

Cariboo Region Forest Health Strategy

2013 - 2016



Table of Contents

Cariboo Region Forest Health Strategy 2013 - 2016.....	i
List of Figures	ii
List of Tables	ii
Executive Summary.....	2
A. Cariboo Region Forest Health Vision	2
B. Planning Framework	3
1) Legislative Framework	3
2) Government Policy	3
3) Provincial Forest Health Policy	4
4) Regional and District Forest Health Roles & Responsibilities	4
C. Forest Health Factors and Management	6
Monitoring and Treatment Cost Benefit Rationale	7
Appendix 1	11
2014-15 Forest Health Funding Priorities, Actions and Required Resources	11
Appendix 2	19
Hazard Ratings	19
Appendix 3	27
Minimizing forest health impacts resulting from climate change	27
Appendix 4	28
Impact of Forest Health Factors on Timber Supply	28
Appendix 5	31
Forest Health Research Needs – Entomology.....	31
Forest Health Research Needs – Pathology.....	32
Appendix 6	33
Cariboo Region Priority Pest Profiles	33
Insects	33
a) Bark Beetles	33
b) Defoliators	36
c) Weevils	40
Diseases.....	41
a) Root Rots.....	41
b) Stem Rusts	44
c) Cankers.....	46

d) Foliage Diseases	46
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List of Figures

Figure 1. Major forest health factors in the Cariboo Region by BEC zone based on stand development monitoring surveys conducted between 2009 and 2013.	25
Figure 2. Area of infestation for western balsam bark beetle by forest district based on aerial overview survey data.....	35
Figure 3. Historic occurrence of Western Hemlock Looper in the eastern Cariboo	38
Figure 4: Combined incidence of western gall rust and comandra rust in the Quesnel District based on RESULTS data (courtesy of Richard Reich) Figure 5: High Rust Hazard Polygons in the Quesnel TSA (yellow) overlaid on BEC map.	45

List of Tables

Table 1: Regional and district responsibilities as they relate to the Forest Health Implementation Strategy	5
Table 2: List of important forest health factors in the Cariboo, the risk they pose, and the management objective currently being used to address them.	7
Table 3: Entomology forest health priorities, actions and required resources in 2014-15	12
Table 4: Pathology forest health priorities, actions and required resources in 2014-15	15
Table 5: Regional and District forest health priorities, actions and required resources in 2014-15	17
Table 6: Landscape level hazard rating by forest health agent for biogeoclimatic subzones within the Cariboo Region.....	19
Table 7: Landscape level hazard by biogeoclimatic subzone for forest health agents within the Cariboo Region. Pest codes can be found in the Field Guide to Forest Damage in British Columbia.....	23
Table 8: Mean incidence of forest health factors by BEC zone/subzone based on SDM surveys conducted between 2009 and 2013. The top three forest health factors by BEC are highlighted.	25
Table 9: Non-recoverable (unsalvaged) losses used in most recent timber supply reviews.....	28
Table 10: Non-recoverable (unsalvaged) losses as a percentage of AAC on Jan 2013.....	29
Table 11: Mean hectares affected from the Aerial Overview Survey 2007-2011.	29
Table 12: Impact of mountain pine beetle in young stands in the Cariboo Region (modified from Maclauchlan 2008).....	30
Table 13: Potential for black army cut worm defoliation	39

Acknowledgements: This document was modeled after the Coastal Timber Supply Areas Regional Forest Health Overview and a number of provincial, regional, and district forest professionals provided input and advice on the contents.

Executive Summary

The Cariboo Region faces significant uncertainty in terms of mid-term-timber supply, biodiversity values and the impacts of ongoing climate change. The Cariboo Forest Health Strategy outlines the vision for forest health stewardship in the region, the current forest health policy, and risks and best management practices in forest health across the region. Appendix 1 contains the annual strategic plan for the 2014-15 year, and includes budget requests and staffing requirements for each item in the prioritized list. Appendix 2 focuses on hazard ratings; Appendix 3 contains information on climate change strategies for dealing with forest health agents; Appendix 4 summarizes non recoverable losses currently accounted for in the timber supply reviews for the three timber supply areas; and Appendix 5 highlights forest health research needs. Finally, Appendix 6 contains specific information on insects and diseases of particular importance in the Cariboo Region. Investments in the forest health program are critical to manage the complex forest landscape in the region, minimizing pest losses and protecting forest resources for future generations.

A. Cariboo Region Forest Health Vision

The Cariboo Forest Region is comprised of three Forest Districts/Timber Supply Areas (TSAs): Quesnel, Cariboo/Chilcotin (Williams Lake TSA), and 100 Mile House. The Cariboo Region Forest Health Strategy is a guiding document for Forest Health management within the Cariboo Region. Forest health issues from insects, diseases and abiotic factors (e.g., fire, snowpress, flooding) are highly integrated across the landscape affecting timber supply, forest resilience and stewardship values such as biodiversity. The Cariboo Region faces future uncertainty in terms of mid-term-timber supply and the impacts of climate change. It is crucial that appropriate investments are made in forest health treatments, monitoring, and operational research that minimize pest losses, reduce the likelihood of another province wide insect epidemic (i.e., mountain pine beetle), and increase forest resilience to support provincial and regional management strategies.

The key areas of investment required to protect the value and productivity of the forested land base and to foster sustainable management of landscape values in the Cariboo Region are focused on monitoring and control of forest health agents. Monitoring and assessment activities are essential for informing decision making, best management practices, timber supply reviews and filling information gaps. Control activities have an important role to play in mitigating timber losses in the Region and in maintaining the integrity of other stewardship values. Ongoing climate change is likely to result in changes to our current understanding of hazard and risk to various forest health agents that will require a comprehensive approach to pest management that seeks to reduce susceptibility and risk in the long-term

The purpose of this document is to describe strategies for dealing with forest health agents in the Cariboo Region by providing the following information:

1. A list of priority forest health agents;
2. An assessment of the risk posed by these forest health agents and the specific management objectives and strategies ;
3. Strategies for minimizing risks posed by forest health factors in a changing climate;
4. Description of the extent and significance of the major forest health agents, and their impact on timber supply;

5. Research Priorities.

District Forest Health Strategies are tactical in nature and should be consulted for specifics regarding forest health agents of concern and their management in specific TSAs¹.

B. Planning Framework

1) Legislative Framework

Forest Health Management in B.C. is largely a voluntary activity that relies on the professional reliance of forest professionals acting as stewards for the people of B.C. There are a number of provincial Acts and Regulations that govern the management of Forestry in B.C. including the: Forest Act, Ministry of Forests and Range Act, Forest and Range Practices Act, and Forest Planning and Practices Regulation. The information presented here is a brief overview of pertinent legislation and forest health provisions under these acts. A more comprehensive summary can be found in Appendix A of the Forest Health Implementation Strategy². The reader should consult the official version of the legislation for exact wording, or interpretation of the intent of the legislation.

The Forest and Range Practices Act (FRPA)³ contains some provisions for forest health, primarily in the form of exemptions as a result of forest health occurrences. However, there are no specific requirements outlined for license holders to manage forest health issues unless specifically directed by the Minister. The main tools for planning and managing public forest lands are the Forest Stewardship Plan, and the Woodlot License Plan. There are no requirements for holders of Forest Stewardship Plans or Woodlot Licenses that harvest timber to address forest health concerns except through the requirement to establish a free growing stand. Section 26 of Forest Planning and Practices Regulation (FPPR)⁴ allows the Minister to direct private land owners or agreement holders under the Forest Act to propose reasonable measures to control or dispose of insects, diseases, animals, or abiotic factors that cause damage to a forest. This section of FPPR guides stocking standards proposed under an FSP, which must meet several key tests that adequately address immediate and long-term forest health risks⁵.

The Chief Forester has the power to establish or revoke standards respecting stocking standards required for a free growing under Section 169 of the FPPR. A free growing stand is defined as a stand of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs, or trees. In one of the few instances where the legislation provides clear and specific measures to deal with a specific forest health issue, Section 41 requires an agreement holder who uses trap trees or pheromones to concentrate insect populations to destroy the insect brood before the insects emerge.

2) Government Policy

¹ http://www.for.gov.bc.ca/hfp/health/TSA_strategies.htm

² <http://www.for.gov.bc.ca/hfp/health/Strategy/FH%20Impl.%20Strategy.pdf>

³ <http://www.for.gov.bc.ca/code/>

⁴ http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/14_2004

⁵ <http://www.for.gov.bc.ca/hfp/silviculture/Guidance%20for%20assessing%20FSP%20stocking%20standards%20June%2021%202012.pdf>

The Ministry of Forest, Lands and Natural Resource Operations (FLNRO) Service Plan⁶ outlines the key challenges, opportunities, objectives and priorities for the Ministry. Objective 2.2 states that natural resource productivity is optimized through conservation, stewardship, and effective policy, legislation, and external relationships. The strategies for meeting this objective include:

- Increasing timber quality and supply through silviculture;
- Carbon investments, and sustainable forest management practices;
- Mitigating timber supply impacts caused by the mountain pine beetle;
- Working collaboratively with multi-sector partner groups and First Nations to increase ecosystem health by restoring degraded ecosystems through invasive plant management, ecosystem restoration, remediation and best management practices.

Effective forest health strategies are an important component of both stewardship and best management practices.

3) Provincial Forest Health Policy

The Provincial Forest Health Strategy⁷ outlines three key strategic forest health objectives. These are:

1. Protect forest resources from pest damage by direct actions when operationally possible and justified.
2. Implement stand establishment activities to minimize the expected impact of known forest pests.
3. Assess pest impacts on forest values to improve estimates of timber yield from B.C. forests and to prioritize management treatments.

4) Regional and District Forest Health Roles & Responsibilities

The Forest Health Implementation Strategy outlines eleven functions of the forest health program:

Legislation and Policy Support

1. Develop Forest Health Strategies
2. Participate in interagency efforts
3. Support statutory decision makers

Program Delivery

4. Program planning, management, and partnering
5. Detect, assess, and predict pest damage
6. Treat pest outbreaks and prevent the establishment of key exotic pests
7. Manage endemic pests and prevent establishment of invasive plants during forest operations
8. Developing agents for biological control of invasive plants
9. Monitor and evaluate treatment regimes

Adaptive Management

⁶ http://www.bcbudget.gov.bc.ca/2013_June_Update/sp/pdf/ministry/flnr.pdf

⁷ <http://www.for.gov.bc.ca/hfp/health/Strategy/Forest%20Health%20Strategy.pdf>

10. Extension

11. Operational research

Pest detection (#5) and treatment of pest outbreaks (#6) account for 22% and 66% of the Provincial Forest Health operating budget, respectively. Within the core functions identified above there are specific regional and district roles and responsibilities (Table 1). Districts are primarily responsible for developing a District Forest Health Strategy, liaising with local licensees, setting priorities for bark beetle management units, conducting bark beetle surveys and treatments, and providing support for regional forest health activities. Regional specialists are primarily responsible for executing treatment programs (e.g., regional defoliator control); managing monitoring and surveying programs (e.g., aerial overview survey, invasive species); developing best management practices, and hazard and risk ratings; providing forest health information for timber supply review, training, extension, and technical advice; and conducting monitoring and operational research trials.

Table 1: Regional and district responsibilities as they relate to the Forest Health Implementation Strategy

Function	Region	District
1.FH Strategy	<ul style="list-style-type: none"> • Provide regional FH strategy (long-term focus) • Develop and implement regional standards and procedures • Provide guidance and review for District FH strategies • Identify regions specific research topics • Participate on committees (e.g., climate change, TSA/FH) 	<ul style="list-style-type: none"> • Lead in preparation of TSA or District FH Strategy (operational focus) • Review FSPs • Provide feedback for FREP • With assistance of regional FH staff identify priority research topics in District FH Strategy; incorporate advice and/or policy changes on climate change
2. Inter-agency	<ul style="list-style-type: none"> • Participate in committees and task forces 	<ul style="list-style-type: none"> • Liaison with other agencies
3.Decision Maker Support	<ul style="list-style-type: none"> • Help interpret policy and technical matters pertaining to forest health • Improve forest health management • Host forest health training and workshops 	<ul style="list-style-type: none"> • Support district manager, supervisor, and others • Promote forest health training and workshops
4.Program Planning and Implementation	<ul style="list-style-type: none"> • Plan and administer regional budgets and projects • Manage and implement defoliator treatment and monitoring program • Roll-up district and regional funding requests to Provincial FH lead 	<ul style="list-style-type: none"> • Set priorities for beetle management units (BMUs) and surveys • Submit district-based funding requests to regional staff • Manage forest health contracts • Integrate forest health with other programs such as small scale salvage
5. Pest Damage detection, assessment, and prediction	<ul style="list-style-type: none"> • Contract management for aerial overview survey of region • Forecast epidemic pest outbreaks • Update hazard and risk ratings • Develop standards for and conduct monitoring surveys • Support TSR determinations 	<ul style="list-style-type: none"> • Review draft overview survey results for the district • Provide logistical support for surveys • Identify abnormal levels of damage and monitor forest health conditions • Participate in FREP stand development monitoring (SDM)
6. Treat Pest Outbreaks	<ul style="list-style-type: none"> • Treat native defoliators • Assist in BMU strategy setting • Assign mitigating strategies where appropriate through District FH Strategy 	<ul style="list-style-type: none"> • Define treatment regimes in conjunction with the region (e.g. bark beetles) • Develop and implement contracts to deal with bark beetle infestations
7. Manage	<ul style="list-style-type: none"> • Provide technical input for best 	<ul style="list-style-type: none"> • Provide local advice to implement and

Endemic Pests	management practices and mitigating strategies and tactics <ul style="list-style-type: none"> • Cooperate with federal agencies on monitoring invasive species such as gypsy moth 	develop best management practices
9. Monitor Treatments	<ul style="list-style-type: none"> • Coordinate regional monitoring program and provide training and support for FREP SDM 	<ul style="list-style-type: none"> • Assist region in monitoring • Conduct FREP SDM surveys
10. Extension	<ul style="list-style-type: none"> • Communicate innovative practices • Update guidebooks • Conduct training 	<ul style="list-style-type: none"> • Facilitate courses set up by regional specialists
11. Pest Behaviour Monitoring	<ul style="list-style-type: none"> • Design and conduct operational applied research • Develop and refine hazard and risk models 	<ul style="list-style-type: none"> • Establish district operational trials • Assist in locating research sites

At the regional and district levels the capacity to carry and perform these responsibilities is dependent on staffing levels and funding. Decisions around relative staffing and funding levels must take into consideration the risks and benefits of carrying out forest health activities in relationship to other forest management programs. Presently, none of the three districts in the Cariboo region have dedicated forest health staff to carry out district forest health functions. Instead stewardship foresters are responsible for forest health functions in addition to their regular duties. The lack of dedicated forest health staff at the district level poses a significant challenge to managing FH factors, which can significant impacts on forest stewardship across the region.

C. Forest Health Factors and Management

Forest health agents of particular concern in the Cariboo region are listed by relative importance for insects, diseases and abiotic factors. 2014-15 Forest Health Funding Priorities, Actions and Required Resources are detailed in Appendix 1. The information provided in Table 2, particularly the probability and severity columns, are closely linked with the pest hazard rating information provided in Appendix 2. The impacts of pests on the non-recoverable losses for TSR are in Appendix 4. Appendix 6 has more specific information on individual pests/diseases and their management.

It is important to note that some forest health agents are not priorities in all TSAs. For example, Armillaria root disease is given a moderate priority for the Cariboo Region even though in many parts of the Quesnel TSA and the Chilcotin it is not present. Another example is the western spruce budworm, which has had sustained outbreaks Williams Lake and 100 Mile TSAs in recent years, but is relatively absent in the Quesnel TSA. For an overview of *current* pest conditions as determined from aerial overview flights refer to the most recent version of the Annual Overview Survey Report⁸ and the Overview of Forest Health for Southern British Columbia⁹. The annual overview report only details those pests that can be easily detected from the air, thus many important diseases are excluded due to poor detection from the air.

Forest health spending in the region is allocated at the provincial level based on forest health priorities and available funds (primary funding source is the Land Based Investment Fund (LBI)). The majority of

⁸ <http://www.for.gov.bc.ca/hfp/health/overview/overview.htm>

⁹ <http://www.for.gov.bc.ca/rsi/ForestHealth/Overview.htm>

provincial forest health funding, in order of priority, goes to monitoring annual insect trends in the aerial overview survey, funding a defoliator spray program and monitoring insect defoliator populations in order to reduce their impacts, and managing bark beetles. Recently defoliator management in the form of operation treatments has focused on managing the western spruce budworm. Bark beetle control efforts in the region have focused primarily on Douglas-fir beetle. After these provincial priorities are funded remaining funds focus on forest health monitoring. In the past few years funding cutbacks to the provincial forest health program have created deficits, and forest health monitoring has not been funded.

Monitoring and Treatment Cost Benefit Rationale

The annual aerial overview survey (priority #1) is critical for tracking and documenting the occurrence of insect outbreaks over time and calculating non recoverable losses for timber supply planning. The cost of the annual aerial overview survey had been estimated to be \$0.01/ha. Defoliator treatment, e.g., western spruce budworm, in the form of aerial application of Btk is estimated to be \$30/ha.

The direct economic benefits of treating Douglas-fir beetle and spruce beetle are not well documented and can vary considerably depending on wood quality and timber value at the time of treatment. Anecdotal evidence suggests that Douglas-fir beetle treatments are effective at reducing the overall impact of the beetle but detailed studies comparing treated and untreated areas are lacking. What is clear, is that losses to Douglas-fir beetle and spruce beetle within the Cariboo Region are significant. Spruce and Douglas-fir beetle non-recoverable losses (NRLs) account for 1.2% of the AAC in 100 Mile TSA and 0.8 % of the AAC in the Williams Lake TSA (Appendix 4). A study of the impact of Douglas-fir beetle in mule deer winter range in the Chilcotin IDfxm, indicated that over a five year period from 2005 to 2009 Douglas-fir beetle mortality resulted in a nearly 17% reduction in the net merchantable volume of stands (Rusch 2010) all in the form of NRLs. Although this represents a worst case scenario and the volume harvested from this area does not contribute significantly to the annual allowable cut in the region, it highlights the potential impacts from Douglas-fir beetle in the Cariboo Region and the types of losses that can occur if no attempt is made to recover beetle killed wood. Perhaps more significant from a mule deer winter range perspective was a drop in the live basal area for trees over 37.5 cm dbh (a measure of mule deer winter range suitability) from 7.8m²/ha to 4.9 m²/ha (37% decrease), which falls below the post harvest basal area target for low stand structure Habitat Class stands in the IDfxm of 6m²/ha (Rusch, 2010).

In recent years, some of the greatest impacts of Douglas-fir beetle have been seen in Douglas-fir areas impacted by fires in 2009 and 2010, two years in which there were a number of large fires that impacted the Cariboo Region. Some of the burned areas with low and moderate fire severity ratings have been completely killed by Douglas-fir beetle. With the number and severity of fires expected to increase as a result of climate change this could become an increasingly important source of future timber losses.

Table 2: List of important forest health factors in the Cariboo, the risk they pose, and the management objective currently being used to address them.

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
<i>Insects</i>					
Western Spruce	High	Mod	High	Aerial treatment of priority	There have been no

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
Budworm				areas with moderate to high risk of defoliation	recent outbreaks in the Quesnel area or the western Chilcotin
Douglas-fir Beetle	Mod	High	High	Reduce existing populations through salvage and sanitation harvesting and trap trees in suppression beetle management units and prevent build ups of beetle populations around fires and windthrow. Monitor in inaccessible areas	2013 saw increases in beetle levels in the Chilcotin and Nazko. Beetle populations continue to be extremely high around 2010 fires
Spruce Beetle	Mod	High	High	Sanitation and salvage harvest in unconstrained areas to recover losses and reduce populations. Monitor in constrained/inaccessible areas	Has been very active in 100 Mile and parts of the Cariboo in recent years. 2012-13 marked a decrease in beetle numbers
2-year Cycle Budworm	Mod	Mod-Low	Mod	Monitor, develop treatments	Higher risk in even years, though 2013 saw greatest mapped impact east of Quesnel despite being an off year
Balsam Bark Beetle	Mod	Low	Low	Monitor	Endemic beetle levels mostly at higher elevations resulting in sporadic and low level mortality
Mountain Pine Beetle	Low	Low	Low	Salvage in accordance with Chief Foresters guidelines.	Mountain pine beetle is still active in the southern Chilcotin
Hemlock Looper	Low	Mod	Mod	Monitor and aerially treat populations when warranted	Historically outbreaks have been confined to relatively small areas but result in high levels of mortality
Douglas-fir Tussock Moth	Low	Mod	Low	Monitor	Historically only damaging along the southern boundary of 100 Mile TSA
Forest Tent Caterpillar	Mod	Low	Low	Monitor	Some outbreaks in the Quesnel TSA in recent years
Aspen Serpentine Leaf Miner	High	Low	Low	Monitor	Several years of repeated defoliation may be negatively impacting aspen and contributing to overall decline

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
Black Army Cutworm	Low	Low	Low	Delayed planting after fires, monitor	2012 outbreaks around Pelican Fire.
Gypsy Moth	Low	High	High	Monitor (trapping in cooperation with CFIA)	In 2013 first positive ID of male gypsy moth at McLeese Lake
Lodgepole pine terminal weevil	Mod	Low	Low	Monitor	Widespread but impacts generally low
Spruce Weevil	Mod	Low	Low-Mod	Mitigate impacts through silviculture planning or alternate silviculture systems	Can cause moderate impacts in high hazard areas
Warren's Root Collar Weevil	Low	Low	Low	Mitigate impacts, monitor	Higher hazard in Quesnel TSA
<i>Diseases</i>					
Armillaria Root Disease	Mod	Mod	Mod	Mitigate during stand regeneration	High hazard in the ICH. Absent from parts of the Chilcotin and Quesnel
Laminated Root Disease	Low	Low	Low	Treat during stand regeneration	High hazard in portions of 100 Mile district
Tomentosus	Mod	Low	Mod	Treat during stand regeneration may lower culmination age of some heavily impacted spruce stands	Spruce, impact under estimated
Lodgepole pine dwarf mistletoe	Mod	Low-Mod	Low-Mod	Sanitation spacing to remove overhead seed sources	High hazard on zonal sites in the SBPSxc
Western Gall Rust	High	Low	Mod	Plant higher densities/ use mixed species in high hazard areas	Very prevalent and widespread throughout the region
Commandra Rust	Mod	Mod	Mod	Plant higher densities/use mixed species in high hazard areas	Can cause severe impacts in high hazard areas
Stalactiform Rust	Mod	Mod	Low	Plant higher densities/use mixed species in high hazard areas	Can cause severe impacts in high hazard areas
Atropellis canker	Low	Low	Low	Assess prior to spacing after age 14	Dense pine stands >14yrs old
Elytroderma Needle Cast	Low	Mod	Mod	Where possible regenerate species other than lodgepole pine in high hazard areas	Severely impacted areas in 100 Mile and the east Chilcotin
Lophodermella Needle Cast	Low	Low	Low	Monitor	Growth losses during outbreaks
Mammal Damage	Mod	Low	Low-mod	Monitor	Currently high risk of bear damage on lodgepole pine in ICH & ESSF
<i>Abiotic Damage</i>					
Fire	Mod	Mod-	High	Depends on risk	Engage in Douglas-fir

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
		High			bark beetle trapping immediately post-fire as populations increase dramatically around fires
Wind	Low	Mod	Low	Monitor, salvage	
Flood	Low	Low	Low	Monitor	Higher risk near water bodies
Drought	Low	Low	Low	Monitor	Hazard varies depending on local soil and climate
Snow press	Mod	Mod	Mod	Monitor and avoid planting lodgepole pine or Douglas-fir in the ESSF & ICH	Lodgepole pine and Douglas-fir in the SBS, ICH & ESSF
Winter desiccation	Low	Low	Low	Monitor	

Appendix 1

2014-15 Forest Health Funding Priorities, Actions and Required Resources

The *Cariboo Forest Health Community of Practice* (FH CoP) is a group of government practitioners at the district and regional level with responsibilities in forest health issues. This group had their first meeting in late-January where we were tasked with producing a *ranked priority* list of forest health issues facing the Cariboo in 2014-15 to assist RMT in their area planning.

The following document was developed by the FH CoP, with forest entomology (Table 3) and pathology issues (Table 4) being prioritized individually. The final table (Table 5) includes subjects with both pathology/entomology and district/region responsibility. The priorities and their rank reflect our current understanding of forest conditions based on the results of the Aerial Overview Survey, detailed surveys, and ground monitoring. This list does not include applied/operational research priorities related to insect management.

A comparison of the priorities in the table below to the staffing resources required to tackle these issues, shows that there will likely be some priorities that will not be addressed. The largest source of *risk* in the coming year is our collective inability to manage bark beetles in the region, both Douglas-fir and spruce beetles. There are many reasons for this including, but not limited to: reduced staff capacity, licensee engagement, closure of small scale salvage programs, a move towards table rates and away from minimum stumpage, difficulties in managing beetles in constrained areas, and funding cut-backs to the Forest Health Program provincially. Traditionally bark beetle management responsibilities have resided within the districts, however licensee engagement in Douglas-fir bark beetle management needs to be encouraged and obstacles to salvage programs need to be addressed (stumpage, OGMA's, MDWR).

Douglas-fir beetle is a significant source of non recoverable losses in the region. More work is needed to conclusively demonstrate the economic benefits of Douglas-fir bark beetle management. Research on this topic at the regional level will contribute to our understanding of this issue in the coming years. Given this uncertainty if we leave bark beetle hotspots untreated we face potential epidemic losses which may further endanger the mid-term timber supply and result in loss to valuable wildlife habitat. This also creates greater uncertainty in TSR processes in the future.

We feel that RMT should prioritize staffing positions within the District in order to effectively manage forest health issues, or at the *minimum* consider hiring one full-time regional Forest Health technician, who would primarily support district forest health priorities such as detailed bark beetle survey, monitoring and treatment and young stand monitoring

Table 3: Entomology forest health priorities, actions and required resources in 2014-15

Priority	Forest Health Issue	Goal	Recommended Action	Risks associated with not addressing the issue	Role of Ministry	Resources Required (proportion of FTE)	Funds requested 2014/15
1	Western Spruce Budworm	Management of uneven-aged Douglas-fir stands for mid-term timber supply and habitat and biodiversity protection. Aerial treatment of high populations of the western spruce budworm protects tree volume and quality, and minimizes mortality, especially in the understory.	In 2014/15 aerial treatment will focus on ~33,000 ha in the southern area of region (west of 100 Mile House). This year new damage and budworm numbers were low in the DCC/DCH and DQU, but continued monitoring (annual) is required to direct further control activities, especially as susceptibility increases (e.g., DQU). Responsibility: Regional Entomologist (with assistance from student or auxiliary seasonal staff)	Continued defoliation in typically uneven-aged stands results in mortality in the younger understory and eventually overstory trees. Cumulative defoliation can severely impact stand growth, condition and regeneration potential, and often habitat values (e.g., MDWR). Aerial treatment is often targeted in stands with silviculture treatments and investments; failing to protect these stands reduces or eliminates return on investment.	The Regional Entomologist coordinates and conducts the following: a) Aerial Overview Survey (AOS) b) Egg mass surveying c) Spray block design and verification through spring bud-mining surveys d) Spray Operations – June e) Efficacy monitoring (post-spray) Note: Thompson Okanagan Forest Entomologist handles the application and reporting for the pest management plan (PMP).	Reg Ent - 0.5 FH tech – 0.25 Districts: DQU – NA DCC – 0.02 DMH – 0	\$418,000 (LBI)

2	Bark Beetle Management (Douglas-fir beetle)	Proactive beetle management that stays ahead of beetle population increases, by designating appropriate Beetle Management Units as Suppression in order to protect timber values, habitat and biodiversity values and minimize non-recoverable losses.	It is very important that management activities focus on beetle treatment before the insect population increases to epidemic level. Removal of red and green attacked trees can significantly reduce beetle populations and minimize spread. Management of the Douglas-fir bark beetle continues to be a <i>high</i> priority in the Cariboo Region. Responsibility: Districts coordinate with licensees to engage in revenue generating activities such as sanitation harvesting and trap trees. In areas with poor access or with landscape constraints fall and burn activities are recommended or deploying anti-aggregation pheromones (MCH but only with < 5 trees/stand). <i>Caution</i> should be exercised with funnel traps as there is a high risk of spillover and maintenance is labour intensive.	Potential epidemic losses which may endanger the mid-term timber supply.	Activities leading to treatment: a) AOS survey (Regional Entomologist). b) Overwinter Mortality Survey (Regional Entomologist) c) Detailed overview flights (late summer) Regional Entomologist will coordinate contracting with District input required for flight plans and focus. d) District staff consult and coordinate with licensees and First Nations to determine what activities are required and where (all harvesting actions should conform to the Biodiversity Update 7b). Regional Entomologist can participate in meeting if requested. e) Ministry focus on areas that licenses are unwilling to operate in.	Reg Ent – 0.15 FH tech - 0 Districts DQU – 0.25 ¹⁰ DCC – 0.75 DMH – 0.25	\$246,519 (LBI) Regional (detailed flight) – \$81,206 Districts: DQU – \$24,030 DCC – \$109,303 DMH – \$31,900
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¹⁰ Requires auxiliary employee, Co-op student, or other short-term worker

3	Insect Population Monitoring -Gypsy Moth -Tussock Moth	To have consistent and annual monitoring for the detection of the Gypsy Moth, an invasive species, and potential range expansion of the highly damaging Douglas-fir Tussock Moth, whose current range limits are directly to the south of the 100 Mile District boundary.	To continue to run an annual monitoring program for identified pests. In 2013 there was a first positive catch for Gypsy Moth at McLeese Lake. Gypsy Moth – Responsibility: Regional Entomologist coordinates; Districts deploy and collect traps (late June, late September) across Districts. Tussock Moth – Responsibility: Regional Entomologist.	As Gypsy Moth is an invasive species its establishment has serious implications for international trade. So far it has not become permanently established due to aggressive monitoring and eradication programs. The Douglas-fir tussock moth is a fast acting and aggressive defoliator causing significant damage and mortality in all age classes. Range spread of the tussock moth would have serious implications for mid-term timber supply.	Gypsy Moth trapping is done in cooperation with the federal government. Traps for the entire region are sent to the Regional Entomologist. Traps and trap site list are sent to Districts who deploy between late-June to early-July and are collected from late-Sept to early- Oct. Tussock Moth monitoring is part of the defoliation program that is managed at the Regional level.	Reg Ent – 0.1 FH tech - 0.05 Districts: DQU – 0.01 DCC – 0.08 DMH – 0.02	None - activity currently paid for by defoliator management budget.
4	Two-year Cycle Budworm	Monitoring of the 2-year cycle budworm to gain an understanding of its population dynamics in the Quesnel TSA, how AOS mapped damage compares to impacts within stand, and what populations levels lead to significant volumes losses and mortality. Build a business case for aerial spray operations in the future.	A preliminary aerial treatment in 2012 in the Mt Tom area to protect the health of subalpine forests proved to be effective at reducing budworm numbers in treated stands. In 2014/15 establish permanent monitoring plots in areas with mapped defoliation. Responsibility: Regional Entomologist with District support (e.g., site selection, PSP set-up).	As the salvage of beetle killed pine stands winds down in DQU, subalpine fir will become an increasingly important economic species for harvest. It has been suggested that at current levels of mortality and crown damage that volume estimates overestimate actual volume due to greater than expected damage to balsam and spruce.	The Regional Entomologist, in cooperation with District staff and licensees needs to initiate a monitoring program to determine how much damage and mortality is occurring in “on” and “off” years of this insect in order to protect mid-term timber supply in TSA.	Reg Ent – 0.1 FH tech - 0.1 Districts: DQU – 0.05 DCC – NA DMH - NA	None

5 ¹¹	Aerial Overview Survey (AOS)		Aerial overview surveys provide a coarse picture of the location, extent and severity of a number of forest health agents. Detailed aerial surveys provide a further refinement for pinpointing operational treatments and salvage, or areas requiring further investigation in the field. Responsibility: Regional Entomologist	Without data from the AOS we would be unable to identify presence and severity of a number of forest health agents, and trends in infestation/damage levels. AOS is a critical data source for guiding the Regional and District strategies, as well as licensees to direct operational treatments and harvesting. Threat to mid-term timber supply.	The Regional Entomologist tenders and manages the contract for this survey. Regional Entomologist/Pathologist does ground checks of damage when required, and along with Provincial AOS coordinator conducts validation flying to check accuracy of surveyed damage and damaging agent.	Reg Ent – 0.2 Districts – N/A	\$165,500 (LBI)
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Table 4: Pathology forest health priorities, actions and required resources in 2014-15

Priority Order	Forest Health Issue	Goal	Recommended Action	Risks associated with not addressing the issue	Role of Ministry	Resources Required (proportion of FTE)	Funds requested 2014/15
1	Young stand monitoring (all species):	Provide information on the impacts of forest health factors in young stands to guide silviculture activities and strategies and TSR.	-Carry out SDM surveys -Support young stand monitoring efforts carried out by forest analysis and inventory branch -Monitor existing PSPs -Summarize forest health information available in RESULTS -Carry out monitoring activities for specific forest health factors Responsibility: Districts carry out SDM surveys with assistance from regional staff. Other monitoring activities are primarily the responsibility of regional staff	Timber supply documents, silviculture strategies, and stocking standards that don't adequately address forest health in young stands. A poorer understanding of how climate change may impact pest of young stands	Monitor and oversee the collection of monitoring data Summarize data and present information to various groups.	Reg Path – 0.1 SDM Total: 0.18 - 0.30 (0.06 to 0.1/TSA for ~8 surveys) Districts: - DQU –0.1 - DCC – 0.1 - DMH –0.1	None
2	Pine stem Rusts	Analyze results of rust surveys conducted in 2013 to provide future	Information is critical for developing a stem rust management strategy and	Stem rusts are one of the most important forest health factors in young pine	Conduct monitoring activities and develop appropriate mitigations	Reg Path - 0.2 Districts:	None [\$30,000 received

¹¹ Aerial Overview Survey program is the number one priority for the Provincial Forest Health Program, and will be funded at exclusion of other FH activities.

		direction for stem rust management Responsibility: Regional Pathologist	quantifying the impacts of stem rusts in young managed stands	stands and have the potential to impact mid-term timber supplies Poor silviculture decisions and a reduction in future timber supply	strategies	- DQU - 0.02 - DCC – NA - DMH - NA	last fiscal]
3	Elytroderma Needle cast	Develop a better understanding of the distribution, impacts, and progression of Elytroderma needle cast over time, develop management recommendations and explore and develop possible treatments such as using resistant stock	Set up operational trials to assess possible treatment options and gather information on the progression of the disease over time. Create management recommendations. Responsibility: Regional Pathologist	Impacts to mid-term timber supply due to reduced growth in areas heavily impacted Uncertainty about the role of climate change on changes to the incidence of needle cast over time	Develop Management strategies and monitor impacts over time	Reg Path - 0.2 Districts: -DQU – NA - DCC – 0.02 - DMH – 0	\$5,000 to initiate a long term project to look at natural resistance
4	Dwarf Mistletoe	Quantify the impact of dwarf mistletoe on timber supply, evaluate the effectiveness of sanitation treatments, and the effect of possible changes in mistletoe management in order to increase moose screening in the south Chilcotin	Set up long term trials to look at the effectiveness of sanitation spacing and future impacts of mistletoe on timber supply Responsibility: Regional Pathologist	Lack of information on the effects of dwarf mistletoe moose mitigation strategies on timber supply and the effect of the mountain pine beetle epidemic on future mistletoe impacts	Collect information necessary for statutory decision makers to make informed land management decisions and balance competing land management objectives	Reg Path - 0.2	\$30,000 (LBI)
5	Root Disease	Evaluate the effectiveness of current and proposed management strategies and gain a better understanding of the distribution and impacts of root disease in the Cariboo Region	Monitor and evaluate current installations and stumping efficacy research being carried out in other jurisdictions Apply for funding to conduct aerial detection surveys to quantify the extent and distribution of Armillaria root disease in the Cariboo Region. Responsibility: Regional Pathologist	Inadequate treatments for managing root disease and a loss in stumpage for ineffective treatments paid for through stumpage offsets in the form of silvicultural allowances. Intensification of root disease in managed stands resulting in future lost productivity Unaccounted losses to timber supply from root disease	Evaluate current and proposed management techniques	Reg Path - 0.2	\$60,000 (LBI) Conduct aerial root disease survey of young stands in Cariboo

6	Snow Press	Provide information to forest managers on the current impacts of snow press damage in young stands as shown from SDM monitoring data so that this information can be used to improve reforestation decisions and silvicultural practices and guide revisions to stocking standards	Disseminate information through SISCO and other training and extension activities	Poor silviculture decisions and inadequate stocking standards leading to a reduction in future timber supply Possible increased risk of losses due to freak weather events resulting from climate change	Disseminate current information to improve forest management and fulfill climate change adaptation commitments	negligible	None
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Table 5: Regional and District forest health priorities, actions and required resources in 2014-15

Priority Order	Forest Health Issue	Goal	Recommended Action	Risks associated with not addressing the issue	Role of Ministry	Resources Required (proportion of FTE)	Funds requested 2014/15
1	Regional and District Forest Health Strategies	Make sure strategies are updated annually in order to provide guidance and direction to the forest health program	Update and review strategies <i>Annually</i> . Responsibility: District staff are responsible for updating district strategies, regional staff update regional strategy and review district strategies	Lack of focus and direction to guide forest health priorities and expenditures. When strategies are not updated annually the time required for bringing strategy up-to-date increases considerably, potentially taking 0.1 FTE (versus 0.02-0.05 FTE).	Produce and update strategies consistent with higher level objectives set out by government, and guide FH operational activities within Districts/TSAs.	Reg Ent - 0.05 Reg Path - 0.05 Districts: DQU – 0.05 DCC – 0.04 DMH – 0.03	Region - none

2	Training / Extension/ Consultation	Provide training and extension opportunities to Increase awareness of the Forest Health issues and risks; improve identification skills; and provide guidance and consultation for better management decisions. Responsibility: Regional Entomologist/Pathologist and District staff as requested/required.	Conduct annual training and extension activities. Provide consultation when requested.	Extension and training are key elements in facilitating good knowledge and highlighting importance of forest health factors across the region. Failing to provide this service occurs at the detriment of good forest health management.	Advocate for better and more effective management of forest resources	Reg Ent – 0.05 Reg Path – 0.05 Districts: DQU – 0.01 DCC – 0.04 DMH – 0.02	Region - none
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Appendix 2

Hazard Ratings

Hazard or susceptibility, is the degree to which stand or tree characteristics make them vulnerable to damage from a particular forest health agent. Risk is the probability of sampling damage due to a particular forest health agent and is related to a number of factors such as proximity of the forest health factor and its incidence. For example, stands in the SBPSxc have a higher hazard for dwarf mistletoe than stands in the MSxv. Since long distance seed dispersal is not that common for dwarf mistletoe, the risk of mistletoe infection in the middle of a mistletoe free stand in the SBPSxc is low. Conversely, the risk of infection along the edge of a lodgepole pine stand adjacent to a mistletoe infected stand in the MSxv would be high given the proximity to a dwarf mistletoe seed source.

Long-term monitoring data from inventory plots, the Forest and Range Evaluation Program's stand development monitoring program (SDM), information obtained from the RESULTS database, and monitoring surveys conducted by regional staff contribute to our knowledge of pest hazard in the Cariboo Region. Hazard is summarized by pests based on BEC zones and compiled using a variety of sources, including forest practices code guidebooks, Forrex stand establishment decision aids (SEDAs) and SDM monitoring results (Table 6). Alternatively, hazard is summarized by BEC zone (Table 7). It is important to keep in mind that absence of information for a pest or BEC zone does not necessarily mean that the hazard is low, only that there is no good information currently available.

Recent SDM results are contributing to our knowledge of pest hazard in the Cariboo Region (Fig.1, Table 8). SDM samples stands 20-40 years of age, that are over 5 ha in size and that have been surveyed in RESULTS. Damaging agents were only recorded if they exceeded a pre-determined damage threshold. The top pests by incidence over the entire region based on SDM data were western gall rust (4.3%), mountain pine beetle (2.3%), snow press (1.9%), and elythroderma needle cast (1.1%) (Fig 1). Some subzones had a much higher proportion of total trees affected by forest health factors than others (last column in Table 8). This was particularly true for the SBPSmk and the SBS subzones. High pest incidences in the SBS have also been found in other pest surveys (Heineman et al. 2010; Westfall and Brooks 2001). Higher stocking standards are warranted in the SBS and SBPSmk to compensate for higher pest losses in pine stands in these subzones.

Table 6: Landscape level hazard rating by forest health agent for biogeoclimatic subzones within the Cariboo Region

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
Spruce Bark Beetle (IBS)	-	Through-out host range	H	Bark Beetle FPC Guidebook ¹²
Douglas-fir Bark Beetle (IBD)	-	Through-out host range	H	Bark Beetle FPC Guidebook
Mountain Pine Beetle (IBM)	-	Through-out host range	H	Bark Beetle FPC Guidebook
Balsam Bark Beetle (IBB)	-	Through-out host range	H	Bark Beetle FPC Guidebook

¹² <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/beetle/betletoc.htm>

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
Black Army Cutworm (IDA)	ICH	mk3 mw3 wk2 wk4	M H MH MH	Forrex 3 Forrex 3 Forrex 3 Forrex 3
Western Hemlock Looper (IDL)	ICH	mw3 wk2 wk4	M H M	Forrex 3 Forrex 3 Forrex 3
Western Spruce Budworm (IDW)	CWH	ds1	MH	Forrex 4
	IDF	dk3	H	Forrex 3
		dk4	M	Forrex 4
		mw2	M	Forrex 3
		ww	H	Forrex 3&4
		xh2	H	Forrex 3
		xm	H	Forrex 3
		xw	MH	Forrex 3
2- year cycle budworm (IDB)	ESSF	wc3	MH	Regional specialist observation
Spruce Weevil (IWS)	ICH	dk	MH	Forrex 2
		mk3	H	Forrex 2
		mw3	H	Forrex 3
		wk2	H	Forrex 2
		wk4	H	Forrex 2
	SBS	dw1	H	Forrex 2
		dw2	M	Forrex 2
		mc1	MH	Forrex 2
		mc2	MH	Forrex 2
		mh	M	Forrex 2
		mw	H	Forrex 2
		wk1	H	Forrex 8
Lodgepole Pine terminal weevil (IWP)	ESSF	xc3	M	Forrex 1
		xv1	M	Forrex 1
	IDF	dk3	H	Forrex 1
		dk4	H	Forrex 1
	MS	xk	M	Forrex 1
	SBPS	xc	M	Forrex 1
Warren's Root Collar Weevil (IWW)	ICH	dw1	M	Forrex 1
		dw2	M	Forrex 1
		dk	M	Forrex 7
		mk3	MH	Forrex 2
		mw3	M	Forrex 7
	SBS	wk2	H	Forrex 7
		wk4	H	Forrex 7
		dk	MH	Forrex 2
		dw1	M	Forrex 2
		dw2	M	Forrex 2
		mc	H	Forrex 7
		mh	M	Forrex 7
		mw	H	Forrex 2
		wk1	H	Forrex 7
Armillaria Root Rot (DRA)	ICH	mk3	H	Root Disease FPC

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
		wk2	H	Guidebook ¹³
	IDF	dk3 mw2	H H	Root Disease FPC Guidebook
	SBPS	mk	H	Root Disease FPC Guidebook
	SBS	dw1	M	Regional specialist observation
Laminated Root Rot (DRL)	CWH	ds1	M	Forrex 5
		ms1	M	Forrex 5
	ICH	mk3	H	Forrex 2
		mw	H	Forrex 6
		wk2	H	Forrex 2
		wk4	MH	Forrex 2
	IDF	dk3 dk4 dw mw ww	M M M H M	Forrex 2 Forrex 2 Regional specialist observation Forrex 6 Forrex 5&6
Tomentosus Root Rot (DRT)	ICH	dk	M	Forrex 2&9
		mk3	M	Forrex 2&9
		mw	M	Forrex 2&9
	SBPS	mk	M	Forrex 9
	SBS	dk	H	Forrex 9
		dw	H	Forrex 9
		mc1	H	Forrex 9
		mc2	H	Forrex 9
		mh	H	Forrex 9
Dwarf Mistletoe (DMP)	IDF	dk3	H	SDM
		dk4	H	SDM
	SBPS	xc	H	Forrex 1
Western Gall Rust (DSG)	ESSF	wk1	M	SDM
	ICH	mk3	MH	Forrex 1
	IDF	xm	H	Forrex 1
		xw	H	Forrex 1
		dk3	M	SDM
		dk4	MH	SDM
		dw	H	Forrex 1
		mw2	H	Forrex 1
	MS	xk	MH	Forrex 1
	SBPS	xv	H	SDM
		xc	MH	SDM
		dc	H	Forrex 1
		mc	H	Forrex 1
		mk	H	Forrex 1

¹³ <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/root/roottoc.htm>

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
	SBS	dw1	H	Forrex 1
		dw2	H	Forrex 1
		mc1	H	Forrex 1
		mc2	H	Forrex 1
		mh	H	Forrex 1
		mm	H	Forrex 1
		mw	H	Forrex 1
		wk1	H	Forrex 1
Comandra Rust (DSC)	ESSF	wk1	L	SDM
	ICH	mk3	H	Forrex 1
		wk	MH	Forrex 1
	MS	xk	MH	Forrex 3
		xv	M	SDM
	SBPS	dc	MH	Forrex 1
		mk	MH	SDM
		xc	M	SDM
	SBS	dw1	M	SDM
		dw2	MH	SDM
		mc2	H	Forrex 1
		mw	MH	Forrex 1
Stalactiform Rust (DSS)	ESSF	wk1	L	SDM
	ICH	mk3	H	Forrex 1
		wk	M	SDM
	MS	Xk	MH	Forrex 3
		xv	M	SDM
	SBPS	dc	M	SDM
		mk	M	SDM
		xc	M	SDM
	SBS	dw1	M	SDM
		dw2	MH	SDM
		mc2	H	Forrex 1
		mw	MH	Forrex 1
Atropellis Canker (DSA)	ESSF	wk1	L	
	SBPS	dc	M	Forrex 2
		mk	MH	Forrex 2
		xc	M	SDM
	SBS	dw1	M	Forrex 2
		mc2	M	Forrex 2
		mw	M	Forrex 2
Lophodermella needle cast (DFL)	IDF	dk3	H	Forrex 1
		dk4	H	Forrex 1
	SBPS	xc	H	Forrex 1
		dc	H	Forrex 1
		mc	H	Forrex 1
		mk	H	Forrex 1

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
	SBS	dw1 dw2 mc1 mc2 mh mm mw wk1	H H H H H H H H	Forrex 1 Forrex 1 Forrex 1 Forrex 1 Forrex 1 Forrex 1 Forrex 1 Forrex 1
Elytroderma Needle Cast (DFE)	IDF	dk3 dk4	H H	Regional specialist observation
	SBPS	mk xc	H (100 Mile TSA) H	Regional specialist observation
Drought Damage	IDF	xm	M	Regional specialist observation
Snow Press	ESSF	wk1	H	SDM
	ICH		H	SDM
	SBS		H	SDM

Table 7: Landscape level hazard by biogeoclimatic subzone for forest health agents within the Cariboo Region. Pest codes can be found in the Field Guide to Forest Damage in British Columbia¹⁴

BEC zone	BEC subzone	High	Moderately High	Moderate
CWH	ds1		IDW	DRL
	ms1			DRL
ESSF	dc3			
	mv1			
	wc3	IBB, IBS, IDB		
	wk1	IBB, IBS, NY		DSG
	xc3			IWP, DMP
	xv1	IBB, IBM, IBS		IWP
	xv2	IBB, IBM, IBS		
ICH	dk		IWS	DRT
	mk3	IBB, IBD, IBS, IDA, IWS, DRA, DRL, DSC, DSS, NY	IWW, DSG	DRT
	mw3	IDA, IWS, DRL, DRR		IDL, DRB, DRT, IWW
	wk2	IDL, IWS, IWW, DRA, DRL, IWW, NY	IDA,	DSC, DSS
	wk4	IBB, IBS, IWW, DMP, DRL	IDL	DSC, DSS
IDF	dk3	IBD, IDW, IWP, DFL, DFE, DMP, DRA,		DRL, DSG
	dk4	IBD, IWP, DFL, DFE, DMP	DSG	IDW

¹⁴ <http://www.for.gov.bc.ca/hfp/publications/00198/>

BEC zone	BEC subzone	High	Moderately High	Moderate
	dw	IBD,, DSG		DRA, DRL
	mw2	DRL, DSG	IDW	DRA
	ww	IBD, IDW		DRL
	xh2	IDW		
	xm	IBD, IDW, DSG		
	xw	DSG	IDW	
MH	mm2			
MS	dc2	IBB, IBM, DMP	DSC, DSG	
	dv	IBM, DMP		
	xk2	DSG	DSC, DSG	IWP
	xk3	IBM, DMP	DSC, DSG	IWP
	xv	IBM, DSG		DSC,DSS
SBPS	xc	IBM,IBS, DFL, DFE, DMP, DSG		DSA, DSC, DSS, IWP
	dc	IBM,IBS, DFL, DSG	DSC	DSA, DSS
	mc	IBM,IBS, DFL, DSG		IWW
	mk	IBM,IBS, DFE, DFL, DRA, DSG	DSA,DSC	DRT, DSS
SBS	dk	DRT	IWW	
	dw1	IBM,IBS, IWS, DFL, DMP, DRT, DSG,, NY		IWP, IWW, DRA, DSA, DSC, DSS
	dw2	IBM, IBS, DFL, DMP, DRT, DSG, NY	DSC, DSS	IWP, IWS, IWW
	mc2	DFL, DRT, DSG, IWW	IWS	DSA
	mc3	IBM,IBS, DMP, DRT, IWW		
	mh	IBM,IBS, IWS, DFL, DMP, DRT, DSG		IWS, IWW
	mm	DFL, DRT, DSG		IWW
	mw	IBM,IBS, IWW, DFL, DRT, DSG	DSC, DSS	DSA
	wk1	IBM,IBS, IWS, DFL, DRT, DSG		IWW

SDM Pest Incidence by BEC

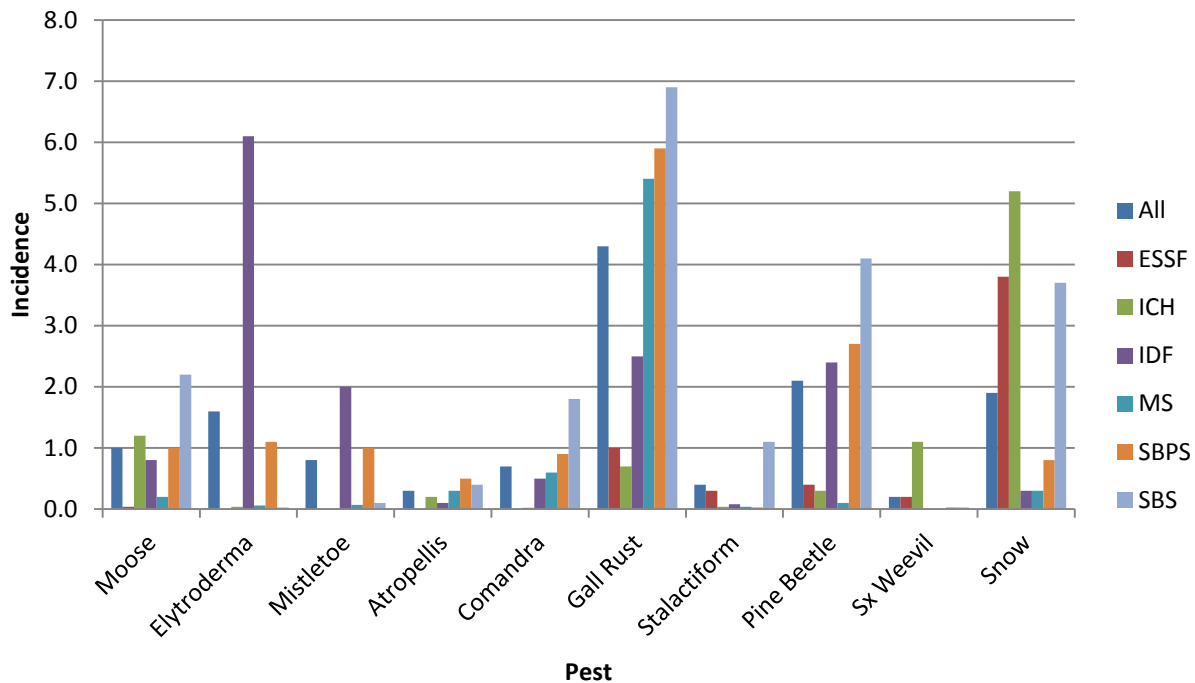


Figure 1. Major forest health factors in the Cariboo Region by BEC zone based on stand development monitoring surveys conducted between 2009 and 2013.

Table 8: Mean incidence of forest health factors by BEC zone/subzone based on SDM surveys conducted between 2009 and 2013. The top three forest health factors by BEC are highlighted.

BEC	Sample size	Average Incidence by forest health factor (as percentage)										
		AM	DFE	DMP	DSA	DSC	DSG	DSS	IBM	IWS	NY	All
ESSFwk1	11	0.0	0	0	0	0	1.0	0.3	0.4	0.2	3.8	7.4
ICH	23	1.2	0.0	0	0.2	0.0	0.7	0.0	0.3	1.1	5.2	11.3
IDFdk3	15	1.4	6.4	1.5	0.0	0.3	2.0	0.0	3.9	0	0.5	15.6
IDFdk4	15	0.2	5.8	2.5	0.1	0.7	3.0	0.0	0.9	0	0.0	14.8
MSxv	13	0.2	0.0	0.0	0.3	0.3	5.4	0.4	0	0	0.3	10.0
SBPSdc	7	1.3	0.5	0.2	1.1	1.6	8.0	0.2	2.0	0	0.4	16.4
SBPSmk	19	2.2	0.5	0.6	0.8	1.6	8.4	0.5	7.0	0.0	1.9	19.4
SBPSxc	29	0.0	1.6	1.4	0.2	0.3	3.8	0.2	0.1	0.0	0.1	10.2
SBSdw	17	1.4	0.0	0.2	0.2	0.8	6.4	1.3	5.8	2.9	1.2	17.0
SBSmc/mw	7	4.1	0	0	0.8	4.1	8.2	0.7	0	0	5.4	25.3
All	156	1.0	1.6	0.8	0.3	0.7	4.3	0.4	2.1	0.2	1.9	13.9

AM=Moose, DFE=Elytroderma Needle Cast, DMP = lodgepole pine dwarf mistletoe, DSA=Atropellis Canker, DSC=Comandra blister rust, DSG=western gall rust, DSS=stalactiform blister rust, IBM=mountain pine beetle, IWS=spruce weevil, NY=snow press

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Appendix 3

Minimizing forest health impacts resulting from climate change

Climate change and forest health, are the most significant challenges facing British Columbia's Forest Industry. There is a growing body of evidence that global climate change has contributed to an increase in the incidence and severity of a number of forest health agents (Woods et al. 2010). The recent mountain pine beetle epidemic, the sustained and severe western spruce budworm outbreak, and northern range expansion of *Dothiostroma* needle blight in northwestern BC are good examples of this. The BC Ministry of Forests, Lands and Natural Resource Operations has committed to adapting to climate change through its Climate Change Adaptation Strategy¹⁵ and Forest Stewardship Action Plan for Climate Change Adaptation¹⁶.

A familiar concept in forest health is the model of the pest triangle. Host, pest, and environment make up the three corners of the triangle: a change in anyone of these three components can affect the balance between host and pest. Forest health agents have evolved in close association with their hosts across a range of environments. The geographic distribution of trees and the diseases and insects that depend on them are generally limited to some extent by climate and some pests depend on seasonal changes in climate to trigger different stages of their lifecycles. Sudden changes in climate can have a profound impact on the balance between host and pest. In northern climates, where cold temperature limits the range of insect and disease organisms, this is especially the case. Changes in temperature and precipitation can extend the range of insects and diseases into new habitats and influence natural predators and parasite interactions. The reverse is also true; changes in climate can reduce the suitability of certain habitats for some insects and diseases. Climate change may also facilitate the establishment of exotic pests, particularly those originating from warmer climates.

The biggest impact of climate change from a forest health perspective is the uncertainty it creates about the risks posed by various forest pests. There will likely be more insect and disease outbreaks as climate changes. Unfortunately, it is very difficult to predict how global climate change will effect local precipitation and temperature and what effect this will have on host/pest interactions. In many cases, there are considerable knowledge gaps on how current climate impacts host/pest interactions. Although it is very difficult to make predictions there are a number of steps that can be taken to reduce the likelihood of catastrophic pest outbreaks. These can include things as simple as planting a diversity of tree species over a range of different stand conditions, careful monitoring of changes in forest pests and conditions over time, the careful use of facilitated migration to aid in the migration of species or tree provenances as climate changes, and strict controls to limit the movement and accidental introduction of exotic pests.

References:

Woods, A.J. et al. 2010. Forest health and climate change: A British Columbia perspective. *Forestry Chronicle* 86(4): 412-417.

¹⁵ http://www.livesmartbc.ca/attachments/Adaptation_Strategy.pdf

¹⁶ http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/MFLNR_CCAadaptation_Action_Plan_2012_final.pdf.

Appendix 4

Impact of Forest Health Factors on Timber Supply

Forest health factors are generally accounted for in Timber Supply Review (TSR). 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. 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. A third method of accounting for pests is through non-recoverable (or unsalvaged) losses (NRLs).

Within OAFs there are two categories: 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.

NRLs 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 timber harvesting land-base (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 Model¹⁷. NRLs used in the latest TSRs in the Cariboo Region (Table 9), and NRLs as a percentage of the TSA AAC as of January 2013 (Table 10) illustrate how various damage agents are accounted for. Five-year average losses based on annual overview survey from 2007-2011 indicate the landscape level impact, in areas including and outside of the THLB (Table 11). The numbers indicate that there is a large amount of variation in the different TSAs. It is important to note that these differences are partly a result of when the TSRs occurred and how the losses were calculated in different TSAs. Starting in 2014, NRLs will be calculated provincially, which should add some consistency and allow for better comparisons across TSAs.

Table 9: Non-recoverable (unsalvaged) losses used in most recent timber supply reviews

Species	Cause	NRLs by TSA (m ³ /year)		
		Quesnel (2009)	100 Mile (2012)	Williams Lake (2012)
All	Fire	8,000	53,892	35,480
All	Windthrow	10,000	4,540	8,684
Fdi	Douglas-fir Beetle		14,474	18,846
Fdi	Spruce Budworm		14,770	55,542
Sx	Spruce Beetle		10,537	31,000
All	All insects	30,000		
Salvaged losses not accounted for in estimates			(15,000)	
Total		48,000	83,213	149,553

¹⁷ <http://www.for.gov.bc.ca/hre/bcmapb/>

Table 10: Non-recoverable (unsalvaged) losses as a percentage of AAC on Jan 2013

Species	Cause	NRLs as a % of AAC		
		Quesnel (4,000,000 m ³ /yr)	100 Mile (2,000,000 m ³ /yr)	Williams Lake (5,770,000 m ³ /yr)
All	Fire	0.2	2.7	0.6
All	Windthrow	0.25	0.2	0.2
Fdi	Douglas-fir Beetle		0.7	0.3
Fdi	Spruce Budworm		0.7	0.9
Sx	Spruce Beetle		0.5	0.5
All	All insects	0.75		
Salvaged losses not accounted for in estimates		-	(.7)	-
Total		1.2	4.1	2.6

Table 11: Mean hectares affected from the Aerial Overview Survey 2008-2013.

Forest District & Damaging Agent	Area (ha)					
	Trace	Light	Moderate	Severe	Very Severe	Total
<i>Douglas-fir Beetle</i>						
100 Mile House	3,817	1,729	337	48		5,844
Quesnel	236	772	171	64		1,144
Williams Lake	6,075	3,653	583	129		10,214
<i>Spruce Budworm</i>						
100 Mile House	-	56,414	3,514	104	-	59,949
Quesnel	-	5,478	2,025		-	6,288
Williams Lake	-	99,401	14,160	1,920	-	114,521
<i>Spruce Bark Beetle</i>						
100 Mile House	462	2,034	1,947	960	66	5,032
Quesnel	54	274				328
Williams Lake	1,946	3,201	2,321	1,286	62	6,652

Bark beetles severity is the % of trees recently killed: T<1%, L=1-10%, M=11-29%, S=30-49%, and VS>50%. Spruce budworm impacts: T=NA, L=barely visible from air, M=Top third of many trees severely defoliated, S=completely defoliated tops and most tree >50% defoliation, and VS=NA.

Mountain Pine Beetle Impact in Young Stands

The approach taken for assessing the impact of mountain pine beetle (MPB) in young stands varies within the Cariboo Region. In the 100 Mile TSA the OAF1 was increased from the default value of 15% to 35% to account for reduced site occupancy in mountain pine beetle impacted stands. MacIaughlan (2008) examined the impacts of mountain mine beetle in young stands and summarized the percentage of impacted stands and average mortality in impacted stands by age class. The percent of impacted stands was multiplied by the average percentage of attack (rounded to the nearest 5%) to estimate percent volume loss due to MPB (Table 12). Some of the negative impact to volume may be offset by natural ingress. Since 2007, the provincial aerial overview survey has mapped visible young pine damage attributed to MPB, which will provide Forest for Tomorrow key landscape-level information for

investment decisions by identifying heavily impacted stands. Recent stand development monitoring data suggests that the impacts of mountain pine beetle in young lodgepole pine stands less than forty years of age may be considerably overestimated in table 12.

Table 12: Impact of mountain pine beetle in young stands in the Cariboo Region (modified from Maclauchlan 2008)

TSA & Stand Age	Stands impacted (%)	Average attack (reds & greys, %)	Volume loss (%)
<i>100 Mile House</i>			
20-25	88	32	30
26-30	100	45	45
31-40	100	51	50
41-50	100	53	55
51-55	100	48	50
<i>Central Cariboo</i>			
20-25	88	25	20
26-30	96	38	35
31-40	100	40	40
41-50	100	42	40
51-55	100	38	40
<i>Quesnel</i>			
20-25	82	25	20
26-30	98	43	40
31-40	97	47	45
41-50	87	34	30
51-55	100	30	30

References:

Maclauchlan, L.E. 2008. Determining susceptibility of young pine stands to the mountain pine beetle, *Dendroctonus ponderosae*, and manipulating future stands to mitigate losses.

Appendix 5

Forest Health Research Needs – Entomology

There are a number of applied research topics in forest entomology that require consideration in the coming years, especially in the areas of disturbance interactions and climate change. The interactions between 2-year cycle budworm and balsam bark beetle, western spruce budworm and Douglas-fir beetle, and the population dynamics of various important insects and changing climate all represent knowledge gaps that hinder our ability to adaptively manage forest and biodiversity values. Below is a brief list of operationally focused research that is ongoing or will be initiated in the coming years and that the Forest Entomologist has the capacity to undertake.

Douglas-fir beetle impact assessment

Overwinter mortality and detailed GPS-surveys of the Douglas-fir bark beetle indicate that their population is increasing in the Cariboo region, especially in dry-belt fir stands. While trap tree, fall and burn, and MCH deployment strategies are considered operationally effective there is no science-based information that quantifies the efficacy of these treatments. Research is needed to quantify non-recoverable losses from Douglas-fir beetle; efficacy of operational treatments on Douglas-fir bark beetle populations and subsequent impact. Research on this topic can provide information on the benefit of Douglas-fir bark beetle management, and can assist Districts prioritizing treatments and forest health funding.

The role of silviculture to mitigate western spruce budworm impacts in the Cariboo

Research to evaluate the impacts of western spruce budworm in existing research trails in the Cariboo region to determine how particular treatments affect defoliation levels, growth and larval density. This study would utilize three existing research installations, located in dry-belt Douglas-fir forests in the Williams Lake TSA (2) and 100 Mile House TSA (1). Research trials were established 10 to 20-years ago and each have a variety of treatments, such as: clumpy spacing, various inter-tree distance spacing, logging and thinning, and controls. Monitoring work will focus on quantifying western spruce budworm population densities and defoliation levels annually in treatments and controls at each research installation. This study will contribute important information on how silviculture can influence western spruce budworm damage, addressing issues of forest susceptibility and stand resilience to chronic budworm pressure.

2-year cycle budworm: a changing regime in a changing climate?

Two-year cycle budworm is a damaging insect in the wet belt fir and spruce forests in the eastern region of the Quesnel TSA. Traditionally this insect, which has a 2-year life cycle, incurs the most damage in even-years (e.g., 2010, 2014, 2014). In 2013, the provincial aerial overview survey mapped the largest amount of 2-year cycle defoliation ever recorded in a single year in the Cariboo region, despite it being an “off” year for the insect. Mid-term timber supply assumptions and future needs predicate the need to quantify impacts of this pest on volume loss and understory mortality in balsam and spruce, especially as balsam in this area is a preferred species for future harvest. This research would establish a number of PSPs to measure height, dbh, radial increment growth, defoliation levels and larval density of 2-year cycle budworm in the eastern portion of the Quesnel TSA. This would provide knowledge on impacts of 2-year cycle feeding on balsam and spruce and help determine what level of larval density results in worst damage to the host. From this a rationale can be developed about when to consider

aerial treatment with Btk and how efficacious treatment is in terms of foliage protection and reducing tree mortality.

Forest Health Research Needs – Pathology

Elytroderma Needle Cast

Elytroderma needle cast can cause severe stunting in lodgepole pine plantations in the southern portion of the Cariboo Region. Little is known about the impacts of this disease on timber supply or how to best mitigate future growth impacts. Trials are planned to determine whether underplanting with Douglas-fir is a treatment option on some severely impacted sites. This could become a disease of increasing importance in the 100 Mile House TSA if Douglas-fir leading stands are converted to lodgepole pine plantations. Anecdotal evidence from site prep trials suggest that there may be variation in resistance to Elytroderma needle cast among different lodgepole pine families with families from wetter ecosystems demonstrating more resistance to Elytroderma than those from drier ecosystems. Plans are in the work to apply for funding to conduct progeny testing in areas severely impacted by Elytroderma needle cast. There is also variation in disease progression over time throughout the Cariboo Region. In some areas, the majority of trees appear to recover from the impacts of Elytroderma as they get older while in other areas stunting persists. Further work is needed to understand how stand age and other factors such as site productivity influence the progression of disease over time.

Pine Stem Rusts

Currently research is under way to examine how site factors influence stem rust incidence and whether these factors are useful for predicting future rust hazard. There is a growing body of evidence that indicates that comandra rust incidence is highly correlated with the presence of its alternate host bastard toad flax. Further work is needed to see if sicultural techniques can be used to reduce the abundance of the alternate host. In addition, there are currently seven permanent sample plots in the region in 20 year old young pine plantations. These sample plots were set up to monitor the impacts of stem rusts over time.

Lodgepole pine dwarf mistletoe

Research is currently being planned to look at the growth impacts of lodgepole pine dwarf mistletoe using different sanitation treatments and what effect retaining natural regeneration in the South Chilcotin Planning Area may have on future timber supply. Recent surveys have indicated that dwarf mistletoe may become more severe in the SBPSxc post mountain pine beetle.

Root Disease

The Cariboo Region represents the northern limit for both Armillaria and Laminated root disease. Better information regarding the distribution and impacts of these root diseases in the Cariboo Region are needed. A project in the old Robson Valley District that attempted to map the distribution of Armillaria root disease in young plantations showed promising results that may be applicable in the Cariboo as well. A number of experimental Armillaria root disease management options have been tested in the Cariboo. Further work is needed to evaluate the long term effectiveness of these treatments.

Facilitated migration

Permanent sample plots are needed to monitor the long term health of species currently being planted outside of their historical ranges. In the Cariboo these species include western larch, western white pine, and ponderosa pine.

Appendix 6

Cariboo Region Priority Pest Profiles

This appendix provides a brief description of the significant pests in the Cariboo region and their management. It is not meant to replace other sources of pest information but rather highlight local information that may not be readily available elsewhere and provide references for further more detailed investigation. Each insect or disease common name is followed by the Field Guide to Forest Damage in British Columbia.

Insects

a) Bark Beetles

Mountain Pine Beetle (IBM)

Dendroctonus ponderosae (Hopk.)

The mountain pine beetle outbreak has run its course throughout most of the Cariboo but small populations persist, particularly in higher elevations sites in the south Chilcotin. Licensees continue to salvage mountain pine beetle killed trees. Salvage operations should be consistent with guidance provided by the Chief Forester¹⁸, recommendations pertaining to watershed planning¹⁹, and the beetle action plan²⁰. High priority stands for salvage are low volume stands, stands with low amounts of natural regeneration, and stands in areas with short shelf lives (i.e. wetter areas).

Douglas-fir Beetle (IBD)

Dendroctonus pseudotsugae (Hopk.)

Douglas-fir beetle has been an ongoing problem in the Cariboo and at the peak of the last outbreak (2008/2009), nearly 70,000 hectares were affected by Douglas-fir beetle. The highest risk stands are Douglas-fir leading stands in the IDF with an average dbh of more than 45 cm, south facing, steep aspect, and densities between 650 and 1200 stems/ha (Ministry of Forests, 1995). Douglas-fir bark beetle management consists of detailed helicopter surveys and ground surveys and follows up with treatments where necessary. Treatments include sanitation harvesting, trap trees, anti-aggregation pheromones, and fall and burn. Treatment options are determined based on beetle management units (BMU) established by district stewardship staff. Districts assign strategies of suppression, holding, salvage, or monitor based on a number of different factors such as beetle levels, harvest level, salvage capacity, access, harvesting constraints, and available resources. In BMUs that are in suppression status, every effort is made to try and actively control beetle populations by treating 70-80% of the infestations identified in the aerial overview survey.

Bark beetle sanitation harvesting in mule deer winter range is subject to the conditions laid out in the government action regulations (GAR) pertaining to ungulate winter range (#U-5-001, 002, and 003)²¹. Guidelines for bark beetle sanitation harvesting in old growth management areas can be found in the

¹⁸ http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/Chief_Forester_Hydrology_200703.pdf

¹⁹ http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/

²⁰ http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/

²¹ http://www.env.gov.bc.ca/wld/documents/wha/Amendment_ShallowModerate_Feb07_Ord.pdf

Cariboo Chilcotin Land Use Plan, Regional Biodiversity Conservation Strategy Update Note # 7b²². These guidelines specify the commitments that must be made before going into OGMAs, the minimum infestation size required, the requirement for nearby non-OGMA stands at risk, windthrow treatment requirements, sanitation practices (including volume of access wood that can be removed), and monitoring and reporting requirements.

Effective beetle management requires careful coordination among all licensees in order to meet suppression treatment targets. One way of accomplishing this is through timber supply area (TSA) forest health committees.

Post Fire Management of Douglas-fir Beetle

In the last couple of years, there have been severe outbreaks of Douglas-fir beetle associated with fires. Some Douglas-fir stands with low and moderate severity fire damage are being severely impacted by Douglas-fir beetle, particularly in areas with a history of Douglas-fir beetle and a large number of large diameter fire killed trees. The creation of brood trees through fire guard building activities further exacerbates the problem if these trees are not dealt with prior to beetle emergence. Larger diameter fire killed trees that escaped crown fires, provide ideal habitat for Douglas-fir beetle up to one year following a fire. Trees damaged by fires occurring in the spring are usually attacked in the same year. In subsequent years, the beetles attack fire weakened trees and in some cases when beetle populations become large enough, damage extends into Douglas-fir stands adjacent to the fires. Where feasible and appropriate, aggressive management for Douglas-fir beetle through the use of trap trees, fire salvage, fire guard salvage, and anti aggregation pheromones is critical. Funnel traps may be effective if used in the first year following a fire, provided steps are taken to minimize spillover by using the traps in severely burned or non leading Douglas-fir areas and/or in suitably large opening at least 100m from susceptible Fd. In a recent trial, funnel traps proved ineffective in protecting adjacent Fd when used in the second year following a fire despite high beetle catches. The impact of sanitation/salvage activities on Douglas-fir regeneration, soil stability, wildlife, and other values must be carefully considered before deciding on a treatment strategy. Two years following a fire it becomes difficult and in some cases nearly impossible to try and control Douglas-fir beetle due to the huge increase in beetle numbers. Beetle infestations associated with small fires are much easier to treat than infestations linked to large fires and should be given priority for early treatment.

References:

Ministry of Forests. 1995. Bark Beetle Management. Forest Practices Code Guidebook

Spruce Beetle (IBS)

Dendroctonus rufipennis (Kirby)

As the name suggests, spruce bark beetle attacks all mature spruce species in B.C. The beetle usually takes two years to complete its lifecycle. Spruce bark beetle management can be very difficult for a number of reasons: 1) spruce beetle is very difficult to detect from the air and the ability to detect infested trees can vary considerably based on the year and the timing of the survey, 2) Spruce beetle often occurs in riparian leave strips and flood plains or steep slopes where sanitation harvesting is difficult, 3) spruce beetle occurs in high snowfall areas where winter access can be costly and difficult, and, 4) some areas of high spruce beetle activity occur in areas where harvesting is constrained for

²² http://archive.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/plan/biodiv/biodiv_update7b_dec_11_2006.pdf

management of specific resource values (eg. Cariboo protected areas and old growth management areas). The main method of dealing with spruce beetle in the Cariboo has been sanitation harvesting. Cutblocks should be planned in areas of high spruce beetle activity. One method of ranking stands for sanitation/salvage harvesting is the sanitation harvest index²³. Spruce beetle can be contained within a planned cut block until harvest through the use of baiting or trap trees.

Western Balsam Bark Beetle (IBB) *Dryocetes confusus* (Swaine)

The area infested by western balsam bark beetle in the Cariboo Region, as reported in the annual aerial overview survey are shown in Fig 1. The area of infestation over the last 5 years is down from previous years (especially in the Quesnel District). Most of this area had trace mortality (less than 1% of trees recently killed). Western balsam bark beetle has a 2-year life cycle. No efforts have been made to actively manage for balsam bark beetle in the Cariboo Region. In past timber supply review (TSR) analyses in the Cariboo, western balsam bark beetle mortality has not been accounted for through unsalvaged losses and a study conducted in the Skeena region determined that chronic damage by this beetle are adequately accounted for by Forest Analysis and Inventory Branch's VDYP yield model that is used to estimate mature stand volume over time.

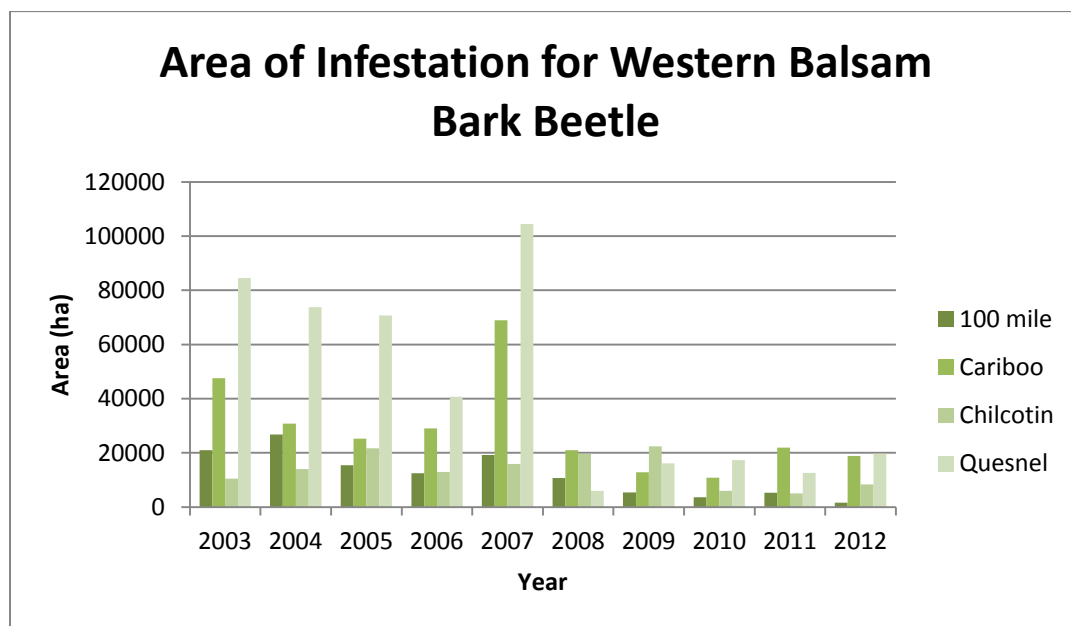


Figure 2. Area of infestation for western balsam bark beetle by forest district based on aerial overview survey data

²³ <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/guidetoc.htm>

b) Defoliators

Western Spruce Budworm (IDW)

Choristoneura occidentalis (Freeman)

Defoliation caused by western spruce budworm impacts Douglas-fir stands. These Douglas-fir stands have become critical for maintaining mid-term timber supply following the mountain pine beetle epidemic. Historically, western spruce budworm outbreaks were confined to the 100 Mile District, but over the last 10 years outbreaks have become common in the Cariboo, extending into the southern part of the Quesnel District and as far west as Puntzi Lake in the Chilcotin. There is a good chance that we will see western spruce budworm outbreaks becoming more common in the Quesnel TSA in the future as global warming continues. During budworm outbreaks mortality is common in understory trees and can result in uneven aged stands becoming under stocked. Mortality is less common in mature trees, but outbreaks can cause top kill and growth losses. Impacted trees may be more susceptible to attack from Douglas-fir beetle.

Maclauchlan and Brooks (2009) found that study sites in the IDF had the maximum consecutive years of defoliation from western spruce budworm. They also concluded that thinning or harvesting to remove dense understory regeneration could lead to less susceptible forests. Unfortunately, thinning treatments are very expensive and don't bring short term returns on investment. There is also the added risk that while thinned stands may be less susceptible in the long term they may also be less resilient in the short term because of the lower stem density. Treatments to reduce the risk of spruce budworm attack are most effective in mixed stands where the percentage of susceptible species (Douglas-fir) can be reduced through selective harvesting or thinning. Much of the IDF ecosystem is Douglas-fir dominated and species conversion is not an option.

The treatment strategy in the Cariboo is to treat stands predicted for moderate to severe defoliation with the biological control agent *Bacillus thuringiensis* Variety *Kurstaki* (Btk). These activities are carried out in accordance with the Southern Interior Region Pest Management Plan for the Forest Health Program. Treatment with Btk is relatively inexpensive (~\$30/ha). Studies in the IDFdk1, have shown that if harvesting occurs within 15 years of spraying for western spruce budworm the return on investment is greater than 15%. Further return on investment studies are needed for other subzones in the IDF. In the Cariboo Region over a 12 year period (1997 to 2008), 84% of the areas sprayed only required a single spray treatment to control western spruce budworm populations. Between 2002 and 2012, egg mass counts in the fall after spraying with Btk were 71% lower on average than in the fall prior to spraying.

References:

Maclauchlan, L. E. and J. E. Brooks. 2009. Influence of past forestry practices on western spruce budworm defoliation and associated impacts in southern British Columbia. BC Journal of Ecosystems and Management 10(2):37-49

Two Year Cycle Budworm (IDB)

Choristoneura biennis (Freeman)

The two year cycle budworm looks very similar to the western spruce budworm but takes two years to complete its lifecycle and higher elevation spruce and true fir stands are at greatest risk. Most of the damage occurs in the second year of the lifecycle and in the Cariboo Region prior to 2013 most of the damage occurred in *even* years. There was over 71,500 ha of light and moderate defoliation in 2013 (mostly in the Quesnel TSA) up from 40,000 ha of light and moderate defoliation in 2012. A trial was

undertaken in the Mt. Tom area (near Barkerville) in 2012 to assess the effectiveness of a single treatment of Btk in controlling two year cycle budworm. Preliminary results indicate that the treatment was effective in reducing the amount of defoliation. Further work is needed to provide a business case to support treatments.

Western Hemlock Looper (IDL)
Lambdina fiscellaria lugubrosa (Hulst)

Hemlock looper outbreaks can cause severe defoliation and mortality in the ICH. In the Cariboo Region outbreaks have been mainly limited to the area around Quesnel Lake and Horsefly Lake, with smaller infestations occurring along the Cariboo River drainage, McKusky Creek, McKinley Creek, and Deception Creek (Fig. 2). In the Chilcotin, outbreaks have also been recorded along the Homathko River in the Coastal Western Hemlock zone (CWHds1). Outbreaks generally occur every 10 years and last 2 to 3 years. The latest outbreaks occurred in 2011 and 2012 around Quesnel Lake (around 5500 ha of light and moderate defoliation in 2011 and again in 2012). During the early 1990's there were 4,000 ha of severe defoliation with up to 80% mortality. Hemlock Looper overwinters as eggs laid on lichen and moss. Areas of severe defoliation can be predicted in advance through the use of pheromone traps and egg sampling. Btk can be used to treat areas that are predicted to have moderate to severe defoliation.

Douglas-fir Tussock Moth (IDT)
Orgyia pseudotsugata (McD.)

Douglas-fir tussock moth has never caused severe defoliation in the Cariboo Region but outbreaks of Douglas-fir Tussock Moth have occurred just south of the 100 Mile District Boundary over the last couple of years. For the last 18 years, the Cariboo Region has carried out a monitoring program in the 100 Mile District to monitor the levels of Douglas-fir tussock moth at established sites using pheromone traps. With anticipated changes in climate, it is likely, that Douglas-fir tussock moth outbreaks will become common in the Cariboo Region in the future. Douglas-fir tussock moth causes severe defoliation and mortality in Douglas-fir stands in the Kamloops Region. Outbreaks often begin near areas of open range. Exposure to the caterpillars can cause an allergic reaction known as tussockosis²⁴.

²⁴ <http://www.for.gov.bc.ca/rsi/foresthealth/PDF/DFTM%20tussockosis.pdf>

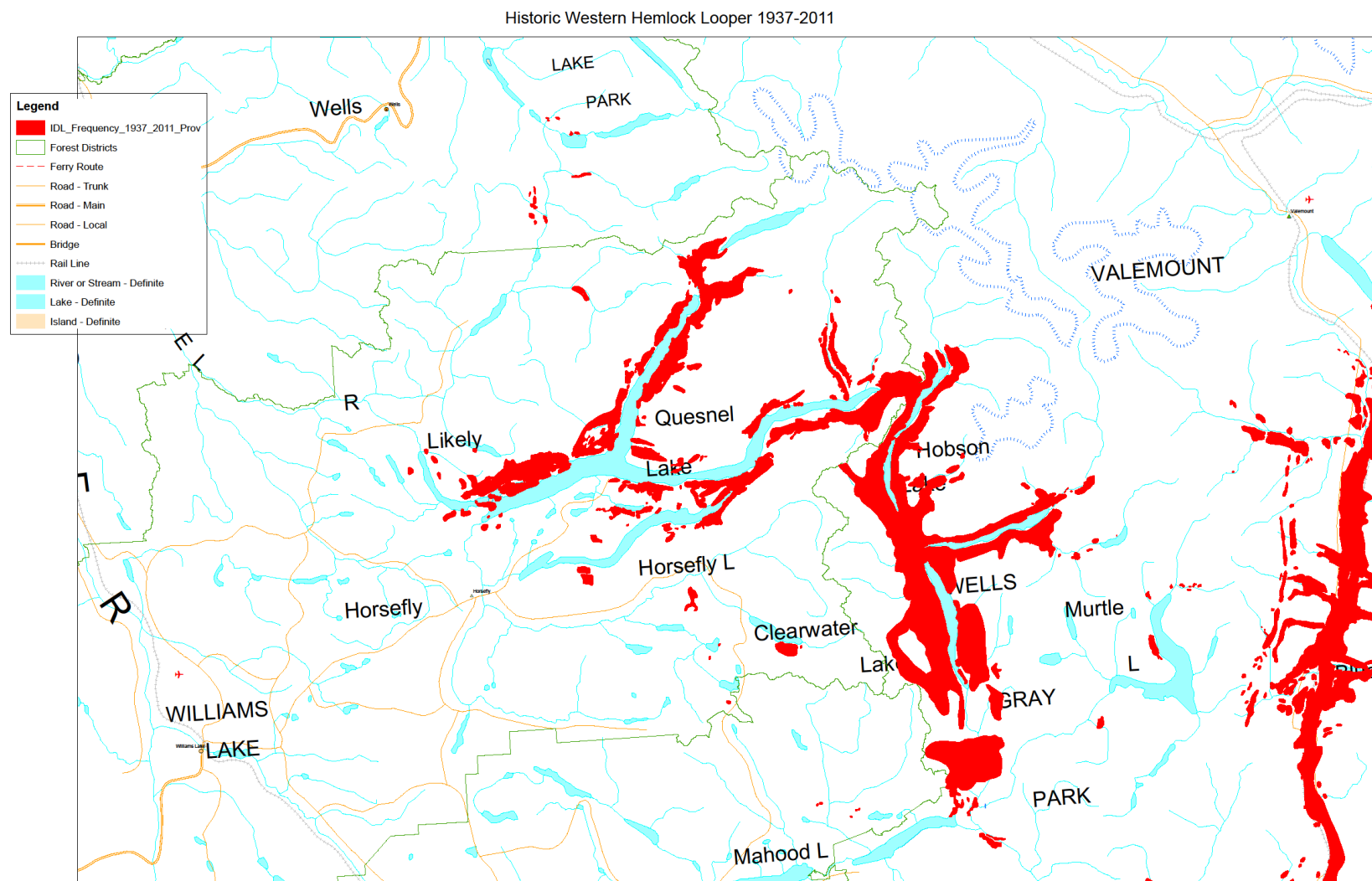


Figure 3. Historic occurrence of Western Hemlock Looper in the eastern Cariboo

Forest Tent Caterpillar (IDF)
Mallacosoma disstria Hbn.

Forest tent caterpillar outbreaks are fairly common in the Cariboo Forest Region. In the Quesnel TSA, there were approximately 35,000 ha and 40,000 ha detected in 2010 and 2011, respectively. In 2013 this dropped to 17,500 ha. Affected trees generally produce a second crop of leaves. Mortality is rare but dead tops and branches as well as growth reduction may occur especially when trees are also impacted by other forest health factors such as Venturia twig blight and Serpentine leaf miner. Forest tent caterpillar outbreaks near population centers often cause serious public concern and the smeared remains of caterpillars on roads and rails can occasionally make travel dangerous.

References:

Wood C.S. 1992. Forest Tent Caterpillar. Forest Pest Leaflet 17 Forestry Canada. Pacific Forestry Centre. 4pp.

Black Army Cutworm (IDA)
Actebia fennica (Tausch.)

Black army cutworm is commonly associated with fires or prescribed burns. Spruce and lodgepole pine seedlings are most commonly attacked but seedlings of all trees species are susceptible. There has been a decline in the number of outbreaks over the last several years as prescribed burning is less commonly used. In 2012, there were outbreaks of black army cutworm associated with the 2010 Pelican fire in the Quesnel TSA. The following recommendations were taken from a standard operating procedure developed in the Kootenay Region. Table 5 outlines the hazard of black army cutworm defoliation based on the number of years and time of year when the fire occurred.

Table 13: Potential for black army cut worm defoliation

Timing of fire	Years after fire			
	1	2	3	4
Spring/early summer	High	High	Low	Low
Mid summer	Low	High	Mod	Low
Late summer/fall	Low	High	Mod	Low

Black army cutworm defoliation prevents root initiation in newly planted seedlings and drought stress is believed to be the major cause of mortality after defoliation occurs. For this reason, south facing slopes with coarse soils are at a higher risk for mortality associated with black army cutworm. Seedlings that have already had a year to develop roots in the field recover much better from defoliation than newly planted seedlings. If planting is scheduled in burned areas during periods of high potential for black army cutworm defoliation, a monitoring program should be carried out.

There are commercially available traps and lures available to monitor black army cutworm populations. Traps should be put out (2-10 evenly spaced traps depending on the size of the area being planted) no later than mid-July and picked up at the end of October. Between 2-10 traps/site are recommended depending on the size of the area to be planted. Trap catches of 10 or more moths indicate areas where black army defoliation could be a problem. Pre-planting inspections should be made prior to carrying out planting. If any defoliation is noted on pioneer herbaceous vegetation, such areas should be mapped out and no planting should occur there until pupation occurs. Planting should also be delayed on south- or west-facing slopes above infestations as larvae often migrate uphill in search of new vegetation.

Larval sampling can also be carried out but it is time consuming and may not be necessary in areas with adequate herbaceous vegetation.

References:

Ross, D.A. & S. Ilnytsky. 1977. The Black Army Cutworm in British Columbia. Pacific Forest Research Centre. Canadian Forestry Service BC-X-154.

Sheperd, R.F., T.G. Gray, & T.F. Maher 1992. Management of black army cutworm. Forestry Canada. Pacific and Yukon Region Information Report BC-X-335

Aspen Serpentine Leaf Miner (ID6)
Phyllocnistis populiella Chambers

Aspen serpentine leaf miner outbreaks have become more and more common in the Cariboo and throughout western North America. Repeated outbreaks likely have an impact on the growth and vigour of aspen in the Cariboo Region, particularly in the drier western portions of the region. The tiny moth overwinters under bark scales. The female moth lays her eggs singly and folds over the leaf edge to protect them. The larvae feed inside the outer layers of the leaf in a serpentine pattern, giving the leaves a silvery appearance and can have a profound impact on the photosynthetic capacity of affected trees. Actual impacts to aspen productivity need to be quantified to determine the importance of the pest in the Cariboo Region.

c) Weevils

Lodgepole pine terminal weevil (IWP)
Pissodes terminallis Hopping

Incidences as high as 40% have been reported in the Cariboo Region (Duncan, 1986). Terminal weevils are likely one of the main causes of forking in lodgepole pine in the Cariboo. Attacks are most common in stands 10-25 years old (Swift et al. 2002) or 1-2m in height (but can occur even earlier). The adult weevil lays her egg in the terminal leader and once the eggs hatch the larvae feed upwards in a spiral fashion. Most larvae overwinter but some may develop into pupae and adults before winter starts. Usually only one or two larvae per tree survive to maturity. Spaced stands younger than 15 years often show an increase in the level of terminal weevil following spacing. Maintain higher stands densities (2500 stems/ha) or avoid spacing altogether when the incidence of terminal weevil is more than 10%.

References:

Duncan, R.W. 1986. Terminal and Root Collar Weevils of Lodgepole Pine in British Columbia. Forest Pest Leaflet 73. Canadian Forestry Service. Government of Canada.

Swift, K., J. Turner, and L. Rankin. 2002. Cariboo Forest Region: Part 1 of 3 Forest Health Stands Establishment Decision Aids. J. Eco. Man. 2(1)

White pine weevil (on spruce) (IWS)
Pissodes strobi Peck

The BECs with the highest hazard for spruce weevil are some of the most productive spruce growing areas in the Cariboo Region. A map showing spruce weevil incidence in the Quesnel District and the old

Horsefly District (as reported in RESULTS) can be found on the provincial forest health ftp site²⁵. This map reflects the free growing rules which only record impacted trees for which the leader has been killed 3 times in the last 5 years, the leader is displaced by more than 30 cm and is above stump height, or there are two leaders above stump height with no dominance expressed in the last 5 years. Hodgkinson et al. (2011) recommend planting genetically resistant seedlings, species mixes, higher densities, retaining deciduous regeneration, and using nurse crops or alternate silviculture systems to reduce the risk from spruce weevil. Open grown spruce stands on warm good sites between 8-30 years of age and 0.5 -12 m tall are at greatest risk of spruce weevil attack.

References:

Hodgkinson, R., K. White, & A. Stock. 2011. British Columbia's Northern Interior Forest Region: Spruce /White Pines Weevil Stand Establishment Decision Aid. BC Journal of Ecosystems and Management 11(3): 51-54.

Warren Root Collar Weevil (IWW)

Hylobius warreni Wood

Lodgepole pine is most susceptible to Warren root collar weevil but spruce and western white pine may also be impacted. Warren root collar weevil is common on lodgepole pine of all ages but normally only young trees between the ages of 5 and 20 are killed. Dominant and co-dominant trees on moister sites with a coarse textured soils and a deep organic duff layer are most susceptible (McCulloch et al. 2009). In young stands, above ground symptoms can be similar to those caused by Armillaria, however Warren root collar weevil is easily distinguished by black pitch, tube like shelters, and root girdling at the base of the trees. Weevil larvae take two years to develop and overwinter as larvae. Weevils may migrate into young lodgepole pine stands from infested mature lodgepole pine along stand edges or existing larvae may continue to develop on the stumps of freshly cut mature lodgepole pine for a period of one to three years (McCulloch et al. 2009). Adult weevils live for up to five years and travel 10-15m a year. On average an adult female weevil lays about 12 eggs/year (Duncan 1986). In heavily infected areas with a low brush hazard, delaying planting for one or two years may reduce the level of weevil mortality. Disc trenching and planting on the mound may also reduce mortality by decreasing duff thickness and moisture. In high hazard areas, delay spacing until after the age of 20 to reduce the risk of subsequent weevil caused mortality.

References:

Duncan, R.W. 1986. Terminal and Root Collar Weevils of Lodgepole Pine in British Columbia. Forest Pest Leaflet 73. Canadian Forestry Service. Government of Canada.

McCulloch, L., B. Aukema, K. White, and M. Klingenberg. 2009. British Columbia's northern interior forests: Warren Root Collar Weevil Stand Establishment Decision Aid. BC Journal of Ecosystem and Management 10(2): 105-107.

Diseases

a) Root Rots

Armillaria Root Disease (DRA)

Armillaria ostoyae (Romagne.) Herink
= *Armillaria solidipes* Peck, Bull.

²⁵ http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/RESULTS%20incidence%20maps/

Armillaria root disease causes mortality in a wide range of conifers and deciduous trees in the Cariboo Region and may increase the susceptibility of infected trees to bark beetles and other pests. Douglas-fir, true firs, and western hemlock are highly susceptible to Armillaria root disease, spruce exhibits medium to high susceptibility, pines are moderately susceptible, and western red cedar and deciduous species have a lower susceptibility. Western larch also appears to be less susceptible to Armillaria after age forty.

Mesic sites in the ICH zone have the highest hazard for Armillaria Root Disease (Cleary et al. 2008). *Armillaria ostoyae* appears to be absent from the Chilcotin Plateau and some portions of the Quesnel District. There is a closely related species of Armillaria (*A. sinapina*) that is weakly pathogenic on deciduous trees and can be saprophytic on conifers. *A. sinapina* likely has a geographic range that extends much further north than *A. ostoyae*. The two species can be distinguished by their pathogenicity to conifers and the branching pattern of the rhizomorphs or shoe strings.

Armillaria root disease is best surveyed prior to harvest by sketch mapping the location of centers and individual trees or by using a transect survey. Pixel surveys are not recommended. Although Armillaria is fairly easy to identify, it can be difficult to identify on dead young trees after the fans are no longer visible.

In the past, stumping has been prescribed to treat Armillaria root disease. The effectiveness of past stumping treatments is currently being evaluated. The results of these studies will be used to evaluate the effectiveness of stumping treatments and help managers to decide whether or not to continue with stumping treatments. At present stumping treatments are still recommended for the treatment of Armillaria root disease. Another approach is to regenerate with a uniform mixture of ecologically suitable species to minimize root to root contacts. Cleary et al. (2008) recommend planting a uniform mixture of 50% less susceptible species when planting with highly susceptible species and a 30% mixture of less susceptible species when planting with moderately susceptible species (highly susceptible species make up less than 30% of the species mix). There is some evidence that natural regeneration may be less susceptible than container stock (Chapman et al. 2011). Research is also currently underway to look at the effectiveness of treating stumps with *Hypholoma irregulare* (sulfur tuft mushroom) inoculum (Chapman et al. 2004) and ring barking.

In unmanaged stands, the severity and size of root rot centers seems to vary considerably from site to site. Variation in disease severity may be due to the frequency of exposure or quality of inoculum (infected roots) present on the site or tree vigour (Cleary et al. 2008). Severely impacted stands often have a significant deciduous component likely due to the lower susceptibility of deciduous species. Trees often form root calluses or swellings in response to Armillaria infection and some stands where Armillaria is present appear to have lower rates of mortality despite the presence of Armillaria calluses on the roots of many of the live trees. Intensification of Armillaria root disease has been reported in association with partial cutting. This is believed to be a result of the rapid spread of Armillaria in stump roots following cutting. There have also been some reports of Armillaria intensification following brushing, therefore to minimize this affect brushing should only be done when absolutely necessary to achieve free growing, and done when the trees are still small to minimize the size of stumps that act as inoculum sources (Cleary et al. 2008). Some researchers have reported no intensification of Armillaria root disease associated with partial cutting (Chapman et al. 2007). More research is needed in order to understand the factors that lead to disease intensification and to come up with better treatment approaches for the management of Armillaria root disease.

References:

- Chapman, W.K., B. Schellenberg, and T. Newsome. 2011. Assessment of Armillaria root disease infection in stands in south-central British Columbia with varying levels of overstory retention, with and without pushover logging. Can J. For Res. 41:1598-1605.
- Chapman, B., G. Xiao, and S. Myers. 2004. Early results from field trials using Hypholoma fasciculare to reduce Armillaria ostoyae root disease. Can J. Botany 82:962-969
- Cleary, M. B. van der Kamp, and D. Morrison. 2008. British Columbia's southern interior forests: Armillaria root disease stand establishment decision aid. BC Journal of Ecosystems and Management 9(2): 60-65.
- Morrison, D., H. Merler, and D. Norris 1991. Detection, Recognition and Management of Armillaria and Phellinus Root Diseases in the Southern Interior of British Columbia. FRDA Report 179. BC Ministry of Forests.

Laminated Root Rot (DRC/DRL)

Phellinus weirii (Murr.) Gilbertson (Douglas-fir type)
= *Phellinus sulphurascens* (Murrill) Gilbertson
= *Inonotus weirii* (Murrill) Kotl & Pouzar
= *Inonotus sulphurascens* (Pilát) Larsen et al.

Laminated root rot is primarily a disease of Douglas-fir. It forms discrete root rot centers or openings with associated windthrown and dead standing trees. Windthrown trees generally have characteristic root balls with laminated decay and typically fall in all directions. Laminated root rot is most prevalent in the 100 Mile District. It is absent from the Chilcotin plateau and the northernmost range of Douglas-fir along the Fraser River but is present in the southern part of the Quesnel District. Root rot centers in the northern Cariboo tend to be small (3-4 trees) and are often associated with Douglas-fir beetle, while those in the south may be quite large. Laminated root rot is fairly easy to manage on its own through stumping or the use of alternate species (pines or cedar) but management becomes much more difficult when it occurs together with Armillaria root rot. Laminated root rot sometimes goes undiagnosed when it occurs in conjunction with Armillaria. Laminated root rot centers are fairly easy to sketch map prior to harvesting. Generally only moderate to high root disease strata are treated (>6% incidence). In young stands, a 3-5 m transect survey with survey lines 50 to 100m apart can be employed to measure incidence. All trees within the transect exhibiting root rot symptoms (reduced growth, chlorosis, and stress cones) are assessed for signs of root disease. Treatment in young stands is difficult. Fill planting with alternate species can be used to fill in gaps. Thinning is not recommended unless there are sufficient alternate species present that can be left as leave trees. Young trees may be killed within a couple of years of infection. As trees get older the period between infection and death becomes longer and longer to the point where old growth trees may survive many years with the disease.

References:

- Cleary, M., R. Sturrock, & J. Hodge. 2011. Southern Interior Forest Region: Laminated root disease Stand Establishment Decision Aid. BC Journal of Ecosystems and Management. 12(2):17-20.
- Thies, W.G. & R.N. Sturrock. 1995. Laminated Root Rot in Western North America. USDA. Forest Service. General Technical Report PNW-GTR-349
- Morrison, D., H. Merler, & Norris, D. 1991. Detection, Recognition and Management of Armillaria and Phellinus Root Diseases in the Southern Interior of British Columbia. FRDA Report 179. BC Ministry of Forests.

Tomentosus Root Disease (DRT)
Inonotus tomentosus (Fr.:Fr.) S. Teng.

Although lodgepole pine is fairly susceptible to Tomentosus root disease, spruce is the primary host for Tomentosus root disease and the disease is generally associated with spruce stands or spruce stumps. Infection can occur via spores, or from root to root contact between trees or trees and stumps. Low elevation, drier and warmer zones within the SBS have the higher hazard for Tomentosus. Tomentosus root disease often goes undetected despite its widespread occurrence in the Cariboo Forest Region and can cause considerable growth loss in mature spruce stands. Five year basal area increment is about 20% less in 60 year old spruce compared to healthy trees (Hunt & Unger 1994). Infected trees are also more susceptible to blow down. The advanced decay produces a characteristic honey combing which is fairly easy to identify on the roots of windthrow. The fruiting bodies are also relatively easy to identify and when they are present they can be used to diagnose Tomentous root disease. Tomentosus root disease can be difficult to assess prior to harvest because it requires root drilling for accurate detection. Post harvest stump top surveys are much easier to do and make it possible to survey 100% of the cut trees. The simplest way of assessing Tomentosus root disease is to assess the butts of trees in log decks since approximately 90% of infected root systems have stain or decay at the stump top (Reich et al. 2013). Treatments for Tomentosus include planting alternate species and avoidance planting. Avoidance planting involves planting spruce trees at least 3 m away from infected stumps and requires that the stumps be marked prior to planting.

References:

Hunt, R.S., and L. Unger. 1994. Tomentosus root disease. Forest Pest Leaflet 77. Natural Resources Canada

Reich, R.W., Lewis, K.J., and Wiensczyk, A.M. Tomentosus Root Rot Forest Health Stand Establishment Decision Aid. Journal of Ecosystems and Management 14(1):1-8.

b) Stem Rusts

As a group, stem rusts account for the largest losses to young lodgepole pine stands (<25 years) in the Cariboo. In the Quesnel District, rust incidences of 10-30% are fairly common in young pine plantations. The number of new rust infections can vary considerably from one year to the next. Years with a high number of new infections are called wave years. Changes in local climate could have an impact on the frequency of wave years in the future. The most complete accounting of rust damage is conducted through the free-growing assessment and is recorded in RESULTS. A map showing the combined incidence of comandra rust and western gall rust reported in RESULTS in the Quesnel District is shown in Fig. 3. This information may be used to predict areas that may have a high rust hazard in the future. This assumes that areas of high rust incidence in the past will continue to have high rust incidences in the future.

Within high rust areas, it is recommended that high densities of lodgepole pine be planted or alternate species be used where appropriate. If you assume a rust incidence of 25% (and no other forest health factors), in order to achieve a target stocking of 1200 stems per hectare it would be necessary to regenerate at least 1600 stems per hectare of pine. It is good practice to plant species other than lodgepole pine as a minor component in lodgepole pine stands whenever possible to further offset potential losses to stem rusts. In the previous example of planting 1600 stems per hectare, if a 15% mixture of spruce is intermixed with the pine, a target stocking of 1200 stems per hectare could still be achieved even if the free growing survey rust incidence on pine was as high as 29.4%. Care must be taken when planting other species with lodgepole pine as some species mixture and densities may result in stands with lodgepole pine of poor quality and value.

References:

Allen, E., D. Morrison, and G. Wallis. 1996. Common Tree Diseases of British Columbia. Natural Resources Canada, Canadian Forest Service

Comandra Blister Rust (DSC)

Cronartium comandrae Peck

Comandra blister rust alternates between lodgepole pine and *Geocaulon lividum* (bastard toad flax) and *Comandra umbellata* (pale comandra). The incidence of Comandra rust on lodgepole pine is highest when lodgepole pine is in close association with the alternate host and decreases dramatically as the distance from an alternate host increases from 1 to 5m (Reich, 2011). Comandra cankers are typically 1.5-4 times as long as they are wide. The spores produced on lodgepole pine are club shaped as opposed to Stalactiform blister rust spores which are spherical.

References:

Reich, R.W. 2011. Comandra blister rust resistance: a needle in the haystack? In: Fairweather, M. Comp. 2011. Proceedings of the 58th annual Western International Forest Disease Work Conference; 2010, October 4-8; Valemount, BC. US Forest Service, AZ Zone Forest Health, Flagstaff, AZ.

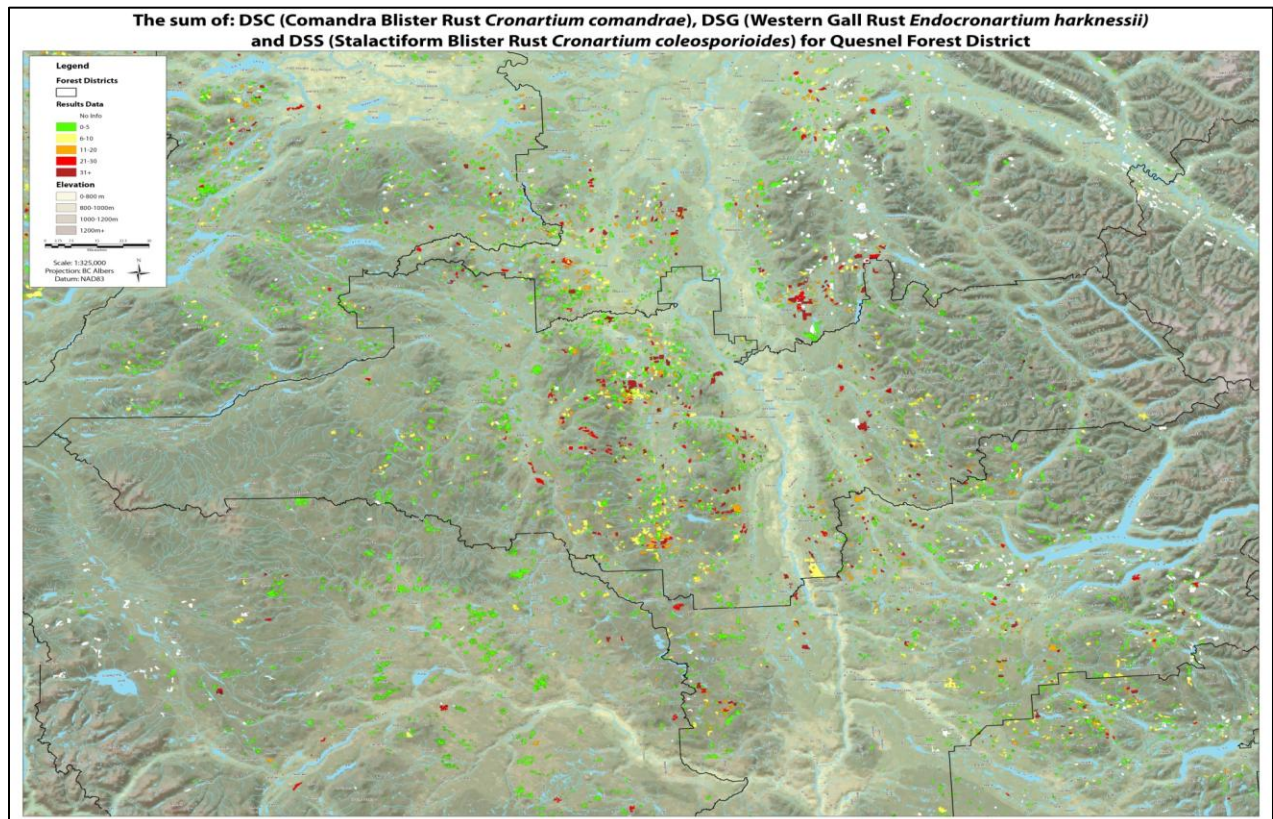


Figure 4: Combined incidence of western gall rust and comandra rust in the Quesnel District based on RESULTS data (courtesy of Richard Reich) Figure 5: High Rust Hazard Polygons in the Quesnel TSA (yellow) overlaid on BEC map.

Stalactiform Blister Rust (DSS)

Cronartium coleosporioides Arthur

Stalactiform blister rust has a number of alternate hosts in the Figwort family including *Castilleja* species (indian paintbrush), *Rhinanthus minor* (yellow rattle), *Pedicularis bracteosum* (bracted lousewort), *Mellampyrum lineare* (cow wheat), and *Orthocarpus luteus* (yellow owl clover). More research needs to be done to determine the relative importance of the various alternate species in transmitting the disease to lodgepole pine. Stalactiform rust cankers are generally 8-10 times as long as they are wide and the spores are more spherical than the club shaped spores produced by Comandra blister rust.

Western Gall Rust (DSG)

Endocronartium harknessii (Moore) Hiratsuka

Western gall rust is common throughout the region and is the most common forest health factor affecting young lodgepole pine stands. Unlike the other stem rusts, there are no alternate hosts required for infection to take place and the spores are capable of travelling long distances. New stem infections mostly occur on the current year's leader. The percentage of infected stems that are killed is much lower than for the other stem rusts but its higher incidence and more widespread occurrence make up for the lower mortality rate.

c) Cankers

Atropellis Canker (DSA)

Atropellis piniphilla (Weir) Loman and Cash

Atropellis canker affects lodgepole pine and occasionally ponderosa pine. Infections usually occur on trees tissue between 14 and 40 years of age and are more frequent in dense stands (especially on drier sites). Spacing before age 15 may reduce the likelihood of subsequent infections (Stanek et al. 1986). When spacing is conducted in stands older than 15 years of age, spacers should be trained on how to recognize cankers. The presence of cankers is indicated by sap, longitudinal furrowing of the stem, black staining in the wood, and small black fruiting bodies around the edges of cankers. Cankers expand longitudinally at a rate of about 5cm/year and circumferentially at a rate of about 0.5 cm/year. Cankers are more common on the northern and northeastern sides of trees (Stanek et al. 1986). The disease is spread by spores which can travel up to 100m. The incidence and impacts of Atropellis in the Cariboo Region have not been well studied. A study in Alberta found that trees with greater than 50% bark circumference killed by one or more cankers had as much as a 56% reduction in volume as compared to healthy trees. (Baranyay et al. 1973).

References:

Baranyay, J.A., T. Szabo, and K. Hunt. 1973. Effect of Atropellis Canker on Growth and Utilization of Lodgepole Pine. Canadian Forestry Service. Pacific Forest research Centre, Victoria BC. Information Report BC-X-86.

Hopkins, J.C. and B. Callan. 1992. Atropellis Canker Forest Pest Leaflet 25. Forestry Canada.

Stanek, W., J.C. Hopkins, and C.S. Simmons. 1986. Effect of spacing in lodgepole pine stands on incidence of Atropellis Canker.

d) Foliage Diseases

Lophodermella Needle Cast (DFO)

Lophodermella concolor (Dearn) Darker

Lophodermella is a needle cast that affects lodgepole pine and ponderosa pine. The previous year's needles turn red in the spring and then turn grey and fall off during the summer. The fruiting bodies are difficult to see. Outbreaks may be associated with wet summers during the year of needle infection. Repeated infections can result in a "Lion's tail appearance" in which only the current years needles are present. Naturally occurring needle parasites that only infect Lophodermella infected needles may be important in controlling outbreaks. The last major outbreak in the Cariboo occurred during the mid to late 1990's. Rankin et al. (2011) established eight plots in 1995 to study the impact of these outbreaks. Height growth for severely defoliated trees was 72% less than for lightly defoliated and unaffected trees and diameter growth for severely defoliated trees was less than half of lightly defoliated and unaffected trees. More work is needed to be able to understand the conditions necessary for outbreaks to occur.

References:

Allen, E., D. Morrison, and G. Wallis. 1996. Common Tree Diseases of British Columbia

Rankin, L. J. Westfall, & J. Brooks. 2011. Pine Needle cast trail assessment. Forest Health project 9. In 2011 Summary of Forest Health Conditions in British Columbia. Ministry of Forest, Lands, and Natural Resource Operations, Victoria, BC. 78pp.

Elytroderma Needle Cast (DFE)

Elytroderma deformans (Weir) Darker

Although widely recognized on ponderosa pine, Elytroderma needle cast often goes unrecognized in lodgepole pine. Elytroderma can cause perennial infections in the shoots of lodgepole pine and ponderosa pine trees that result in short needles and brooming that may be confused with dwarf mistletoe on lodgepole pine. If the infections occur in the upper crown they can cause severe stunting that may reduce height growth to half that of healthy trees. Infected lodgepole pine trees often have thick tapered stems and upturned branches or candelabra branching. Elytroderma forms very subtle cankers that appear as flat spots on the main stem and are very difficult to detect. Elytroderma causes cast symptoms which are similar to Lophodermella but it can be distinguished by the easily recognized brooming it causes on ponderosa pine and the short needles and stunting on lodgepole pine. It also produces fruiting bodies which are relatively easy to identify compared to other needle diseases.

Recent surveys have indicated that Elytroderma needle cast is fairly widespread across a fairly wide area of the Chilcotin and south western portions of the 100 Mile district in lodgepole pine stands. Within this area Elytroderma was not limited to the IDF but included sites in the SBPSmk and SBPSxc. Sites to the north east of highway 97N between 108 Mile and Williams Lake had a much lower incidence and severity of Elytroderma needle cast than sites to the south west of the highway. There are currently no control treatments for Elytroderma Needle cast. Repressed pine stands and pine stands scheduled for spacing treatments should be carefully assessed for Elytroderma needle cast before carrying out spacing treatments. For further information on managing Elytroderma needle cast in the Cariboo refer to (Rusch 2014) available on the R

References:

Hunt, R.S. 1978. Elytroderma Disease of Pines. Forest Pest Leaflet 27. Environment Canada Forestry Service.

Rusch, D. 2014. Elytroderma Needle Cast on lodgepole pine in British Columbia.

<https://www.for.gov.bc.ca/ftp/RSI/external/!publish/Forest%20Health/forest%20health%20references/>

Dwarf Mistletoe/Lodgepole Pine Dwarf Mistletoe (DMP)

Arceuthobium americanum Nutt. ex Engelman

Lodgepole pine dwarf mistletoe occurs throughout the range of lodgepole pine in the Cariboo. The importance of lodgepole pine dwarf mistletoe throughout much of the Cariboo has been much reduced since the mountain pine beetle epidemic killed most of the mature lodgepole pine in the region.

Lodgepole pine dwarf mistletoe management is based on clear-cut harvesting and removing all over story infected residual trees. Overhead residual trees can disperse seeds for a distance of 15m. Tree to tree spread inside a closed canopy without over storey residuals is only 0.4 m/year. Forest Stewardship plans often state that free growing mistletoe guidelines will not apply where a dwarf mistletoe treatment occurs after harvest. It is important that the stewardship plan identify what constitutes a dwarf mistletoe treatment. The recommended treatment for the Cariboo is a 0.5 m knock down within a few years of harvest. Careful design of cut block boundaries and leave tree patches can help reduce spread from the edges of cut blocks. Leaving visual screens along roads should be avoided where possible when there is a risk of dwarf mistletoe spreading into the adjacent block.

The highest incidences of lodgepole pine dwarf mistletoe occur in the SBPSxc on mesic sites where lodgepole pine is the only preferred species. Following the most recent mountain pine beetle outbreak, scattered small diameter mistletoe infected over storey trees were left behind. A study in 2011 (Rusch & Rankin 2011) in the Chilcotin SBPSxc found that all of 15 sampled polygons from unmanaged pine stands had some level of mistletoe and that 14 of the 15 polygons had mistletoe within the surveyed polygon area. In this study, the average incidence based on area was 66%. The average live basal area was 6.5m²/ha. The Hawksworth dwarf mistletoe rating for Layer 3 trees (1.4) was very similar to the rating of the infected over-storey trees (1.6). If it is assumed that the dwarf mistletoe rating will go up by one every 15 years, the results suggest an increase in dwarf mistletoe severity post mountain pine beetle. Information relating dwarf mistletoe rating to volume impacts is lacking for the Chilcotin. Rankin et al. (2011) reported significant differences in dbh and height for lightly infected and severely infected trees in a 30 year old stand. More research is needed to quantify what the future impacts of dwarf mistletoe in the Chilcotin are likely to be.

References:

Hawksworth F.G. & D.W. Johnson 1989. Biology and Management of Dwarf Mistletoe in Lodgepole Pine in the Rocky Mountains. USDA Forest Service General Technical Report RM-169.

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Rusch, D. and L. Rankin. 2011. Lodgepole pine dwarf .mistletoe update. Forest Health Project 7. In 2011 Summary of Forest Health Conditions in British Columbia. Ministry of Forest Lands and Natural Resource Operations, Victoria BC. 78pp.