OMINECA REGION

PRINCE GEORGE, MACKENZIE, AND ROBSON VALLEY TIMBER SUPPLY AREAS

FOREST HEALTH STRATEGY 2017-2018

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

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS **4**

1 MISSION STATEMENT **5**

1.1 INTRODUCTION 5
1.2 SCOPE OF THE FOREST HEALTH STRATEGY 5
1.3 OVERVIEW OF TIMBER SUPPLY AREAS 7

2 OMINECA PEST ALERT! **11**

2.1 ENDEMIC INSECTS AND PATHOGENS 11
2.1.1 WINTER MOTH OR LINDEN LOOPER (*ERANNIS SP.)* 11
2.1.2 PINE SHEATH NEEDLE MINER (*ZELLERIA HAIMBACHI)* 11
2.1.3 "DIESEL ROT" 12
2.2 INVASIVE INSECTS AND PATHOGENS 12
2.2.1 SATIN MOTH (*LEUCOMA SALICIS*) 13
2.2.2 BALSAM WOOLLY ADELGID (*ADELGES PICEAE)* 13
2.2.3 EUROPEAN GYPSY MOTH (*LYMANTRIA DISPAR)* 14
2.2.4 POLAR AND WILLOW BORER (*CRYPTORHYNCHUS LAPATHI)* 14
2.2.5 WHITE PINE BLISTER RUST (*CRONARTIUM RIBICOLA*) 14

3 INTERPRETING THE OMINECA FOREST HEALTH STRATEGY **16**

3.1 MANAGEMENT UNIT BOUNDARIES AND DESIGNATIONS 16
3.2 RANKING OF FOREST HEALTH FACTORS 16

4 MAJOR BARK BEETLES IN THE OMINECA **19**

4.1 MOUNTAIN PINE BEETLE (*DENDROCTONUS PONDEROSAE*) 19
4.2 SPRUCE BEETLE (*DENDROCTONUS RUFIPENNIS*) 24
4.3 DOUGLAS-FIR BEETLE (*DENDROCTONUS PSEUDOTSUGAE*) 29
4.4 WESTERN BALSAM BARK BEETLE (*DRYOCETES CONFUSUS*) 32

5 OTHER PRIORITY INSECTS AND PATHOGENS IN THE OMINECA **33**

5.1 TWO-YEAR CYCLE BUDWORM (*CHORISTONEURA BIENNIS*) 33
5.2 ASPEN LEAF MINER (*PHYLLOCNISTIS POPULIELLA*) 33
5.3 RED BAND NEEDLE BLIGHT (*DOTHISTROMA SEPTOSPORUM*) 34
5.4 ASPEN, POPLAR LEAF AND TWIG BLIGHT (*VENTURIA SPP.*) 34
5.5 TOMENTOSUS ROOT DISEASE (*ONNIA TOMENTOSA*) 35
5.6 ARMILLARIA ROOT DISEASE (*ARMILLARIA OSTOYAE*) 35
5.7 DWARF MISTLETOE OF LODGEPOLE PINE (*ARCEUTHOBIUM AMERICANUM*) 36
5.8 WESTERN GALL RUST (*ENDOCRONARTIUM HARKNESSII*) 36
5.9 STALACTIFORM BLISTER RUST (*CRONARTIUM COLEOSPORIOIDES*) 37
5.10 COMANDRA BLISTER RUST (*CRONARTIUM COMANDRAE*) 38
5.11 LARGE ASPEN TORTRIX (*CHORISTONEURA CONFLICTANA*) 39
5.12 SPRUCE/WHITE PINE WEEVIL (*PISSODES STROBI*) 39
5.13 LODGPOLE PINE TERMINAL WEEVIL (*PISSODES TERMINALIS*) 39
5.14 WARREN ROOT COLLAR WEEVIL (*HYLOBIUS WARRENI*) 40

6 ADDITIONAL INFORMATION **40**

6.1 AERIAL OVERVIEW SURVEY DATA ACCESS 40

6.2 CONTACT LIST 40
6.3 ADDITIONAL INFORMATION AND LINKS 41
7 ABBREVIATIONS 42
8 REFERENCES 43

LIST OF FIGURES

FIGURE 1 - THE OMINECA REGION 6
FIGURE 2 – THE PRINCE GEORGE TSA. 8
FIGURE 3 – THE MACKENZIE TSA. 9
FIGURE 4 – THE ROBSON VALLEY TSA. 10
FIGURE 5 – WINTER MOTH OR LINDEN LOOPER (*ERANNIS SP.*). 11
FIGURE 6 – PINE NEEDLE SHEATH MINER. 12
FIGURE 7 – AN EXAMPLE OF "DIESEL ROT" IN NEWLY CUT SPRUCE LUMBER. 12
FIGURE 8 – LIFE STAGES OF SATIN MOTH. 13
FIGURE 9 – PRINCE GEORGE TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE. 21
FIGURE 10 – MACKENZIE TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE. 22
FIGURE 11 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE. 23
FIGURE 12 – PRINCE GEORGE TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE 26
FIGURE 13 – MACKENZIE TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE 27
FIGURE 14 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE. 28
FIGURE 15 – PRINCE GEORGE TSA FOREST HEALTH STRATEGIES FOR DOUGLAS-FIR BEETLE. 30
FIGURE 16 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR DOUGLAS-FIR BEETLE. 31

LIST OF TABLES

TABLE 1 – RANKING OF ECOLOGICAL AND ECONOMIC IMPORTANCE OF COMMON FOREST INSECTS OCCURING IN THE OMINECA REGION 17
TABLE 2 – RANKING OF ECOLOGICAL AND ECONOMIC IMPORTANCE OF COMMON FOREST PATHOGENS OCCURING IN THE OMINECA REGION. 18
TABLE 3 – RANKING OF ECOLOGICAL AND ECONOMIC IMPORTANCE OF ANIMAL OR ABIOTIC DAMAGE OCCURING IN THE OMINECA REGION. 18
TABLE 4 - RANKING OF DECLINES AND COMPLEXES (FOREST HEALTH ISSUES INFLUENCED BY MULTIPLE FACTORS – ABIOTIC AND BIOTIC) IN THE OMINECA REGION. 18
TABLE 5 – REGIONAL CONTACTS 40
TABLE 6 – FLNRORD CONTACTS FOR SPRUCE BEETLE MANAGEMENT 41

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 – Spruce beetle-killed stands in drainages east of Williston Lake in the Mackenzie 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. It is aligned with and driven by the mission statement of the Provincial Forest Health Strategy to:

"Provide science-based, economically rationalized best management practices and implement treatment programs that prevent or mitigate the impacts of forest health agents."

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.

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 annual allowable cut (AAC) is 17,363,559 m^3/year. For more information on the AAC by TSA and effective dates, please see: https://www.for.gov.bc.ca/hts/aactsa.htm

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.

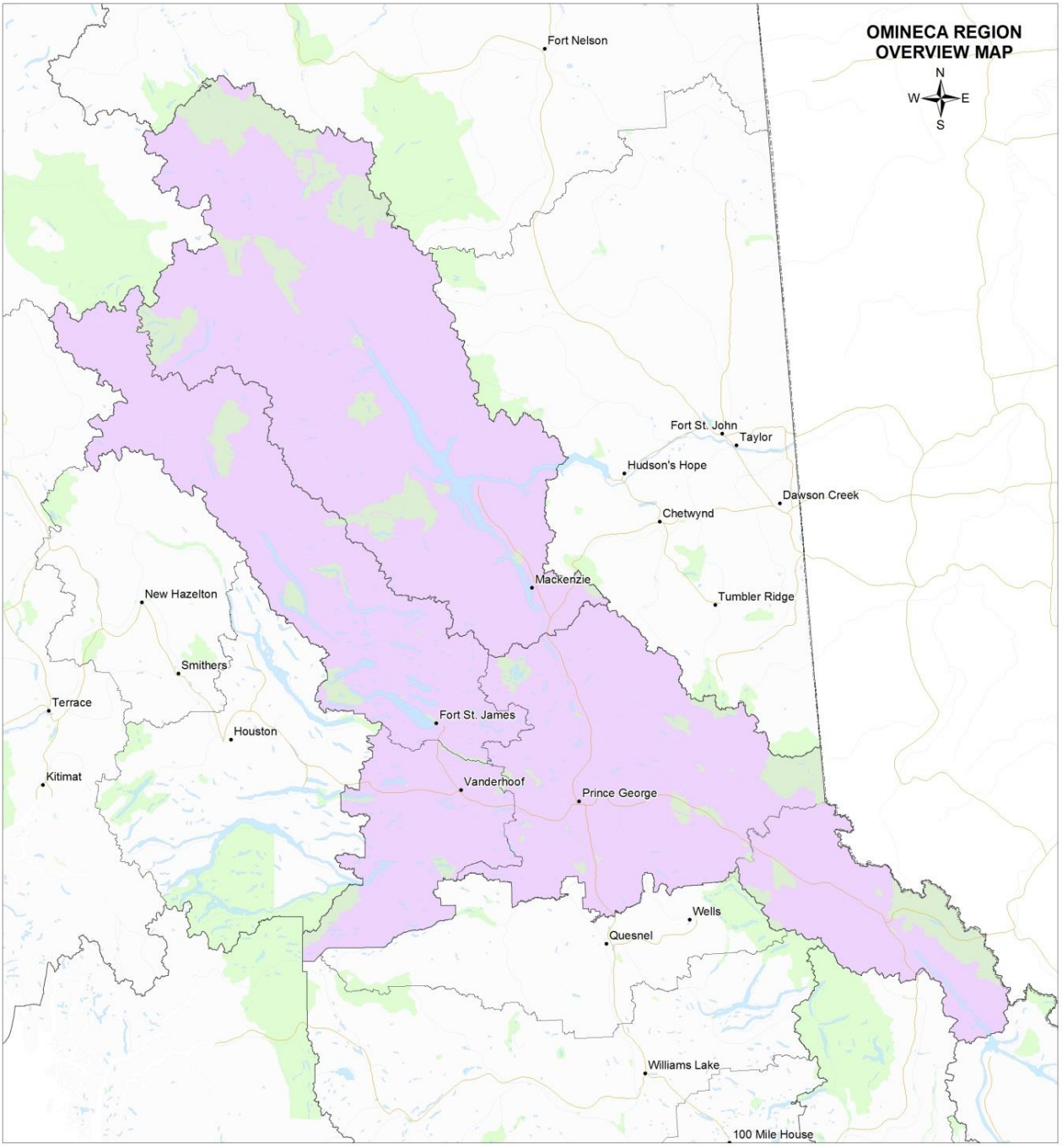


FIGURE 1 - THE OMINECA REGION

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 12,500,000 m^3/year (effective as of 2011) and is one of the largest timber management units in the province.

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).

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 zones. The current AAC is 363,599 m^3/yr (effective as of 2016). This TSA is administered from the Prince George Natural Resource District in Prince George and a field office in McBride.

PRINCE GEORGE TIMBER SUPPLY AREA

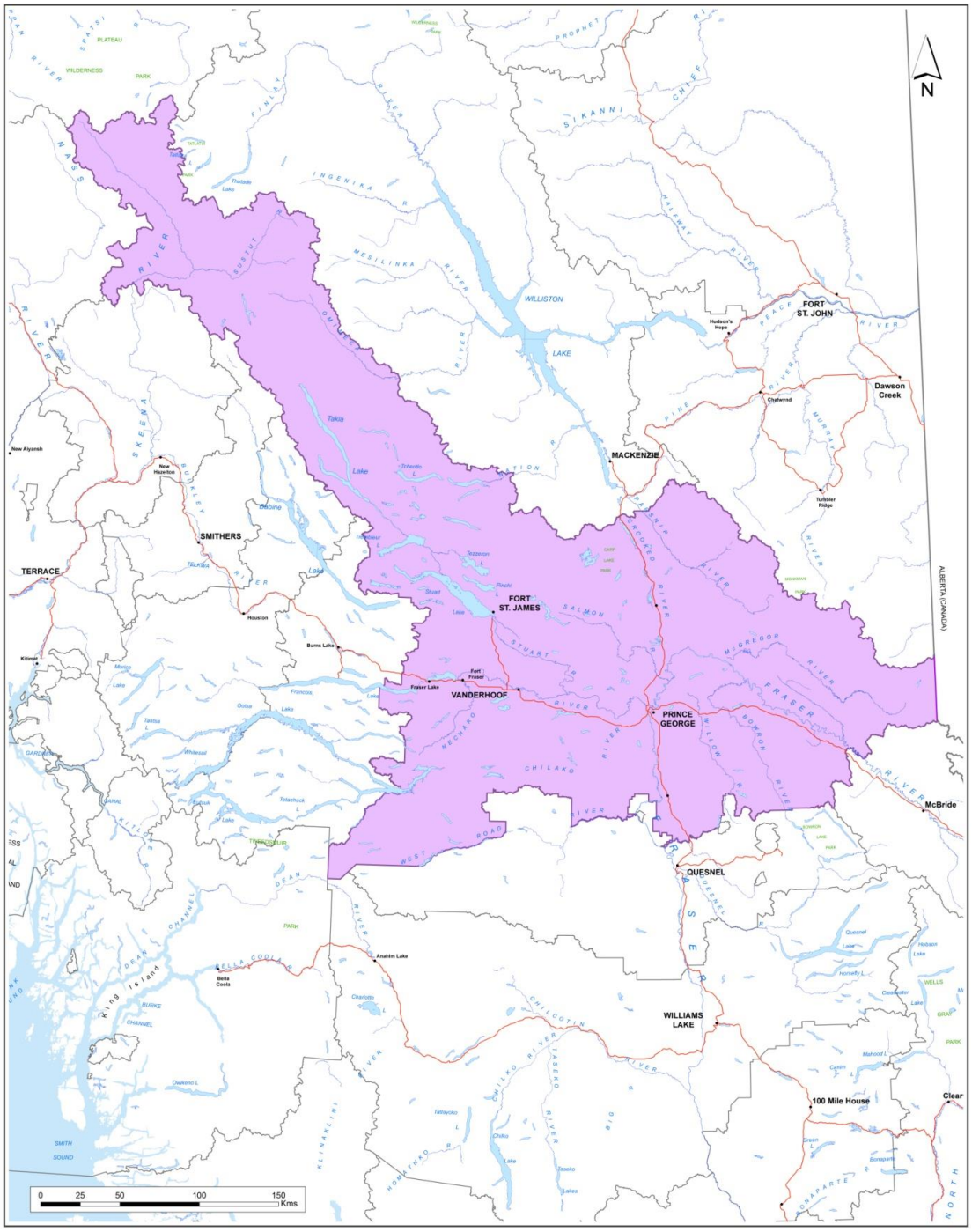


FIGURE 2 – THE PRINCE GEORGE TSA.

MACKENZIE TIMBER SUPPLY AREA

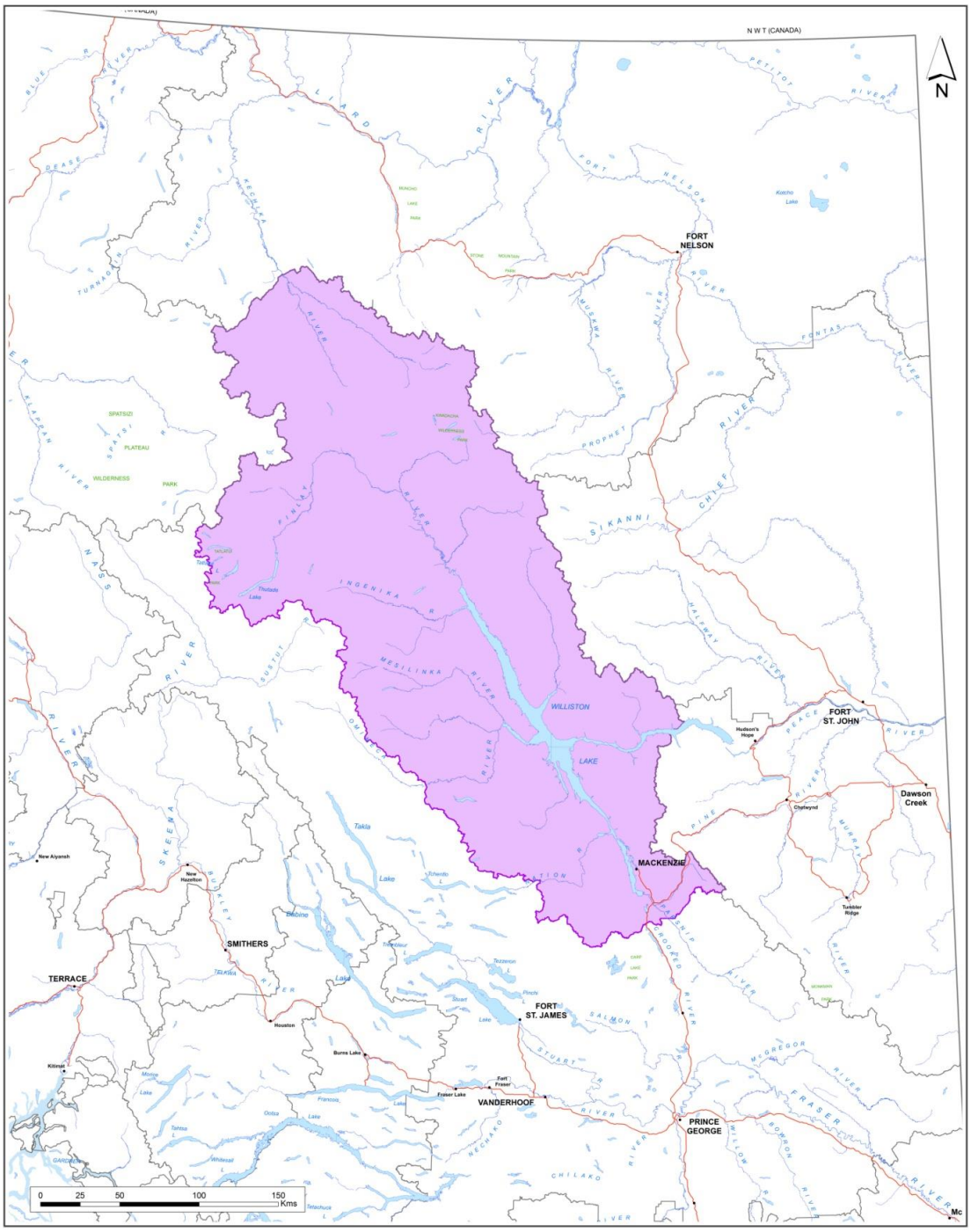


FIGURE 3 – THE MACKENZIE TSA.

ROBSON VALLEY TIMBER SUPPLY AREA

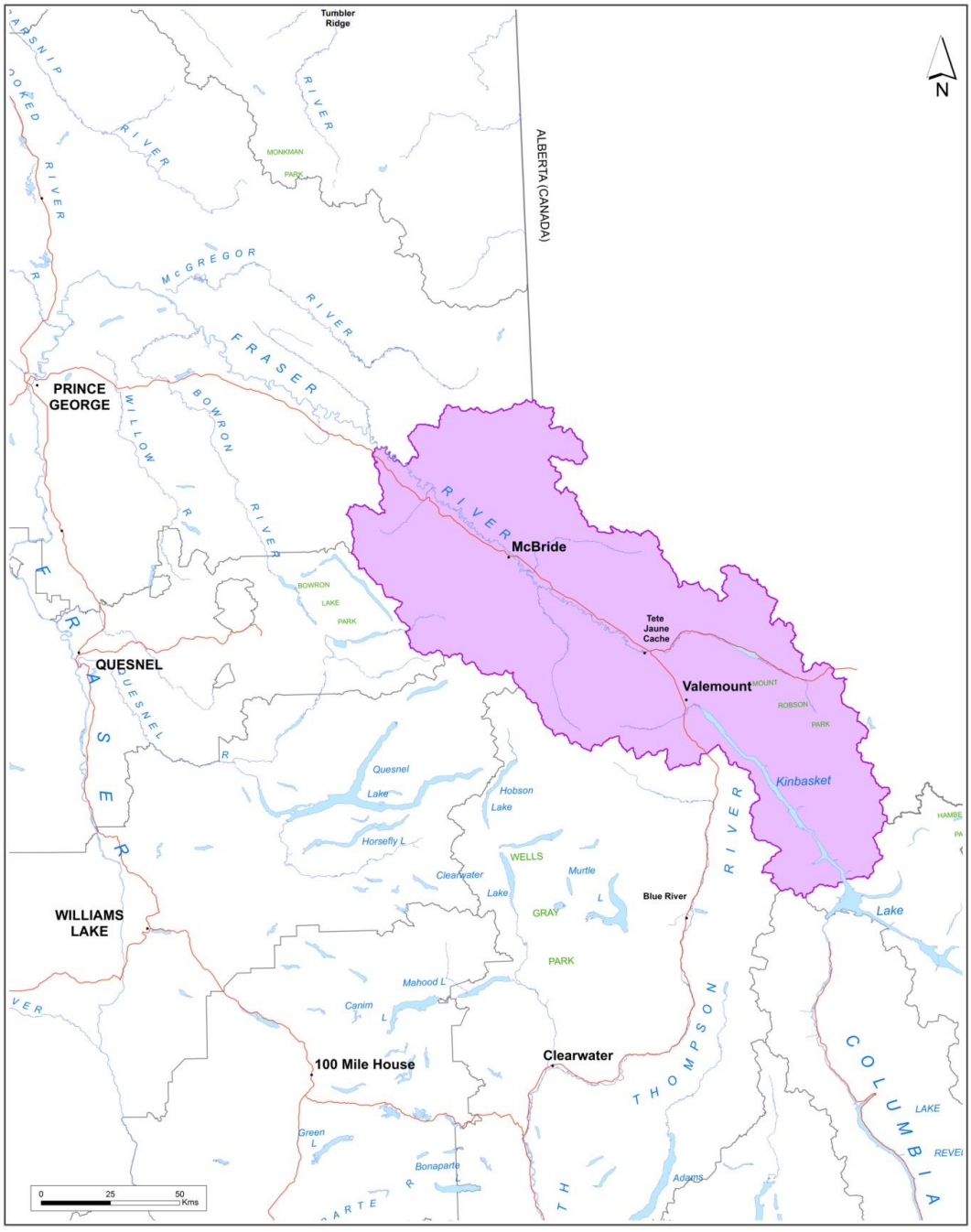


FIGURE 4 – THE ROBSON VALLEY TSA.

2 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.

2.1 ENDEMIC INSECTS AND PATHOGENS

2.1.1 WINTER MOTH OR LINDEN LOOPER (*ERANNIS SP.)*

A small infestation of winter moth, *Erannis sp*., (a.k.a. linden looper) was identified in and around the city of Prince George. Winter moth is not a priority insect in the Prince George TSA, but Figure 5 shows the damage and the caterpillar for this defoliator of birch.

FIGURE 5 – WINTER MOTH OR LINDEN LOOPER (*ERANNIS SP*.).

Photos: (A) Birch defoliation caused by the caterpillar. Photo credit: Tom Foy, Industrial Forestry Service Ltd, (B) and (C: inset) the winter moth caterpillar or 'looper'. Photo credit: Joan Westfall, Entopath Management Ltd.

2.1.2 PINE SHEATH NEEDLE MINER (*ZELLERIA HAIMBACHI)*

Pine needle sheath miner incidence is increasing in the Omineca and is "one to watch" in 2017. Although the total area infested in the region is only 1,305 hectares in the Omineca, this is up from just 72 hectares identified in 2015. This insect is increasing in frequency and severity throughout the province (10,303 hectares damaged provincially), with the highest infestation levels occurring in the Cariboo Region. Damage

over multiple years can cause severe defoliation which makes an ongoing infestation difficult to detect from the air, and therefore the infested area may be larger than reported.

FIGURE 6 – PINE NEEDLE SHEATH MINER.

Photo: A) A pine needle sheath miner infestation 30 Km west of Prince George. B) A closeup of the damaged branch tips. Photo credit: Tom Foy, Industrial Forestry Service Ltd.

2.1.3 "DIESEL ROT"

There have been several anecdotal reports of a brown stain/rot (yet to be formally identified) occurring in the both healthy and beetle-killed spruce trees coming into mills within the Prince George TSA (Figure 7). **At this time it is not known whether the discoloration is associated with reduced wood quality or if the causal agent modifies the wood structure; more information is required in order to determine the relevance of this discoloration.** This year, we will attempt to identify the rot and search for information on its prevalence and life history, if available. If licensees are encountering "diesel rot" in their operating areas, please do not hesitate to contact Jewel Yurkewich, Regional Pathologist, or Jeanne Robert, Regional Entomologist to pass on information regarding the location of "diesel rot" or to submit samples from boards containing the rot. Physical samples of the rot are needed in order to facilitate identification.

FIGURE 7 – AN EXAMPLE OF "DIESEL ROT" IN NEWLY CUT SPRUCE LUMBER.

Photo credit: Canadian Forest Products Ltd.

2.2 INVASIVE INSECTS 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

2.2.1 SATIN MOTH (*LEUCOMA SALICIS*)

A small infestation of Satin moth was identified in the Prince George TSA in 2016. Defoliation of 9,122 hectares, with 7,633 categorized as light infestation and 1,489 hectares categorized as moderate infestation. Although this pest is not necessarily a forest health priority yet, we received several questions about the cause of the associated aspen defoliation. This insect will attack several species of aspen and poplar in the Prince George TSA. Figure 8 shows the identifiable life stages for this defoliator.

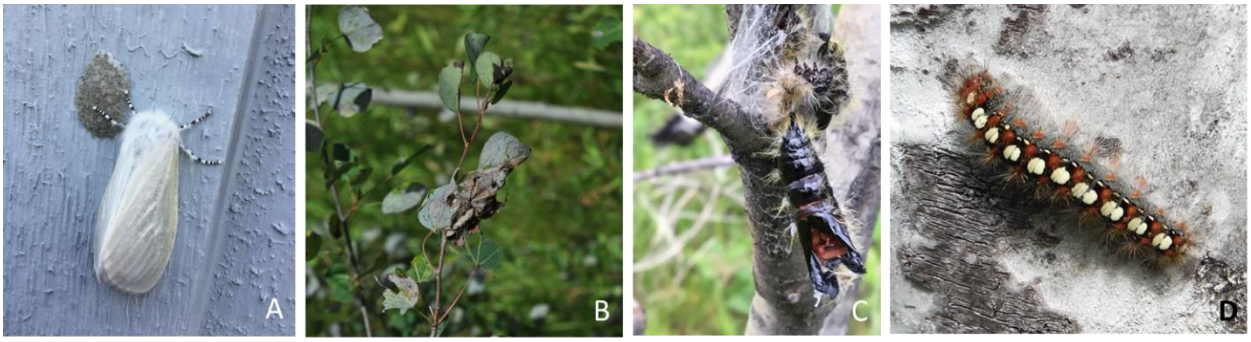


FIGURE 8 – LIFE STAGES OF SATIN MOTH.

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.

2.2.2 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, and because infestations are difficult to diagnose, all 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

Any questions about balsam woolly adelgid should be directed to Tracy Hueppelsheuser, Susanna Acheampong, Dave Woodske, or Dave Trotter at the BC Ministry of Agriculture at AgriServiceBC: 1-888-221-7141.

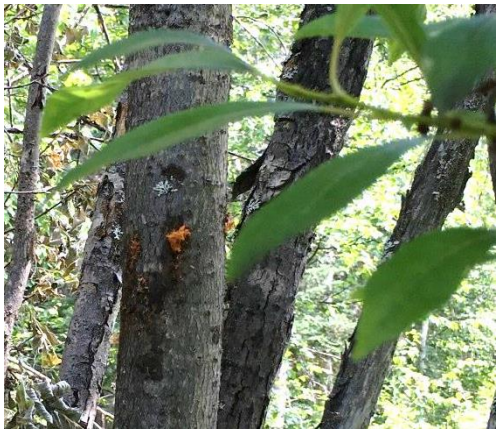
More information on the balsam woolly adelgid, including signs and symptoms, can be found here:
http://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/insects-and-plant-diseases/nursery-and-ornamentals/balsam-woolly-adelgid

2.2.3 EUROPEAN GYPSY MOTH (*LYMANTRIA DISPAR)*

The European gypsy moth is an invasive species that has been identified throughout southern BC. 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 trapping program this year to ensure that the population has not moved north.

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

2.2.4 POLAR 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 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.

2.2.5 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).

Last summer Alana Clason and Bonnie Hooge proceeded with the Sidney Williams Whitebark Pine Assessments 2016 project. They worked to establish permanent transects to complement the initial field work conducted by Stefan Zeglen in 2002, and to assess the health and productivity of the pines. The overall objectives of the project were to:

1) Evaluate the health of the candidate screening trees;
2) Establish long-term white pine blister rust monitoring transects; and

3) Determine the potential cone crop for 2017.

The continuation of the project was funded by the Landbase Investment Strategy (LBIS) and is focused on monitoring the cone production of infected pines for seed collection and resistance screening purposes. A summary report, *Sidney Williams Whitebark Pine Assessments 2016,* was prepared by Alana Clason and is available through Kevin Hoekstra, Senior Ecosystems Biologist (Kevin.Hoekstra@gov.bc.ca). The work on white pine blister rust continues in the summer of 2017 with an emphasis on tree health, population dynamics, and microsite conditions conducive to infection and tree mortality.

In addition to the field work, many experts are gathering in Jasper National Park to host the Whitebark Pine Ecosystem Foundation 2017 Science and Management Meeting in September. For more information please visit: http://www.whitebarkpine.ca/

The publication completed by Stefan Zeglen, Regional Forest Pathologist - West and South Coast (Stefan.Zeglen@gov.ba.ca) can be found at: http://www.nrcresearchpress.com/doi/pdf/10.1139/x02-049

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

A Forest Health Stand Establishment decision Aid (SEDA) for white pine blister rust was developed for the Southern Interior Forest Region. The SEDA is available at: https://www.for.gov.bc.ca/ftp/DSQ/external/!publish/forest%20health/SEDA_WPBlisterRust.pdf

3 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.

3.1 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).

3.2 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			***monitor**
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:			
Comandra blister rust		☑	
Stalactiform blister rust		☑	
Western gall rust		☑	
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.

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			☑

4 MAJOR BARK BEETLES IN THE OMINECA

Although mountain pine beetle populations continue to decline in British Columbia, projected climate change data combined with several consecutive years of 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 suppression 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.

4.1 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 2016 there was a sharp decline of mountain pine beetle infested trees to 76,176 hectares, most of this area (44,160 hectares) is in the Robson Valley TSA. The steady decline resulted in a shift to a moderate 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 5.3], mistletoe [section 5.7], and rusts [section 5.8 - 5.10). **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 recovers.

The mountain pine beetle is now established in Alberta. Overwintering data from 2016 indicates that populations are continuing to increase in a large proportion of the infested area in Alberta. This illustrates the remarkable adaptability of bark beetles and highlights the impact of recent weather patterns that allowed mountain pine beetle to thrive in an area outside its historical range using a novel host species (Jack pine, *Pinus banksiana*) (Cullingham 2011). Mountain pine beetle 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 significantly; 22,551 hectares of trace or light infestations were mapped in 2016. 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 in the Mackenzie TSA to 9,465 hectares of infested area in 2016. This may be an underestimate of the actual infestation in the Mackenzie TSA because a portion of the TSA was not surveyed in 2016 due to poor flying conditions. This area will be a priority for survey in 2017. 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) could be applied to pockets of currently infested trees. Since the majority (44,160 hectares) of the remaining current attack is located in the Robson Valley TSA, and 66% of that attack was designated as a severe infestation, localized areas may warrant suppression or holding tactics, even if the BMU as a whole is designated salvage.

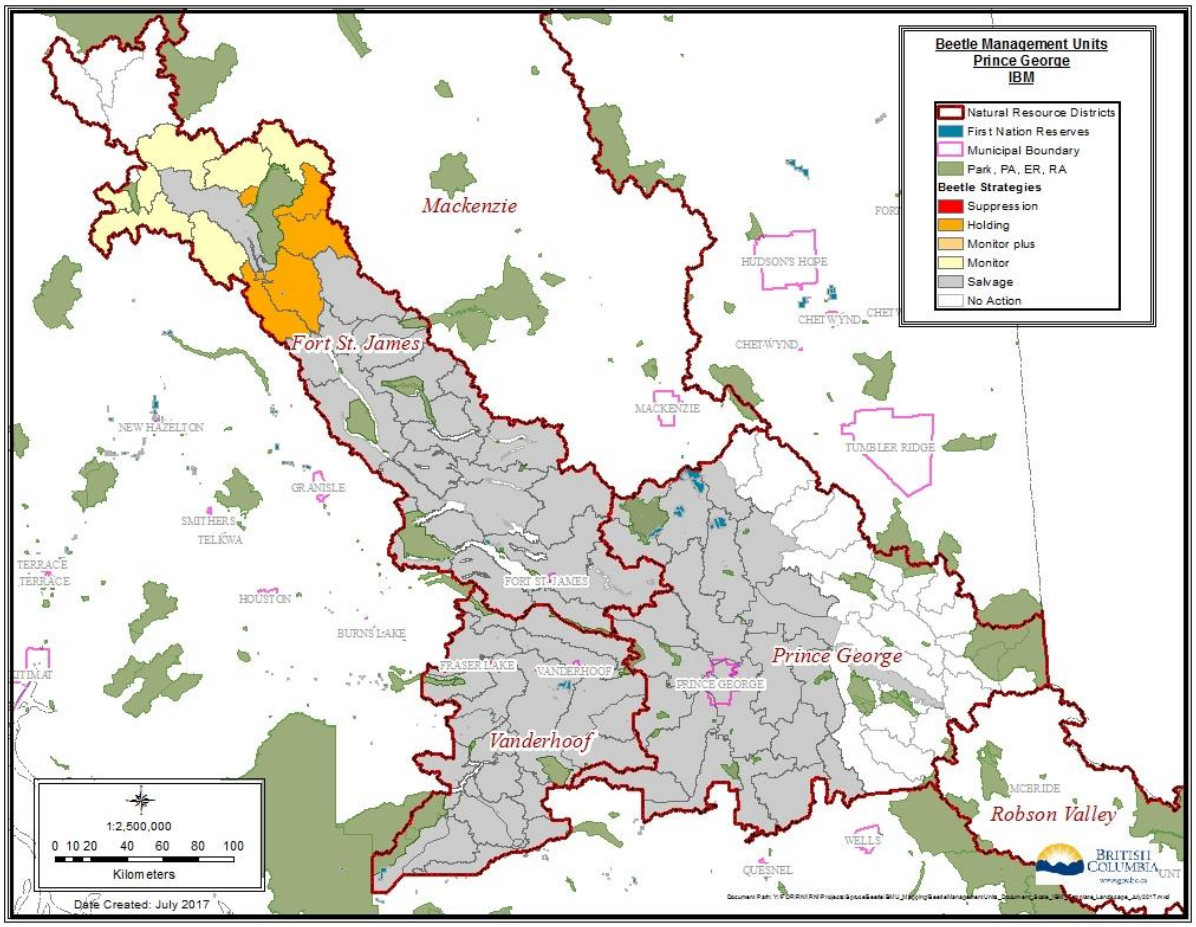


FIGURE 9 – PRINCE GEORGE TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE.

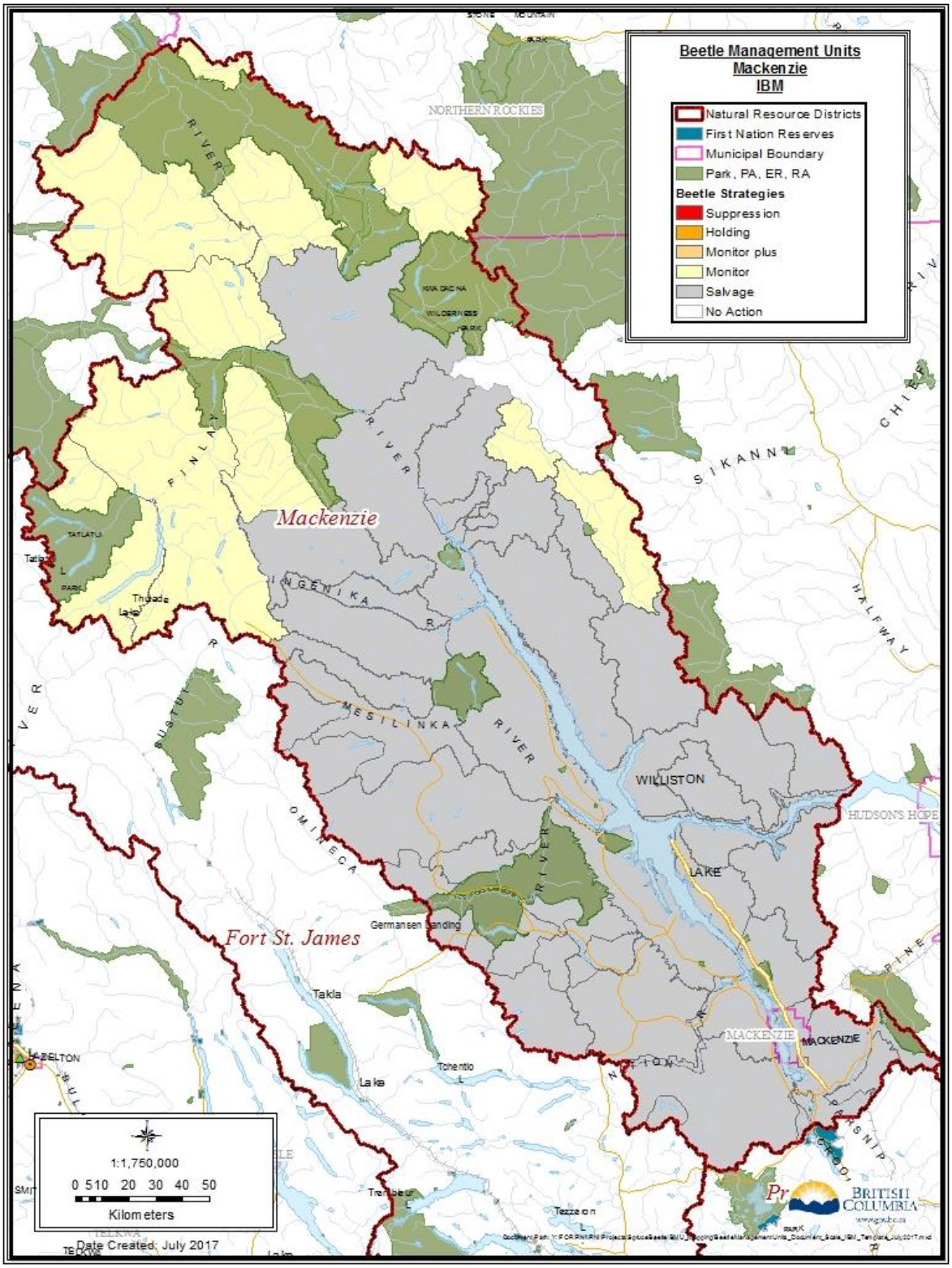


FIGURE 10 – MACKENZIE TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE.

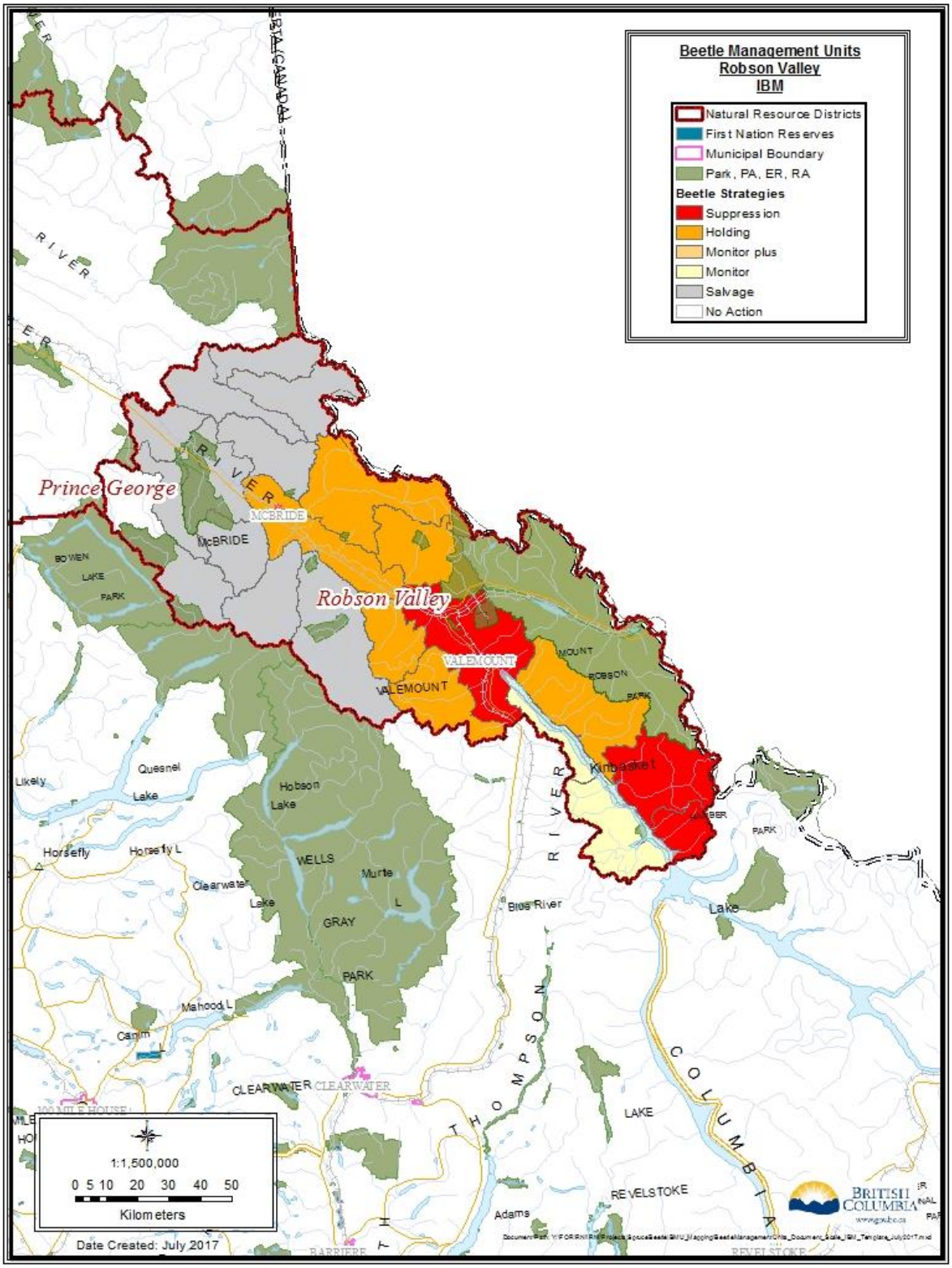


FIGURE 11 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR MOUNTAIN PINE BEETLE.

4.2 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 218,406 hectare outbreak of spruce beetle in the Omineca region in 2016. Overwintering brood success data collected in early 2017 from the outbreak area suggests that beetles are shifting from the more common two-year life cycle to a one-year cycle and showing sufficient overwintering brood survival for a population increase in 2017-2018.

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 Alena Charlston, Stewardship Forester (Alena.Charlston@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 2017 training course.

Working together: A Spruce Beetle Project Manager, Heather Wiebe, was appointed in February 2016 in order to coordinate a consistent and effective response to the current spruce beetle outbreak from licensee and government representatives in the Omineca and Northeast Regions. In 2017, Heather Wiebe is moving on to other projects, but John Huybers, Prince George District Manager is taking over as the Spruce Beetle Project Lead.

The general provincial spruce beetle management strategy can be found here:

http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/bark-beetles/4805dc_ominecasprucebeetlestrategy_web.pdf

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. All accessible BMUs in the Prince George TSA are identified as suppression 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.

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; they are up to over 215,000 combined infested hectares identified in 2016. This, combined with anecdotal reports of spruce beetle-caused mortality south and west of the city of Prince George, indicate that the Robson Valley should be carefully monitored for pockets of increasing spruce beetle populations in 2017-2018.

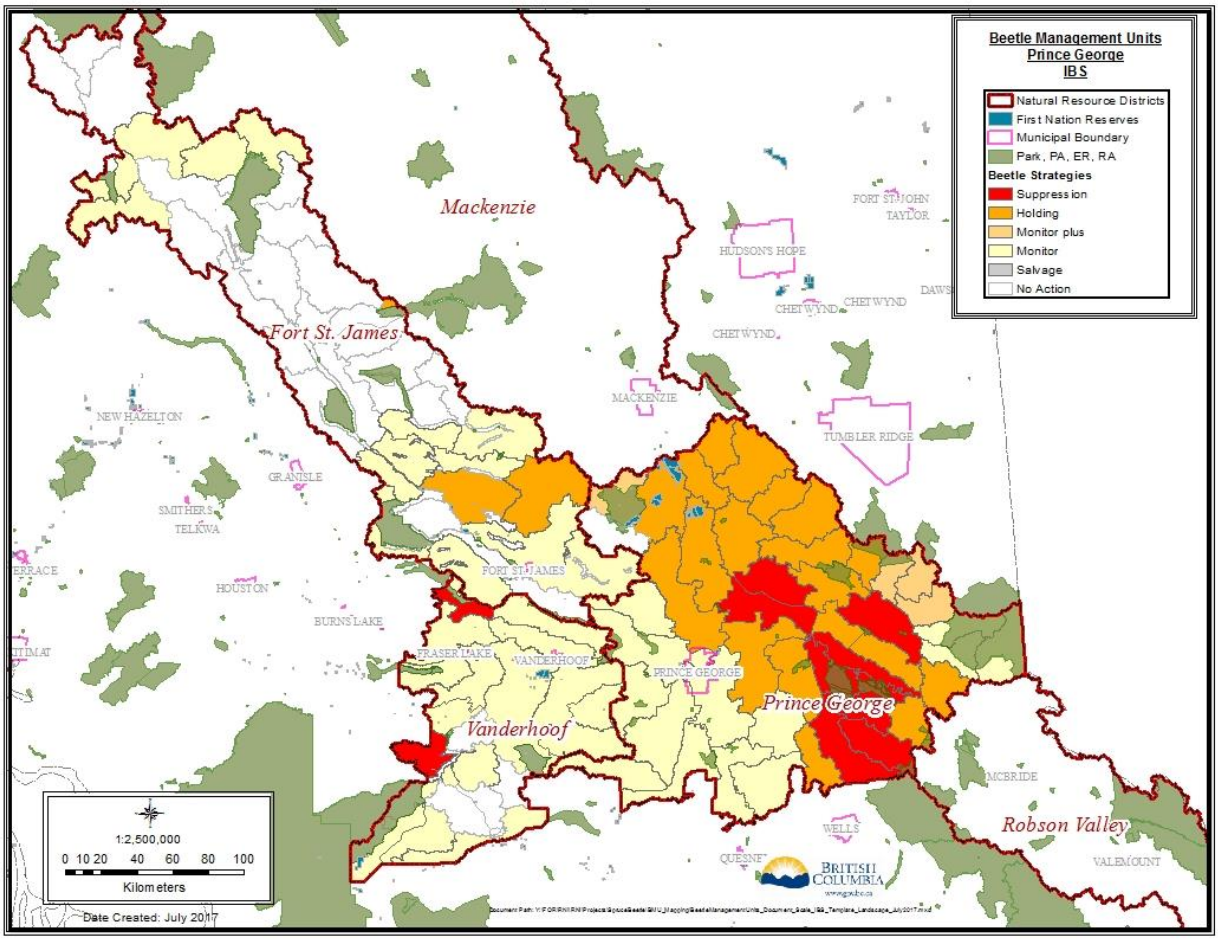


FIGURE 12 – PRINCE GEORGE TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE.

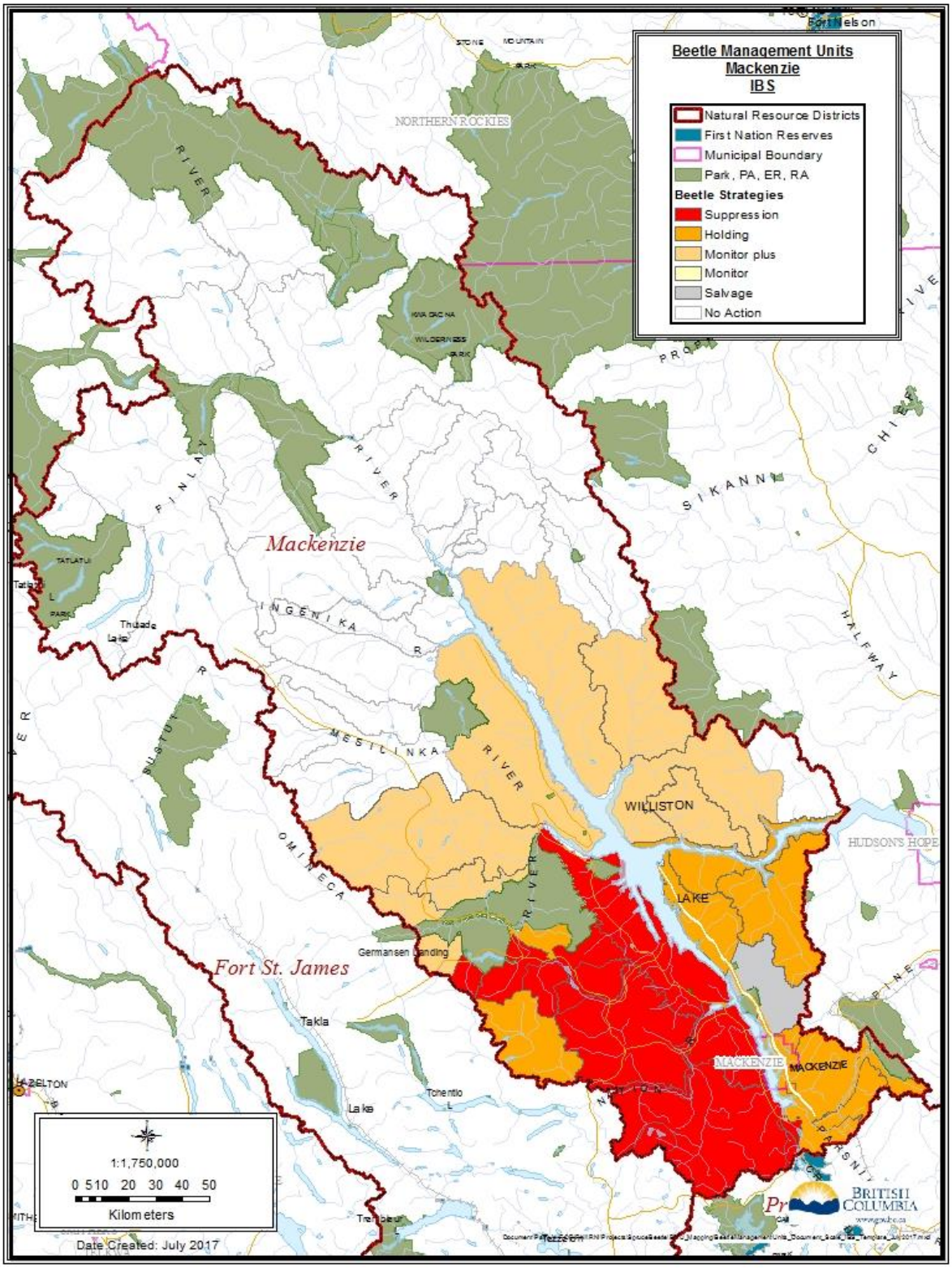


FIGURE 13 – MACKENZIE TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE

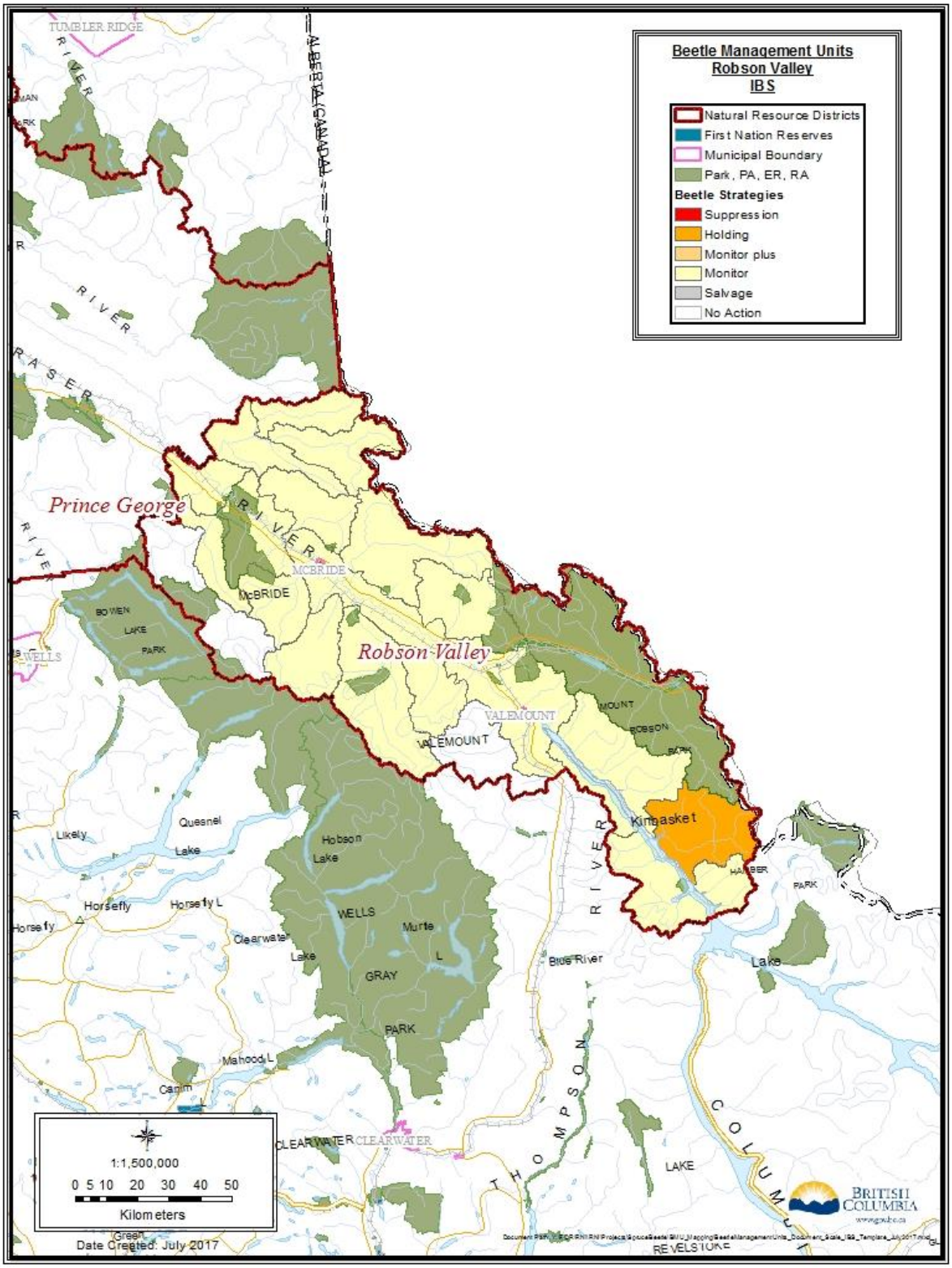


FIGURE 14 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR SPRUCE BEETLE.

4.3 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. The majority of this infestation is located in the Cariboo region (69,418 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.

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 2017 flight. As a result, Douglas-fir BMUs in the Prince George TSA were assigned a suppression strategy this year.

An ongoing Douglas-fir beetle infestation west and north of the city of Prince George have resulted in public concern, particularly over older, large Douglas-fir on private property. Suppression efforts in 2016 were directed by the Prince George District and included small scale sanitation harvesting, trap tree deployment, and dissemination of guidance documents for managing Douglas-fir beetle on private land. Questions regarding the Douglas-fir beetle mitigation efforts can be directed to Alena Charleston, Stewardship Forester (Alena.Chareston@gov.bc.ca) or Jeanne Robert, Regional Entomologist (Jeanne.Robert@gov.bc.ca).

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.

4.3.1.1 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).

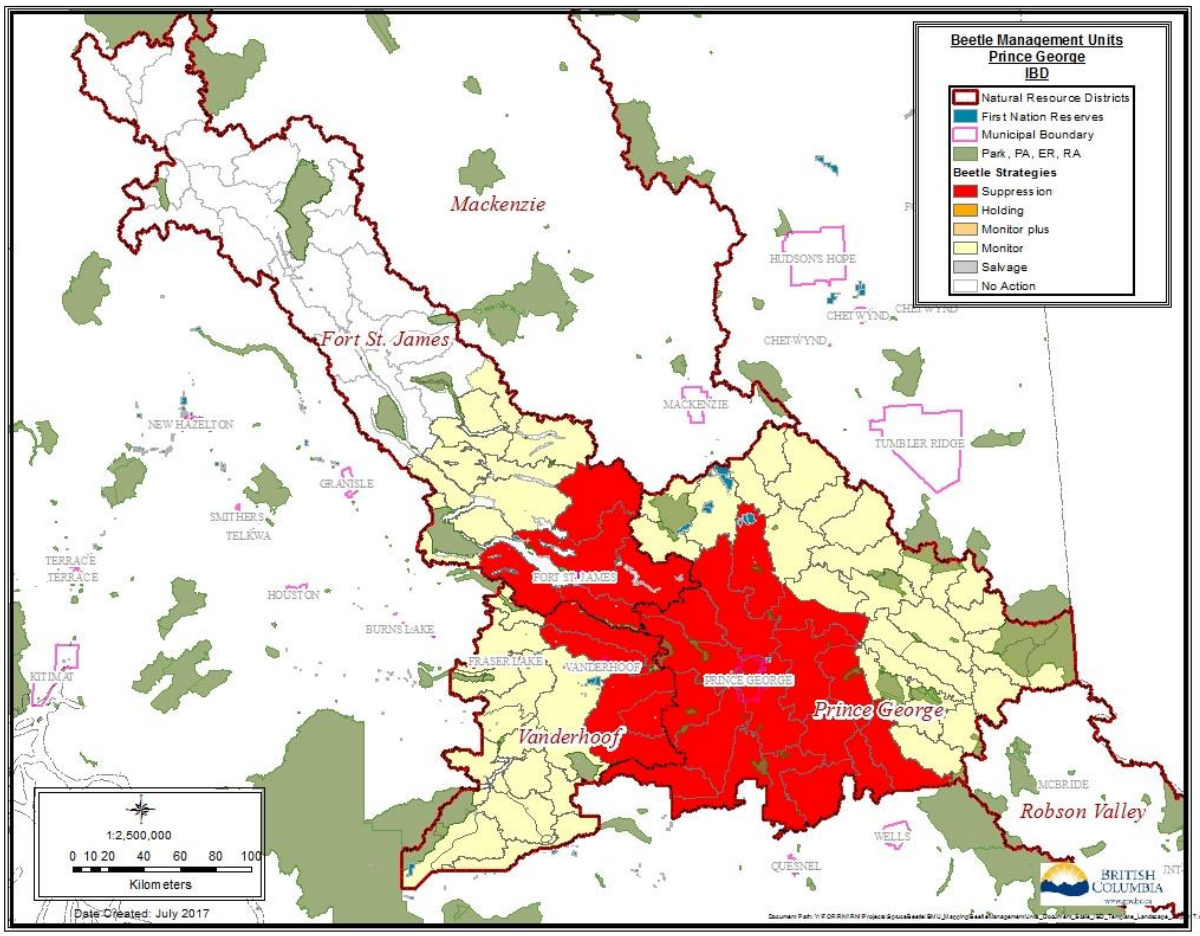


FIGURE 15 – PRINCE GEORGE TSA FOREST HEALTH STRATEGIES FOR DOUGLAS-FIR BEETLE.

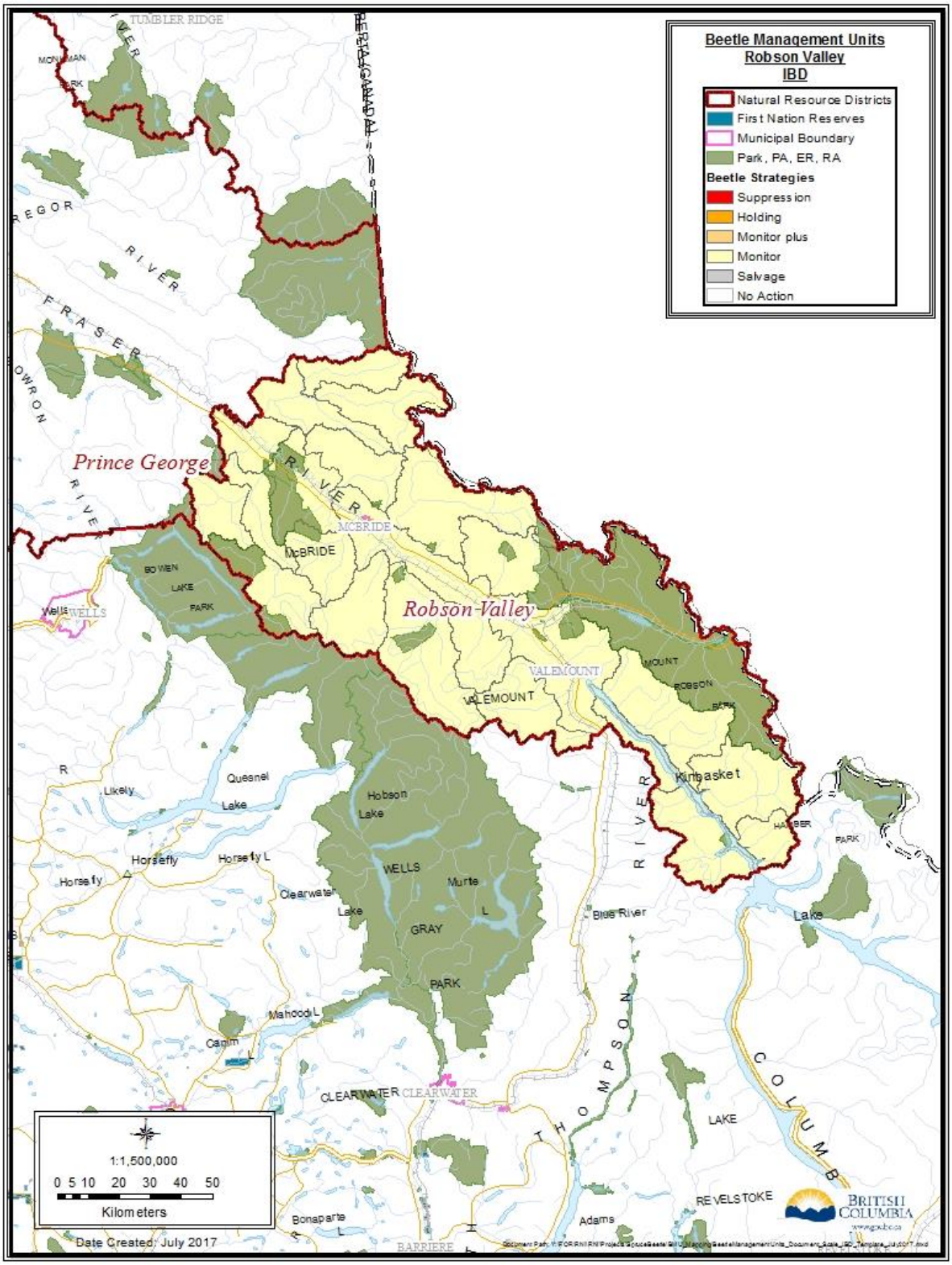


FIGURE 16 – ROBSON VALLEY TSA FOREST HEALTH STRATEGY FOR DOUGLAS-FIR BEETLE.

4.4 WESTERN BALSAM BARK BEETLE (*DRYOCETES CONFUSUS*)

Western balsam bark beetle causes significant mortality of sub-alpine fir (locally referred to as "Balsam") throughout British Columbia. The provincial infestation area for western balsam bark beetle increased in 2016 to **over 3.2 million hectares**. The majority of this damage occurred in the Omineca region with over 1.4 million hectares damaged. This is up 27% from 2015 AOS data.

Although western balsam bark beetle does not historically rank highly for economic and ecological importance in regional 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.

5 OTHER PRIORITY INSECTS AND PATHOGENS IN THE OMINECA

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 procedure, 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 where 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. Acknowledging the information gaps and current limitations of our management strategies provides an opportunity to engage in constructive conversation with the district staff, licensees, tenure holders, and the public regarding how to improve the management of forest pests or mitigate the impacts within the Omineca region.

5.1 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 significantly to 160,143 hectares in 2016. Although the two-year cycle budworm's economic and ecological importance was ranked low in the Omineca region for 2017-2018, the population should be carefully monitored, given this increase.

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

As the infested area in the Omineca is concentrated in the southern portion of the Prince George TSA (55,727 hectares), but the lack of visible defoliation in 2016 suggests that the insect is 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 2017.

ROBSON VALLEY TSA

A 14,639 hectare infestation adjacent to the Prince George TSA infestation was mapped in the Robson Valley TSA in 2016. 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). The lack of visible defoliation in 2016 suggests that the insect is 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 2017.

5.2 ASPEN LEAF MINER (*PHYLLOCNISTIS POPULIELLA*)

The sheer size of the area infested by aspen leaf miner (1,226,265 hectares in BC) elevates this pest to moderate in the forest health factor rankings (Table 1), although the total provincial area is down to about half of the peak in 2014. The Omineca region sustained the highest amount of attack with 386,366 hectares mapped in 2016.

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 5.11), infection by Venturia blight (section 5.4), and/or drought may contribute to a general aspen decline. Continued research into the potential impact of aspen leaf miner and monitoring of disease complexes are priorities for 2017-2018.

5.3 RED BAND NEEDLE BLIGHT (*DOTHISTROMA SEPTOSPORUM*)

In 2016, Dothistroma was the foliar pathogen that caused the most damage in conifer stands with 6,258 hectares and 5,559 hectares reported in Skeena and the Omineca respectively. For the Omineca, the area reported has doubled since 2015 and this year's wet spring makes this species a disease to monitor for in 2017-2018. 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.

It is important to note that the AOS does not align with the most easily detected window of expression (early to late spring before the buds flush) for red band needle blight, and therefore it is important to monitor stands in the early spring, and record and report the location of infected stands to Jewel Yurkewich, Regional Pathologist.

Currently, the provincial team of pathologists are working together to develop a monitoring programme focused on foliar pathogens. The methodology is designed to supplement the AOS and to provide additional, systematic details about the progression of foliar pathogens in targeted areas over time. More information will be available following the 2017 field season.

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* within susceptible areas as well as locations that may be influenced by climatic changes (changes to seasonal precipitation patterns) is a priority.

5.4 ASPEN, POPLAR LEAF AND TWIG BLIGHT (*VENTURIA SPP.*)

In BC, the incidence of *Venturia* blight quadrupled to 55,049 ha from 13,636 ha last year. Although the majority of the infection was found on trembling aspen in the Skeena region, monitoring these pathogens is still important in the Omineca as they reflect the changing growing conditions in adjacent areas. In the Omineca the pathogen was associated with 1,489 ha. According to the 2016 AOS Summary Report "…1,471 ha were mapped in the north tip of Mackenzie TSA from Gataga River south to Bighorn Mountain." In the Prince George TSA, a single disturbance covering 18 ha was delineated south of Tatin 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. However, the area reported as infected by Venturia in the AOS is dominantly composed of mature stands with infected crowns.

5.5 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 details surveys. The location of specific disease centers requires local, expert knowledge and proper documentation. 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. This information will be used to develop a database for areas impacted by Tomentosus that can be used for both management and research applications.

Infected trees may appear healthy, but often have extensive butt cull and reduced annual increment growth. The distribution of infection ranges from scattered individual trees to defined centers dependent on the presence of host species. The fungus spreads from tree to tree at points of root contact; consequently, diseased trees occur in groups and mortality results in stand openings. Windthrow may occur before the death of an infected tree. Fruiting bodies on, or around a tree, indicate that three or more meters of rot may be present in the base of the stem. Tomentosus root rot can be a serious problem in second-growth stands as the stumps of infected trees provide an inoculum source for spread up to 20 years post-harvest.

The FPC Root Disease Management Guidebook is currently under revision and is scheduled to become available to practitioners in 2018. This revision covers best practices, and the strategies and tactics for managing Tomentosus. For more information refer to the Stand Establishment Decision Aid (SEDA) for Tomentosus: http://jem.forrex.org/index.php/jem/article/view/562.

5.6 ARMILLARIA ROOT DISEASE (*ARMILLARIA OSTOYAE*)

The PG and Mackenzie TSAs are located at the northern extent of the known distribution of Armillaria root disease; however, Armillaria has been identified within the Robson Valley TSA. Its infection ranges from scattered individual trees to well defined centers. Currently data is available from both aerial flights and ground assessments, which form the initial hazard and risk rating digital layer and database encompassing the susceptible biogeoclimatic subzones within the TSA.

To date within the Robson Valley TSA, the recommended method for Armillaria root disease detection is ground surveys at the operational planning stage. Armillaria root disease is delineated based on disease incidence. Armillaria hazard and risk digital layer maps have been generated for portions of the Robson Valley TSA. An Armillaria database has also been developed containing site specific attributes and survey methodology corresponding to the digitized overlay base maps. The digital overlay maps and database is available from Jewel Yurkewich, Regional Pathologist.

For more information 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.

5.7 DWARF MISTLETOE OF LODGEPOLE PINE (*ARCEUTHOBIUM AMERICANUM*)

Lodgepole pine dwarf mistletoe, a parasitic plant which causes swelling of tree stems and irregular branching patterns, 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. Insects, particularly secondary bark beetles, frequently invade heavily infected trees and kill them. 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 host across a broad area in the north, it is important to consider how we will manage mistletoe in the regenerating stands. The rate of spread has been reduced considerably since lateral spread from advanced regeneration is not as effective as mistletoe rains from the overstory; however, the survival of mistletoe in the understory will allow the pest to perpetuate and persist into the future. **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 gives guidance on how to deal with mistletoe infection within both clearcut and partial-cut harvesting systems. It also gives guidance 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.

To increase our understanding of stand tending options, a mistletoe sanitation trial is currently underway in the Cariboo Region (conducted by David Rusch, Regional Forest Pathologist for the Cariboo & Thompson Okanagan Regions, David.Rusch@gov.bc.ca). Through this research and continued application of local knowledge, the best management practices for lodgepole pine mistletoe will be revised and adapted to better suit our current growing stock.

Mistletoe was not incorporated into the online Forest Health Survey that we distributed earlier this year. However, it should be considered as moderate importance because it can be expected that as pine stands mature the importance of this parasitic plant will increase to moderate-high importance for management.

5.8 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.

Western gall rust is the most common rust of young lodgepole pine. Western gall rust does not require an alternate host to complete its lifecycle, and therefore infection occurs directly from pine to pine. Infection occurs through the spread of spores which are capable of traveling hundreds of kilometers. When local environmental conditions are suitable for spore spread the resultant infection occurs in a fairly uniform to random pattern. Infection from western gall rust is highest in young stands, with approximately 90% of the susceptible trees becoming infected by age ten on most sites. Western gall rust seldom kills older trees, but can kill young trees with main stem infections.

Free growing surveys conducted as early as age 15 should capture 90% of infection on high risk sites. 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.

Rust hazard maps (Appendix IV) have been generated from the 2012 RESULTS database and the georeferenced pdfs and spatial files are available upon request from Jewel Yurkewich, Regional Pathologist.

5.9 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.

For operational purposes, if stalactiform blister rust is found in a mature stand a walkthrough should be conducted to determine the relative severity, spatial distribution and prevalence of the disease onsite. Please see the Pine Stem Rust Management Guidebook for details pertaining to the walkthrough. If the walkthrough provides considerable evidence for classifying the site as "moderate-high hazard", considerations such as modified planting density or species composition must be made in the site plan prior to harvest. If the area of interest has already been harvested and stalactiform is identified as prevalent onsite after regeneration takes place, it is important to visit the site regularly to monitor the mortality rate. If the disease is found in an area for the first time please contact Jewel Yurkewich, Regional Forest Pathologist.

A hazard and risk rating system is currently in development to help identify localized areas of concern.

District specific rust incidence maps (all species combined) are provided in Appendix IV. 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.

5.10 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. 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. Resistance in lodgepole pine is not believed to be common, although resistance screening holds potential for identification of resistant families.

For operational purposes, if comandra blister rust is found in a mature stand a walkthrough should be conducted to determine the relative severity, spatial distribution and prevalence of the disease onsite. Please see the Pine Stem Rust Management Guidebook for details pertaining to the walkthrough. If the walkthrough provides considerable evidence for classifying the site as "moderate hazard", considerations such as modified planting density or species composition must be made in the site plan prior to harvest. If the area of interest has already been harvested and comandra is identified as prevalent onsite after regeneration takes place, it is important to visit the site regularly to monitor the mortality rate. Keep in mind that the majority of mortality on moderate-high hazard sites is most likely to occur in the first 5 years. If the disease is found in an isolation area for the first time please contact Jewel Yurkewich, Regional Forest 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 (all species combined) are provided in Appendix IV. 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.

***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, whereas further south and in the United States *Comandra umbellata* may also be participate in the lifecycle of this pathogen. This species has multiple common names, and therefore using the scientific name will minimize confusion and promote better understanding of the species of interest. Refer to E-Flora BC for updated common and scientific names.**

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

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

At this time, there is a lack of reliable data for the incidence of comandra blister rust in specific 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. 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.

5.11 LARGE ASPEN TORTRIX (*CHORISTONEURA CONFLICTANA*)

There were no significant populations of large aspen tortrix recorded in the Omineca region mapped in the 2016 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 2017-2018 since outbreaks are short-lived (Cerezke 1992), and no infestation areas were mapped.

5.12 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.

5.13 LODGPOLE 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 “shepherd’s crooks” in the juvenile trees. Localized areas have high occurrences; therefore monitoring this pest in areas of known infestations is essential in 2017-2018, 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.

5.14 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 the Prince George TSA is experiencing increased pressure to have a strong midterm timber supply.

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 planting will reduce the damage impacts from this insect.

6 ADDITIONAL INFORMATION

6.1 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

6.2 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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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	Regional 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
Charlston, Alena	Stewardship Forester	**Prince George TSA** spruce beetle lead and working group coordinator	Alena.Charlston@gov.bc.ca	250-614-7495
Fonda, Anne Marie	Stewardship Specialist	**Northeast region** spruce beetle lead and working group coordinator	AnneMarie.Fonda@gov.bc.ca	250-784-1290
Hancock, Darin	Resource Manager	**Mackenzie TSA** spruce beetle lead and working group coordinator	Darin.Hancock@gov.bc.ca	250-997-2204
Huybers, John	Prince George District Manager	**Spruce Beetle Project Lead**	John.Huybers@gov.bc.ca	250-614-7442
Robert, Jeanne	Regional Entomologist	**Omineca and Northeast region** scientific expertise in forest entomology	Jeanne.Robert@gov.bc.ca	250-561-3461

6.3 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

7 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 REFERENCES

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APPENDIX I 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 II 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		July 25 to September 25
sketch mapping	**Supr. Hold.** Salv. Mon.	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 III – 2016 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	17,126	5419	-	5	-	22,550
IBS=Spruce Beetle	52,978	46,690	42,886	282	-	142,836
IBB=Western Balsam Bark Beetle	421,276	387,230	10,011	251	-	818,769
IBD=Douglas-fir Beetle	5,177	2,674	245	28	-	8,125
All Bark Beetles	**496,558**	**442,014**	**53,143**	**567**	**-**	**992,283**
Defoliators						
ID6=Aspen Leaf Miner	-	79,205	218,251	51,490	-	348,947
IDB=2-Year Budworm	-	48,773	4,952	-	-	53,726
IDF=Forest Tent Caterpillar	-	91,332	17,929	411	-	109,673
IDI=Pine needle sheathminer	-	55	735	514	-	1,305
Total Defoliators	**-**	**255,079**	**243,789**	**52,416**	**-**	**551,285**
Diseases						
DFS=Dothistroma Needle Blight	-	4,269	1,258	-	-	5,527
DLV=Venturia Blight	-	-	18	-	-	18
Total Diseases	**-**	**4,405**	**1,276**	**-**	**-**	**5,682**

Mackenzie TSA

	Trace	Low	Moderate	Severe	Very Severe	Total
Bark Beetles						
IBM=Mountain Pine Beetle	5,959	3,365	121	18	-	9,464
IBS=Spruce Beetle	7,835	31,568	33,513	2	-	72,919
IBB=Western Balsam Bark Beetle	147,603	353,724	7,851	82	-	509,261
IBD=Douglas-fir Beetle	-	-	-	1	-	1
All Bark Beetles	**161,398**	**388,657**	**41,486**	**104**	**-**	**591,647**

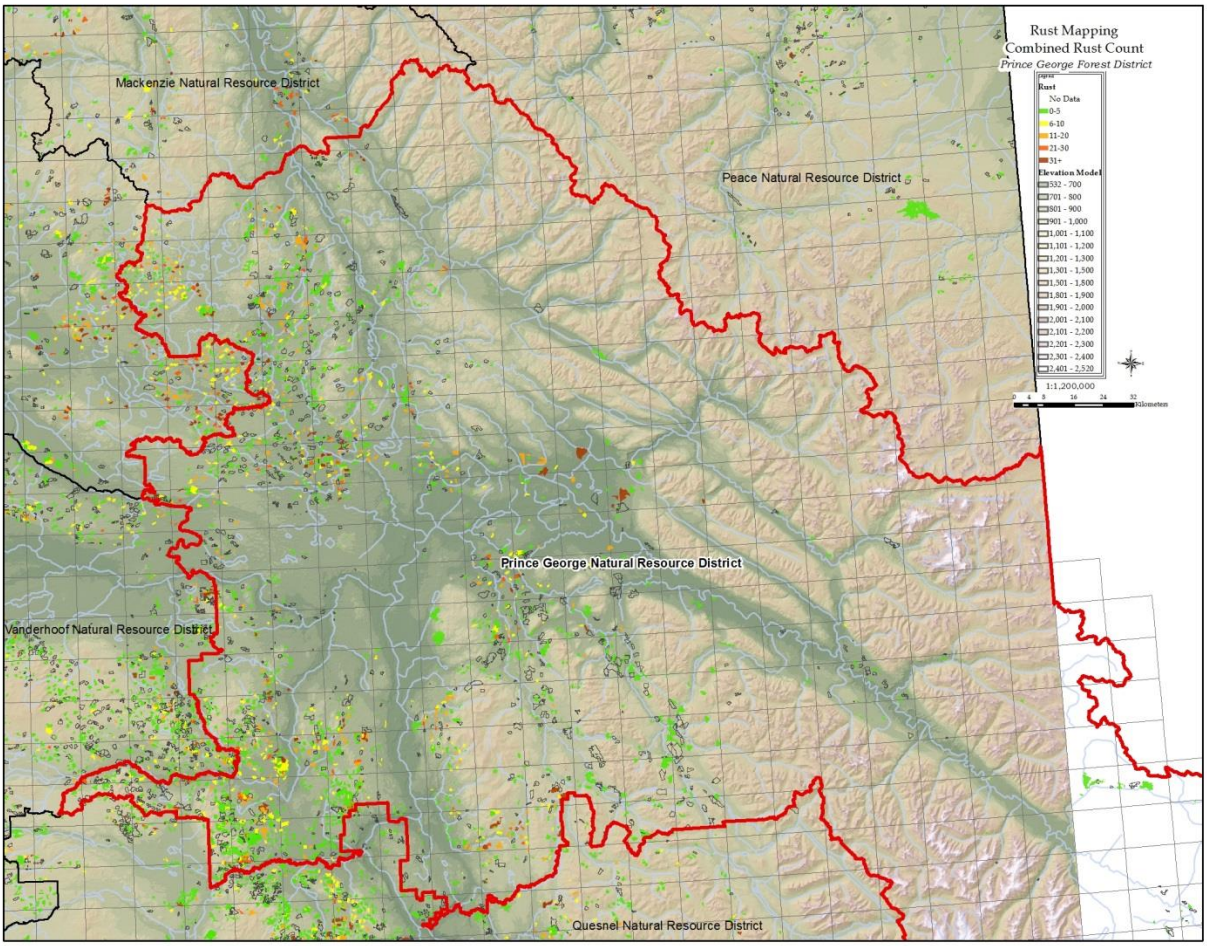
	Trace	Low	Moderate	Severe	Very Severe	Total
Defoliators						
ID6=Aspen Leaf Miner	-	450	30,146	1,503	-	32,100
IDF=Forest Tent Caterpillar	-	25,806	-	-	-	25,806
Total Defoliators	**-**	**46,812**	**30,146**	**1,503**	**-**	**78,462**
Diseases						
DLV=Venturia Blight	-	-	1,467	3	-	1,470
Total Diseases	**-**	**-**	**1,467**	**3**	**-**	**1,470**

Robson Valley TSA

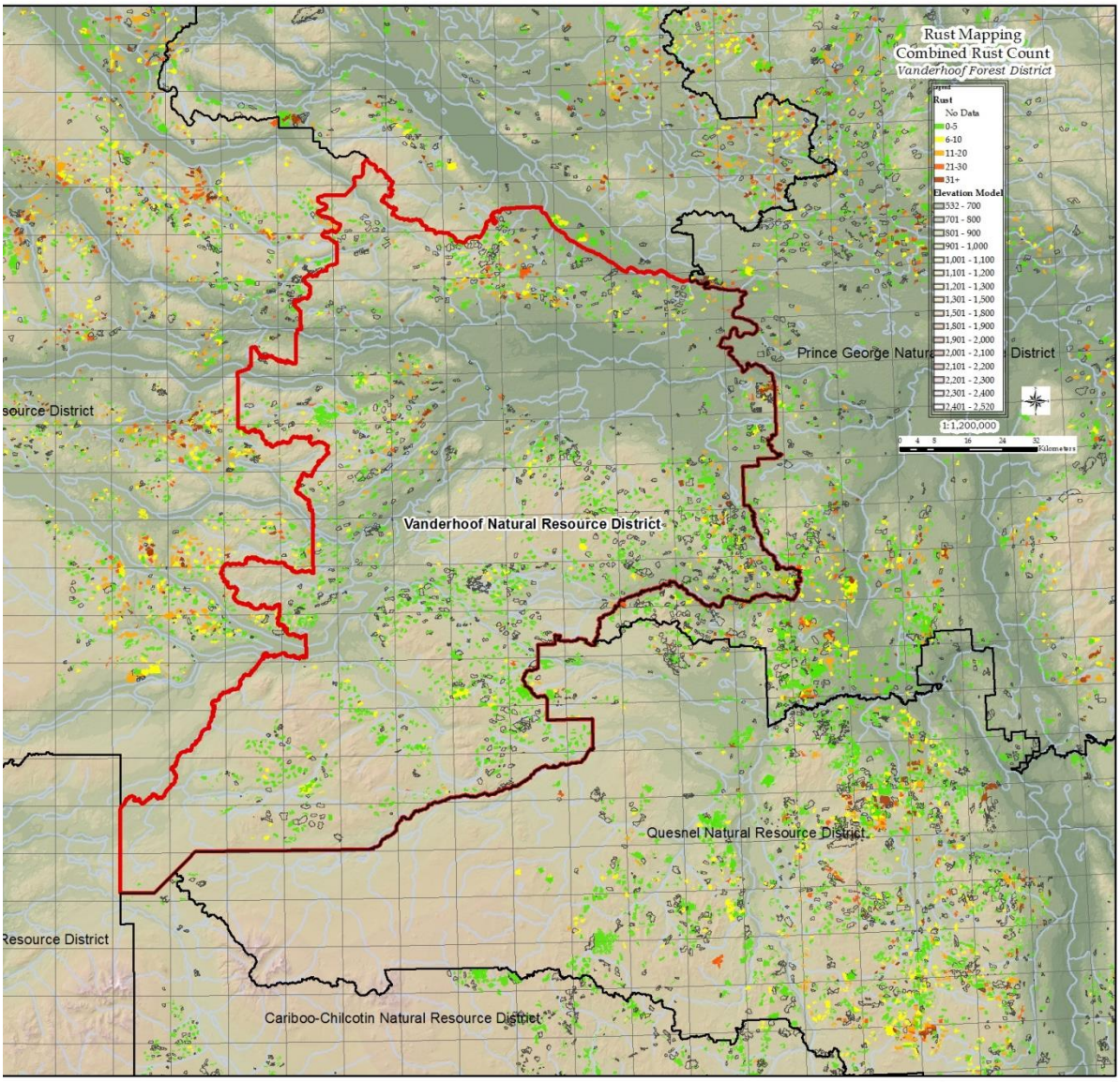
	Trace	Low	Moderate	Severe	Very Severe	Total
Bark Beetles						
IBM=Mountain Pine Beetle	2,297	13,155	20,231	8,475	-	44,160
IBS=Spruce Beetle	372	1,532	719	25	-	2,649
IBB=Western Balsam Bark Beetle	54,672	25,602	5,170	885	-	86,332
IBD=Douglas-fir Beetle	-	-	-	-	-	-
All Bark Beetles	**57,343**	**40,291**	**26,121**	**9,386**	**-**	**133,142.81**
Defoliators						
ID6=Aspen Leaf Miner	-	-	4,066	1,251	-	5,317
IDB=2-Year Budworm	-	12,576	2,062	-	-	14,639
IDN=Birch Leaf Miner	-	296	611	21	-	929
Total Defoliators	**-**	**13,272**	**7,143**	**1,272**	**-**	**21,689**
Diseases						
DFS=Dothistroma Needle Blight	-	30	-	-	-	30
Total Diseases	**-**	**30**	**-**	**-**	**-**	**30**

APPENDIX IV EXAMPLES OF RUST INCIDENCE MAPS BY DISTRICT

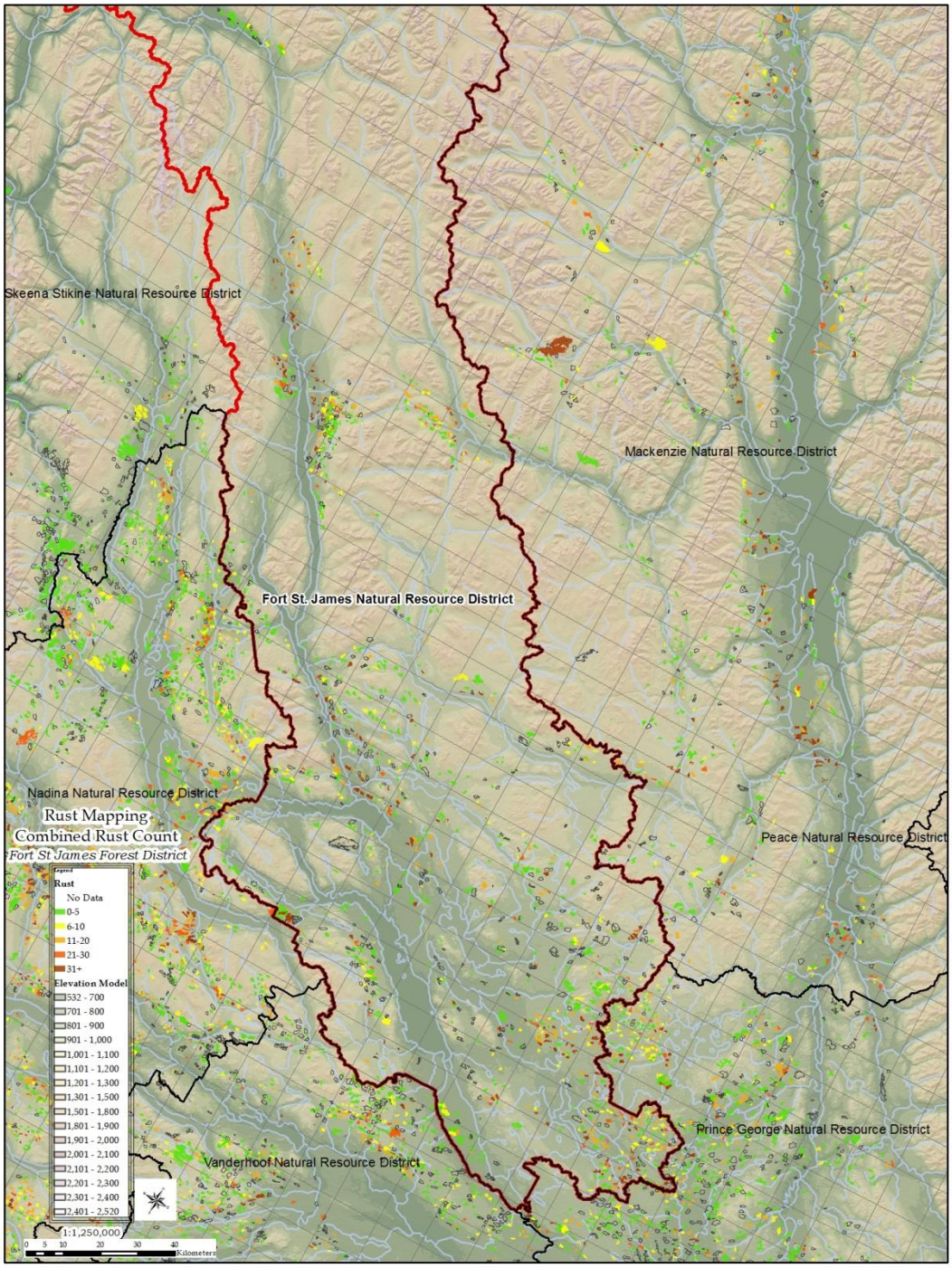
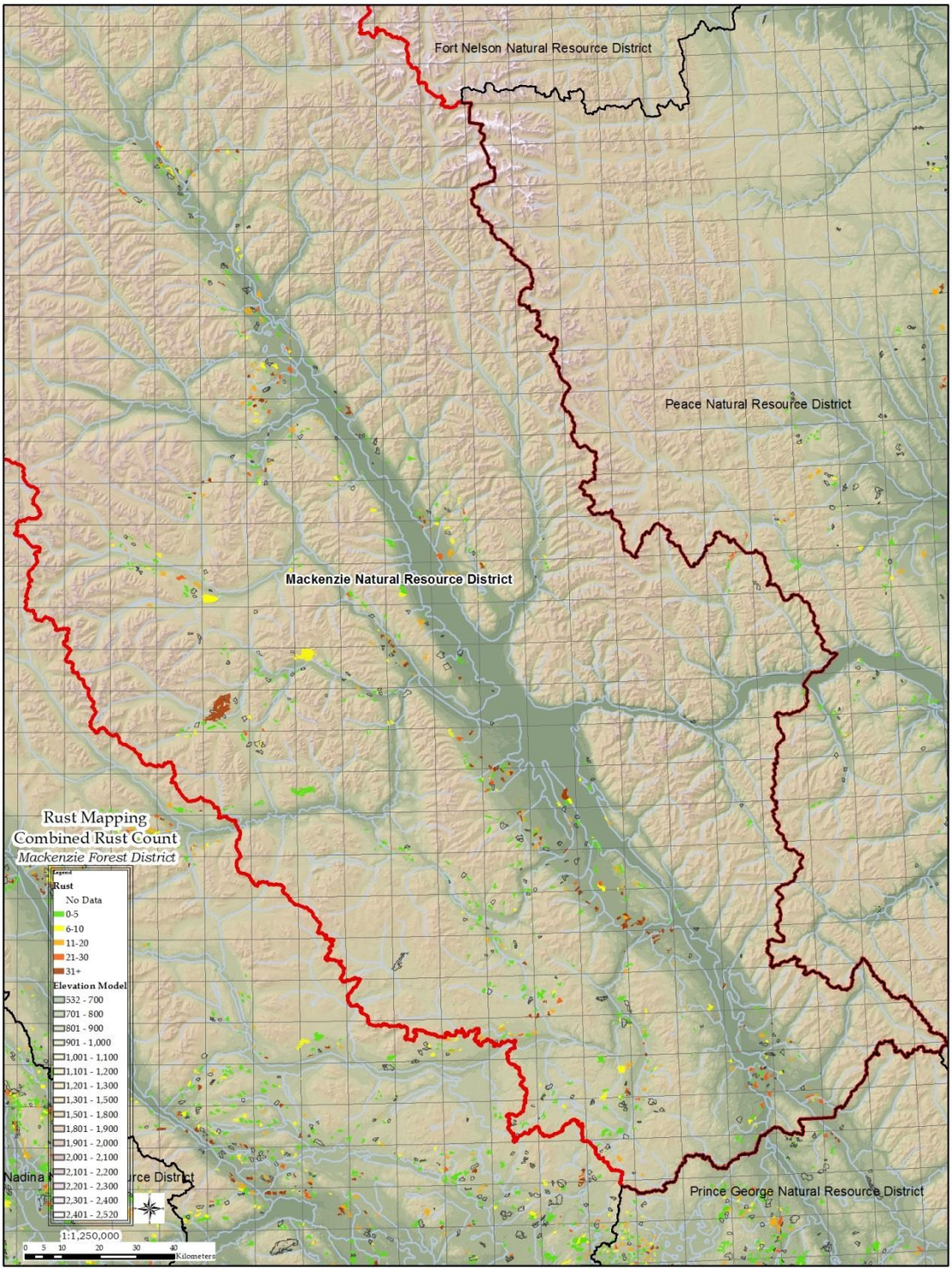
Appendix 4.1: Combined rust count for the Prince George District in 5-10% incidence classes representing relative risk for planting susceptible species.



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.