought is of concern. According to our AOS records since 1999, the first occurrence of satin moth was reported in 2016 with 9,122 ha reported, possibly representing the most northern occurrence recorded. The 2017 AOS captured an alarming 107,088.6 ha which represents an 11.7 fold increase from last year. While conducting rust assessments, we identified a large expanse of infested aspen in Fort Fraser and extending past the western border of the region. Mirroring the collapse of the aspen serpentine leaf miner in the Northeast, the area affected by aspen serpentine leaf miner in the Omineca decreased to 116,390.3 ha from 387,483.6 ha in 2016. Our concern is that this may reflect the overall vigour and health of aspen. However, at this time it is not possible to obtain measurements to support the overall decline of aspen health but the combination of these observations provides support for increased monitoring.

It is crucial that we monitor winter temperatures and the variation in spring temperatures in order to anticipate how the populations will respond. If the satin moth is able to complete its life cycle under northern temperature and conditions this may indicate that we can expect to see other insect populations increase as well.

8 ADDITIONAL INFORMATION

8.1 ADDITIONAL INFORMATION AND LINKS

Bark Beetle Management Guidebook: http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/bark-beetles/bark_beetle_management_guidebook.pdf

Field guide to Forest Damage in British Columbia: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/land/forest-health-docs/field_guide_to_forest_damage_in_bc_web.pdf

Northwest Invasive Plant Council (NWIPC): http://nwipc.org/

Provincial Forest Health Strategy:
https://www.for.gov.bc.ca/hfp/health/strategy/Forest%20Health%20Strategy.pdf

Previous Regional/District Forest Health Strategies:
https://www.for.gov.bc.ca/hfp/health/TSA_strategies.htm

8.2 ABBREVIATIONS

AAC - Allowable Annual Cut

BEC – Biogeoclimate zones

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

8.3 AERIAL OVERVIEW SURVEY DATA ACCESS

The current and historical data from the annual aerial overview surveys (AOS) can be found on the official forest health website from the BC government:

http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys

8.4 CONTACT LIST

TABLE 5 – REGIONAL CONTACTS

Name (Last, First)	Title	Email	Telephone
Bevington, Alex	Research Earth Scientist	Alexandre.Bevington@gov.bc.ca	250-561-3460
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Griesbauer, Hardy	Research Silvicultural Ecologist	Hardy.Griesbauer@gov.bc.ca	778-693-2736
Miller, Brendan	Research Soil Scientist	Brendan.Miller@gov.bc.ca	250-561-3474
Rex, John	Research Hydrologist	John.Rex@gov.bc.ca	250-561-3464
Robert, Jeanne	Regional Entomologist	Jeanne.Robert@gov.bc.ca	250-561-3461
Rogers, Bruce	Research Ecologist	Bruce.Rogers@gov.bc.ca	250-561-3471
Foord, Vanessa	Research Climatologist	Vanessa.Foord@gov.bc.ca	250-561-3459
Yurkewich, Jewel	Regional Pathologist	Jewel.Yurkewich@gov.bc.ca	778-693-3029

TABLE 6 – FLNRORD CONTACTS FOR SPRUCE BEETLE MANAGEMENT

Name (Last, First)	Title	Expertise / role in forest health	Email	Telephone
Ross, Tory	Licensed Authorizations Officer	**Prince George TSA** spruce beetle working group coordinator	Tory.Ross@gov.bc.ca	250-614-7403
Fonda, Anne Marie	Stewardship Specialist	**Northeast Region** spruce beetle lead and working group coordinator	AnneMarie.Fonda@gov.bc.ca	250-784-1290
Burrows, Graham	Stewardship Forester	**Mackenzie TSA** spruce beetle working group coordinator	Graham.Burrows@gov.bc.ca	250-997-2266
Huybers, John	Prince George District Manager	**Spruce Beetle Project Lead** overall coordination and lead for Ominica spruce beetle activities	John.Huybers@gov.bc.ca	250-614-7442
Robert, Jeanne	Regional Entomologist	**Omineca and Northeast Regions** scientific expertise in forest entomology	Jeanne.Robert@gov.bc.ca	250-561-3462

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APPENDIX 1: BEETLE MANAGEMENT CONTROL STRATEGIES

Beetle management unit (BMU) strategies are broad approaches that have specific objectives. The strategy chosen for a BMU should remain in place for as long as objectives are being met, or until additional resources become available to allow a more aggressive strategy to be implemented. Situations change from year to year, and so strategies are reassessed annually. Control strategies are also subject to review and modification based on changes in infestation levels, access, and other higher level plans. A yearly review will include an assessment of the success of the plan and how it may be improved in order to better meet the goals and objectives stipulated.

There are seven broad strategies that can be used to address bark beetle infestations in a BMU. The strategies include: prevention/ suppression, holding action, holding plus, salvage, monitor, undesignated, and protected areas/ecological reserves. Selection of the relevant strategy is based upon the forest health issues in the area, the stated integrated resource management objectives, and the expected impact of beetle activity in adjacent management areas.

The **suppression/prevention** is the most aggressive strategy. It is selected when the infestation status requires aggressive direct control actions. This strategy is best applied in areas that are lightly infested, and resources for direct control or harvesting and milling capacities equal or exceed the amount of infestation. The intent of the strategy is to reduce or keep the outbreak to a size and distribution that can be handled within "normal resource capability".

Holding is defined by vigorous directed harvesting and limited single tree treatments designed to, at least, prevent further population increases. The primary management activity will be directed harvesting (large and small blocks) of currently infested stands; containment baiting would be utilized wherever appropriate. Only limited use of direct control methods such as single tree treatments would be contemplated.

Salvage is applied to areas where management efforts would be ineffective for substantially reducing the beetle populations and subsequent levels of damage. Such areas have extensive outbreaks covering a large proportion of susceptible stands. The objective, in this strategy, is to salvage affected stands and minimize timber value loss. This strategy may also apply to areas with a low economic valuation of host trees – that is, where control is not worth the investment of resources to remove the infestation.

Monitor is the strategy applied to areas where management efforts would be ineffective for substantially reducing the beetle population and subsequent levels of damage, or where there is no short-term (less than five years) possibility of salvaging dead timber. This may be due to management constraints such as in Wilderness areas, Parks, or Ecological Reserves, or because access cannot be put in place before substantial merchantable degradation of the dead material occurs.

Monitoring plus is the strategy where management efforts would be effective for substantially reducing beetle populations (i.e. still early in an outbreak), but current access to the infestation area is limited. Therefore, the unit will be monitored with the intention of accessing the infestation within 5 years as access infrastructure is planned and implemented.

Undesignated are units that have not been assigned a strategy because no forest health factors have been identified for treatment.

Park, Protected Areas, and Ecological Reserves require a description for the protected area polygons on FLNRORD strategic beetle plans and maps. The bark beetle management strategies (e.g. suppression, holding, etc.), do not fit with the mandate BC Parks has to manage these areas. Therefore, a separate category was established to provide direction and management for protected areas and ecological reserves. Beetle management in protected areas uses a different set of values. Planning for beetle management in protected area will occur through co-operation between Ministry of Environment (MoE) and FLNRORD. The control

tactics available for use in BC Parks include allowing natural processes to prevail (i.e. do nothing), pheromone baits and traps, individual tree fall and burn on site, large-scale prescribed burn, and skid piles and burn on-site with low impact machinery. Commercial logging and road building is strictly prohibited in protected areas as directed through the Park Act.

The other resource management zones, which include Multi-Value Areas, Resource Development Areas, Special Management Areas and Settlement/Agriculture Areas, do not restrict strategy selection. However, they may restrict tactic selection.

Selecting the appropriate strategy or combination of strategies for a given area is based on a number of factors. Some of those factors include:

- beetle species and stand hazard;
- extent and distribution of the current and historical beetle infestations;
- expected impact of the beetle within the local and surrounding areas;
- land use objectives and non-timber resource values within the area; and
- stage of the beetle outbreak, strategies in adjacent landscape units, and accessibility.

APPENDIX 2: TACTICS FOR MANAGING BARK BEETLES

Tactics are treatments applied to specific areas or infestations within a BMU. The appropriate combination of tactics must be selected for each strategy to accomplish the stated objectives. Rarely will a single treatment be sufficient to deal with a particular infestation. Normally, a combination of treatments will be necessary. Furthermore, most treatments will have to be repeated annually while the strategy remains in place. Until the composition of the forest has substantial modifications, the susceptibility, and often the risk of subsequent infestation will be similar from year to year. Relevant tactics are described below.

Detection: Infestation presence and intensity was, and will continue to be, assessed with overview flights, detailed flight surveys, and ground detection surveys, which may include walkthrough reconnaissance surveys and/or detailed probe surveys.

Prediction: Hazard and risk ratings and green to red ratio calculations will be used to predict the size and location of both present and future populations. Over-wintering mortality studies and Lindgren funnel traps may be used to predict the size and location of future populations.

Harvesting: Harvesting may be divided into three categories: sanitation, salvage, and high hazard host removal. This includes both small patch and single tree selection in suppression/prevention

Single Tree Treatment: This includes fall and burn or fall and peel for IBM, IBD and IBS.

Baiting and Trap Trees: Aggregation semiochemicals or the intentional creation of patches of preferred host will be used to contain and concentrate beetle populations in areas where harvesting or other treatments are planned and access is available. All baits will be global positioning system (GPS) located and mapped for follow-up treatment.

Hauling Restrictions and Yard Management: These restrictions are generally not required if trucks do not stop between the logging site and the destination and if the infested logs are watered, debarked, or processed promptly. The main goal of yard management is the prompt processing or manufacturing of delivered logs during beetle flight. Pheromone traps (primarily to monitor flight) and watering of log decks may also be employed.

Access Development: Access planning and development is important for the short and long term management of bark beetles in high value or high hazard stands.

Reduction of Stand Susceptibility/Prevention: Silvicultural treatments, including species and age class manipulation on a landscape level with the reduction of large, continuous areas of mature and over-mature forest types, may be used to reduce the level of future damage to the forests. This treatment regime requires a long-term focus and can be considered one of the most effective long-term proactive tactics.

The following tables list the tactics for major bark beetles, mountain pine beetle, spruce beetle, and Douglas-fir beetle with critical dates:

Tactics for MOUNTAIN PINE BEETLE with critical dates for each designated BMU strategy: Suppression (Supr.), Holding (Hold.), Salvage (Salv.), and Monitoring or Monitoring Plus (Mon.).

Tactics	BMU Strategy	Critical Dates
1. Survey / Assessment		
Timing of adult flight	**Supr. Hold.** Salv. Mon.	June 15 to September 15
Infestation intensity rating	**Supr. Hold.** Salv. Mon.	Any time
Hazard rating	**Supr. Hold.** Salv. Mon.	Any time
Risk rating	**Supr. Hold.** Salv. Mon.	Any time
Overview and detailed aerial		July 15 to September 15
sketch mapping	**Supr. Hold.** Salv.	August 1 to September 15
Aerial photography	**Supr. Hold.** Salv.	April 1
Ground probe or walkthrough	**Supr. Hold.** Salv.	Oct - May
2. Harvesting		
Sanitation	**Supr. Hold.**	Any time
Salvage	Salv.	Any time
High hazard host removal	**Supr. Hold.**	Any time
Harvest priority rating system	**Supr. Hold.** Salv.	Any time
3. Single Tree Treatments (STT)		
Fall and burn	**Supr. Hold.**	October 15 to May 1
Verbenone	**Supr.**	April 1 to May 15
Debarking	**Supr. Hold.**	Prior to flight
Small patch / single tree selection	**Supr. Hold.**	Any time
4. Bait Use		
Containment	**Supr. Hold.**	May 1 to June 30
Monitoring	**Supr. Hold.**	July 1 to August 15
Prior and follow-up to STT	**Supr. Hold.**	Treatment to June 30
5. Hauling Restrictions	**Supr. Hold.**	June 15 to September 15, or as per the Regional Guidelines
6. Access Development	**Supr. Hold.** Salv. Mon.	Any time
7. Beetle Proofing	**Supr. Hold.** Salv. Mon.	Any time
8. Silvicultural Treatments		
Long-term species manipulation	**Supr. Hold.** Salv. Mon.	Any time
Age class mosaic manipulation	**Supr. Hold.** Salv. Mon.	Any time

Tactics for SPRUCE BEETLE with critical dates for each designated BMU strategy: Suppression (Supr.), Holding (Hold.), Salvage (Salv.), and Monitoring or Monitoring Plus (Mon.).

Tactics	Strategy	Critical Dates
1. Survey / Assessment		
Timing of adult flight	**Supr. Hold.** Salv. Mon.	May 25 to August 20
Infestation intensity rating	**Supr. Hold.** Salv. Mon.	Any time
Hazard rating	**Supr. Hold.** Salv. Mon.	Any time
Risk rating	**Supr. Hold.** Salv. Mon.	Any time
Overview and detailed aerial sketch mapping (18-24 month delay for faders)	**Supr. Hold.** Salv.	July 15 to October 15
Aerial photography	**Supr. Hold.** Salv.	August 1 to October 15
Ground probe or walkthrough	**Supr. Hold.** Salv.	August 20 to May10
2. Harvesting		
Sanitation	**Supr. Hold.**	Any time
Salvage	Salv.	Any time
High hazard host removal	**Supr. Hold.**	Any time
Harvest priority rating system	**Supr. Hold.** Salv.	Any time
3. Single Tree Treatments (STT)		
Fall and burn	**Supr. Hold.**	October 15 to May 1
Conventional Trap tree - fall	**Supr. Hold.**	March 1 to April 1
Conventional Trap tree - remove	**Supr. Hold.**	August 20 to April 30
Debarking	**Supr. Hold.**	Prior to flight
Small patch / single tree selection	**Supr. Hold.**	Any time
Helicopter logging	**Supr. Hold.**	Any time
4. Bait Use		
Containment	**Supr. Hold.**	May
Funnel Trap Monitoring	**Supr. Hold.**	May 25 to August 20
Follow-up Prior to STT	**Supr. Hold.**	August 20
5. Hauling Restrictions	**Supr. Hold.**	May 1 to August 20, or as per the Regional Guidelines
6. Access Development	**Supr. Hold.** Salv. Mon.	Any time
7. Beetle Proofing	**Supr. Hold.** Salv. Mon.	Any time
8. Silvicultural Treatments		
Long-term species manipulation	**Supr. Hold.** Salv. Mon.	Any time
Age class mosaic manipulation	**Supr. Hold.** Salv. Mon.	Any time

Tactics for DOUGLAS-FIR BEETLE with critical dates for each designated BMU strategy: Suppression (Supr.), Holding (Hold.), Salvage (Salv.), and Monitoring or Monitoring Plus (Mon.).

Tactics	Strategy	Critical Dates
1. Survey / Assessment		
Timing of adult flight	**Supr. Hold.** Salv. Mon.	April 15 to August 15
Infestation intensity rating	**Supr. Hold.** Salv. Mon.	Any time
Hazard rating	**Supr. Hold.** Salv. Mon.	Any time
Risk rating	**Supr. Hold.** Salv. Mon.	Any time
Overview and detailed aerial sketch mapping	**Supr. Hold.** Salv. Mon.	July 25 to September 25 July 25 to September 25
Aerial photography	**Supr. Hold.** Salv.	September to April 15
Ground probe or walkthrough	**Supr. Hold.** Salv.	
2. Harvesting		
Sanitation	**Supr. Hold.**	Any time
Salvage	Salv.	Any time
High hazard host removal	**Supr. Hold.**	Any time
Harvest priority rating system	**Supr. Hold.** Salv.	Any time
Post Harvesting Mop-up	**Supr. Hold.** Salv.	Prior to next flight
3. Single Tree Treatments (STT)		
Fall and burn	**Supr. Hold.**	October to March
Trap tree placement	**Supr. Hold.**	January to March
Trap tree removal	**Supr. Hold.**	September to December
Debarking	**Supr. Hold.**	September to October
Small patch / single tree selection	**Supr. Hold.**	Any time
Helicopter logging	**Supr. Hold.** Salv.	Any time
4. Pheromone Bait Use		
Containment	**Supr. Hold.**	April 15 to August 15
Control with Funnel Traps	**Supr. Hold.**	April 15 to August 15
Follow-up prior to STT	**Supr. Hold.** Salv. Mon.	Continual
5. Hauling Restrictions	**Supr. Hold.** Salv. Mon.	April 15 to August 15, or as per the Regional Guidelines
6. Access Development	**Supr. Hold.** Salv. Mon.	Any time
7. Beetle Proofing	**Supr. Hold.** Salv. Mon.	Any time
8. Silvicultural Treatments		
Long-term species manipulation	**Supr. Hold.** Salv. Mon.	Any time
Age class mosaic manipulation	**Supr. Hold.** Salv. Mon.	Any time

APPENDIX 3: 2017 AERIAL OVERVIEW SUMMARY OF SELECTED FOREST PESTS AND PATHOGENS.

Prince George TSA

	Trace	Light	Moderate	Severe	Very Severe	Total
Bark Beetles						
IBM=Mountain pine beetle	7,719	130	140	9	-	7,999
IBS=Spruce beetle	119,560	108,085	41,784	5,679	-	275,108
IBB=Western balsam bark beetle	662,734	276,871	3,680	231	-	943,516
IBD=Douglas-fir beetle	19,847	12,753	2,323	445	-	35,368
All Bark Beetles	**809,860**	**397,839**	**47,927**	**6,365**	**-**	**1,261,991**
Defoliators						
ID6=Aspen leaf miner	-	11,514	57,219	13,657	-	82,390
IDB=2-Year budworm	-	53,909	60,021	6,683	-	120,613
IDU=Satin moth	-	24,788	46,916	27,683	-	99,387
Total Defoliators	**-**	**90,211**	**164,157**	**48,023**	**-**	**302,391**
Diseases						
DFS=Dothistroma needle blight	-	6,800	7,342	3,900	-	18,042
DFL= Lophodermella needle cast	-	1,750	453	6	-	2,210
DVL= Venturia blight	-	-	-	370	-	370
Total Diseases	**-**	**8,550**	**7,795**	**4,276**	**-**	**20,621**

Mackenzie TSA

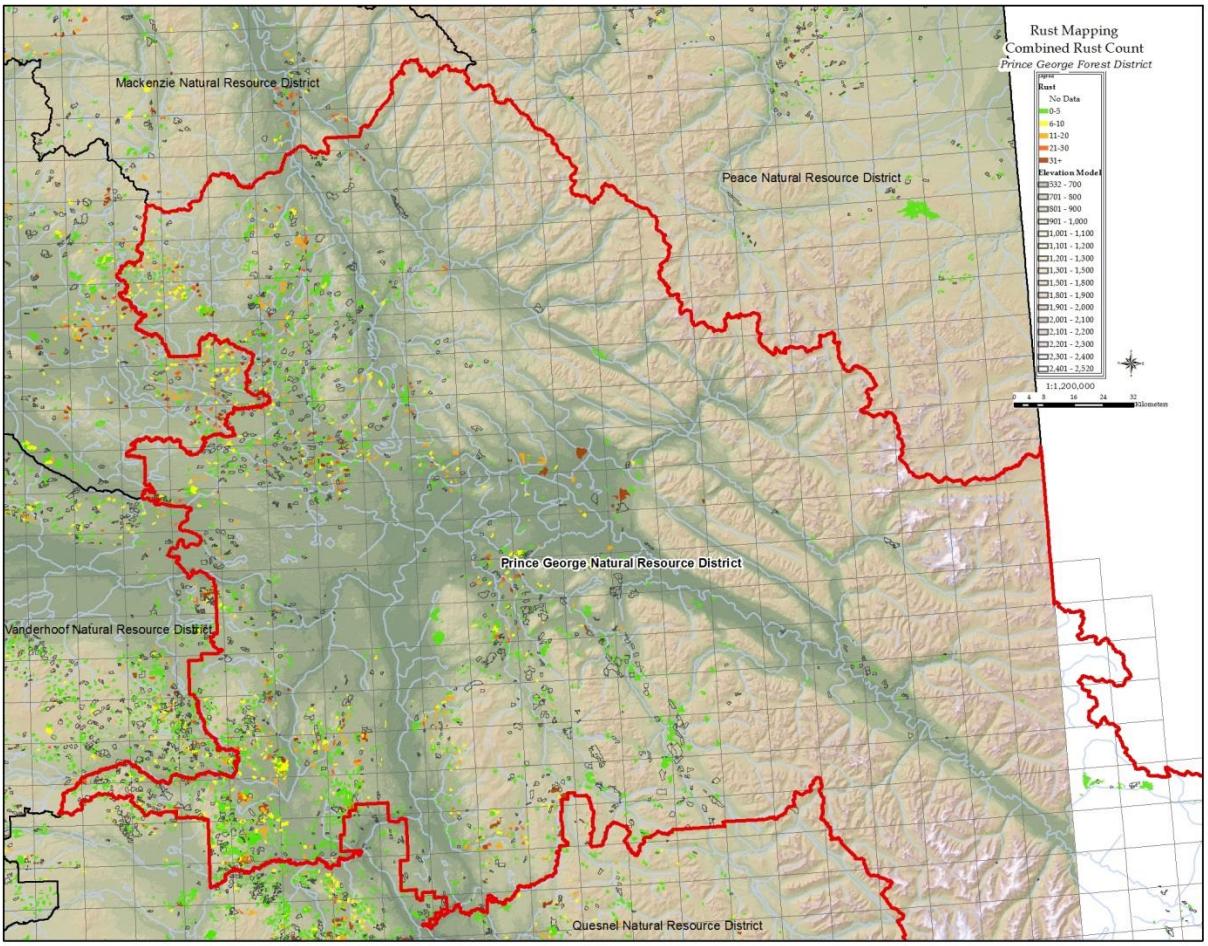
	Trace	Low	Moderate	Severe	Very Severe	Total
Bark Beetles						
IBM=Mountain pine beetle	10,813	273	-	29	-	11,116
IBS=Spruce beetle	39,744	40,602	9,837	10	-	90,192
IBB=Western balsam bark beetle	366,007	218,205	5,984	159	-	590,356
IBD=Douglas-fir beetle	-	5	-	1	-	6
All Bark Beetles	**416,564**	**259,086**	**15,821**	**199**	**-**	**691,670**
Defoliators						
ID6=Aspen leaf miner	-	3,131	24,756	1,236	-	29,123
IDB=2-year budworm	-	23,173	12,799	331	-	36,303
IDU=Satin moth	-	5,745	1,833	37	-	7,615
Total Defoliators	**-**	**32,049**	**39,388**	**1,603**	**-**	**73,041**
Diseases						
DFC=Spruce-Labrador tea rust	-	-	81	50	-	131
Total Diseases	**-**	**-**	**81**	**50**	**-**	**131**

Robson Valley TSA

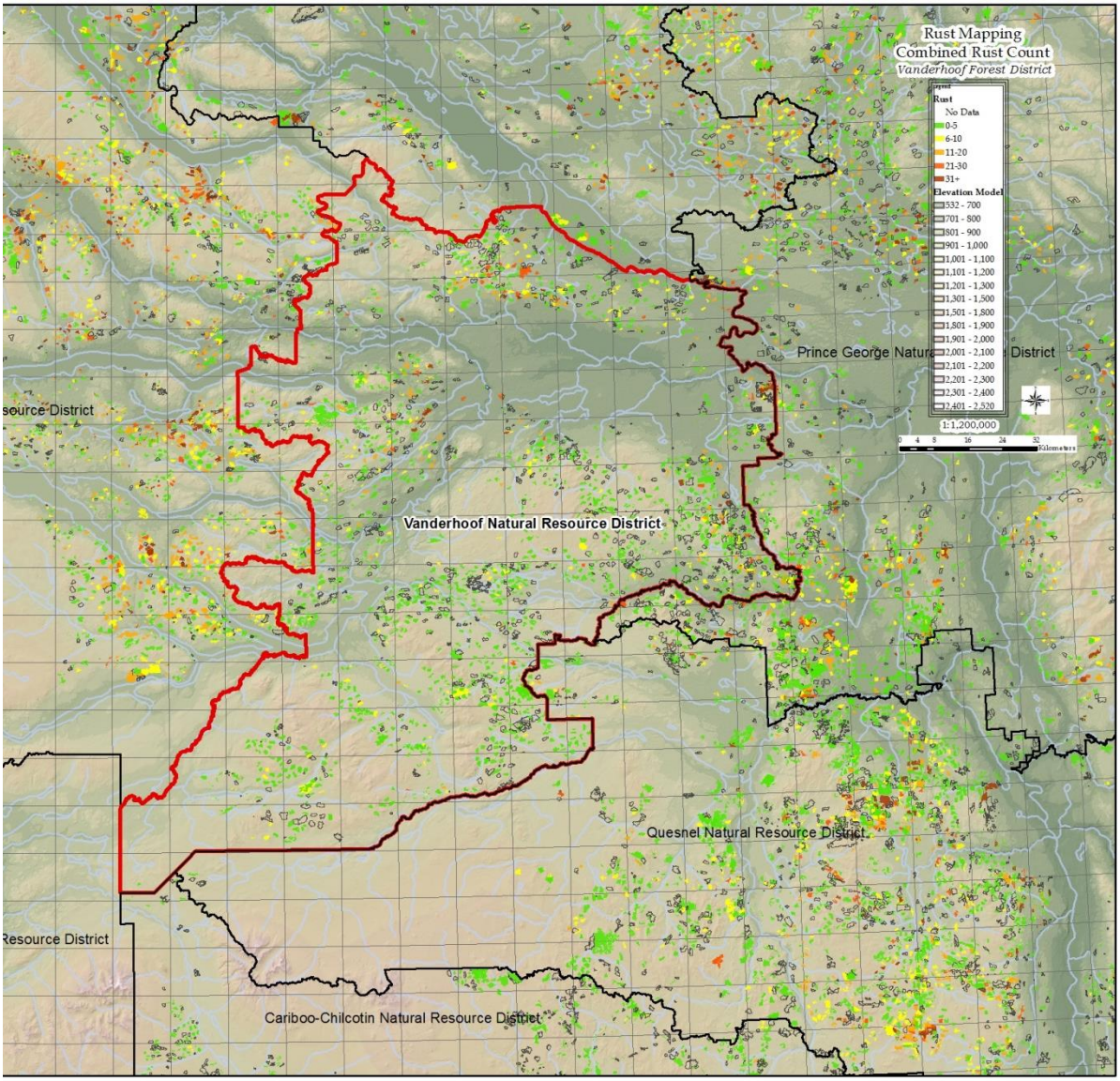
	Trace	Low	Moderate	Severe	Very Severe	Total
Bark Beetles						
IBM=Mountain pine beetle	5,680	13,270	14,420	1,025	-	34,396
IBS=Spruce beetle	2,038	3,293	1,832	20	-	7,182
IBB=Western balsam bark beetle	64,290	11,932	321	22	-	76,565
IBD=Douglas-fir beetle	-	870	-	6	-	876
All Bark Beetles	**72,008.23**	**29,365.85**	**16,572**	**1,073**	**-**	**119,019**
Defoliators						
ID6=Aspen leaf miner	-	578	2,426	1,865	-	4,869
IDB=2-year budworm	-	15,557	6,813	8	-	22,378
IDN=Birch leaf miner	-	746	993	103	-	1,842
Total Defoliators	**-**	**16,881**	**10,232**	**1,975**	**-**	**29,089**
Diseases						
DFS=Dothistroma needle blight	-	557	174	-	-	731
Total Diseases	**-**	**557**	**174**	**-**	**-**	**731**

APPENDIX 4: EXAMPLES OF RUST INCIDENCE MAPS BY DISTRICT

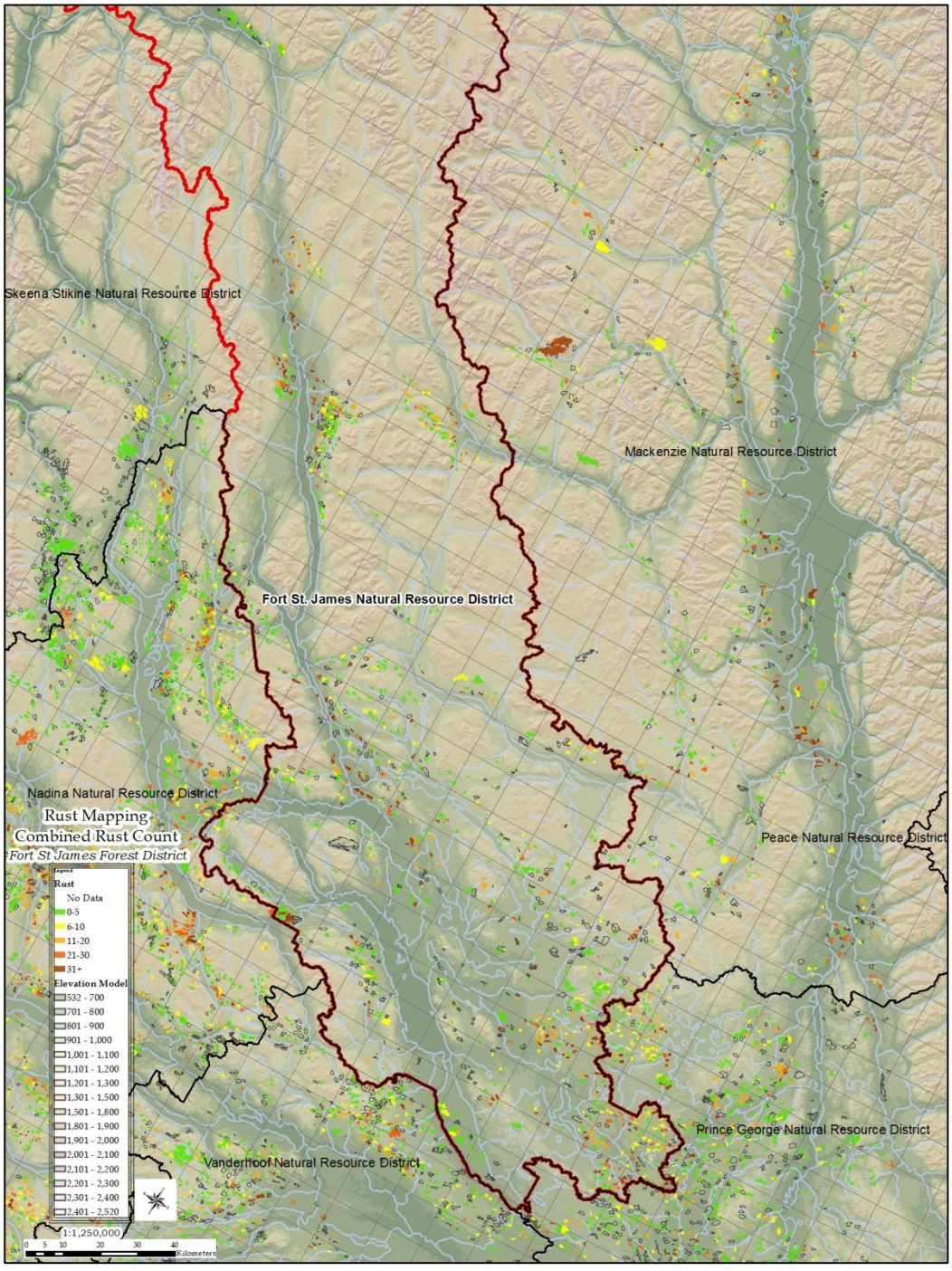
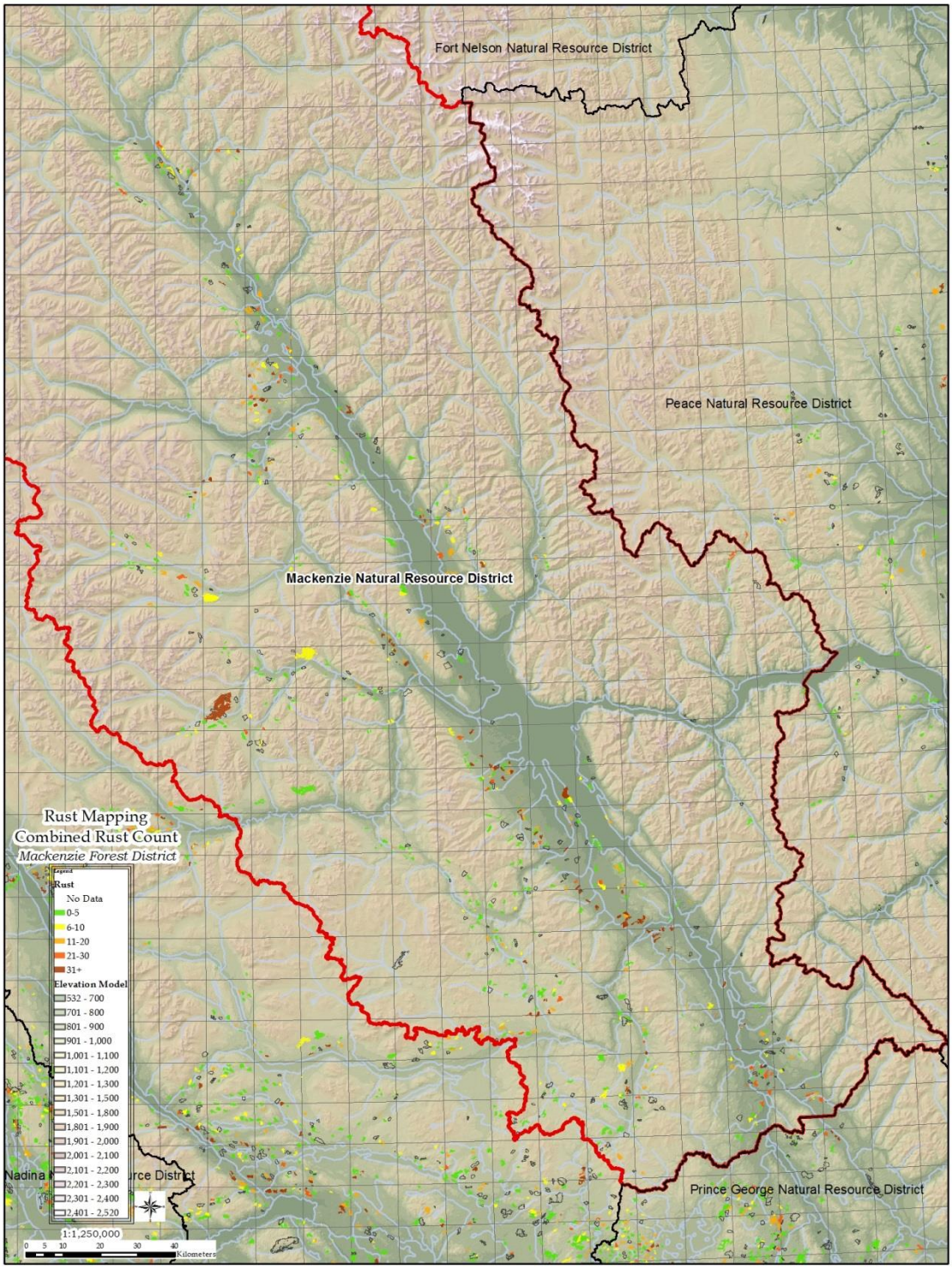
Appendix 4.1: Combined rust count for the Prince George District in 5-10% incidence classes representing relative risk for planting susceptible species.



Appendix 4.2: Combined rust count for the Vanderhoof District in 5-10% incidence classes representing relative risk for planting susceptible species.



Appendix 4.3: Combined rust count for the Fort St. James District in 5-10% incidence classes representing relative risk for planting susceptible species.



Appendix 4.4: Combined rust count for the Mackenzie District in 5-10% incidence classes representing relative risk for planting susceptible species.